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Students' Perspectives on Using Virtual Reality Technology in a University-level Agricultural Mechanics Course

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Abstract

Simulator technologies have become more prominent in many educational contexts in recent years. Simulator technologies such as virtual reality (VR) exist in many forms and can be used for different purposes, including weld process training. University-level course students have previously reported using VR technology can positively contribute to a course experience. 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, we sought to describe the perspectives nine students had on using a VR technology application throughout 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 teaching and learning processes. We recommend faculty who are considering using a VR technology application should carefully analyze current instructional needs and course structures to ensure using VR technology will adequately address students' educational requirements and will complement live weld process training procedures.

Keywords*:* agricultural mechanics; virtual reality

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Introduction

Educational technologies include various types and applications meant to achieve a wide range of different purposes and goals (Saettler, 2004; Smith et al., 2018). Educational technologies can include smartphones (Smith et al., 2018), digital games (Amory et al., 1999), and simulator technologies (Scalese et al., 2008). Regarding simulator technologies, Thiagarajan (1998) noted "[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

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educational interventions (Abrams et al., 1974; Kneebone, 2005; Nikolic et al., 2009; Thiagarajan, 1998; Winn & Jackson, 1999). Additionally, Thiagarajan (1998) noted 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 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 et al., 2015; Stone et al., 2011; Stone et al., 2013; Wells & Miller, 2020), (2) medical science (Cope & Fenton-Lee, 2008; Gallagher et al., 2003; Gor et al., 2003; Kilmon et al., 2010; Seymour et al., 2002), (3) safety training (Filigenzi et al., 2000), (4) science education (Nadolny et al., 2013), and (5) first responder training (Bliss et al., 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 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 et al. (2009) noted 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 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 VR technology can be beneficial to student learning, particularly from the standpoint of the experiential learning process. Incorporating VR technology into a university-level course 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 et al., 2013). For example, medical schools have incorporated VR technology into their curricula as a means of supplementing work with actual clientele (Verdaasdonk et al., 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 conducted by Byrd (2014), Stone et al. (2011), and Wells and Miller (2020) has indicated 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 students in university-level settings often find value in using VR technology to help supplement the learning experiences offered in their courses. Chung et al. (2020) found that students respond positively to using VR technology for welding skill development purposes. Tiffany and Hoglund (2014) indicated 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 students see value in this approach to teaching and learning. Lancelot (1944) suggested capturing student interest and maintaining engagement are key factors to providing effective instruction. Understanding student perspectives on using an instructional approach, such as incorporating VR technology into a formal course structure, 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 et al., 2016).

Prior exploration of users' perceptions of VR welding systems has been conducted outside of university settings. Porter et al. (2005) noted most users of such systems expressed positive sentiments toward using the technology for educating novices. Yunus et al. (2011) found the majority of weld process trainees perceived the welding skill development process can be positively impacted by using a VR technology application. In contrast, Fast et al. (2012) noted 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 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-level agricultural mechanics course may perceive using a VR welding system.

Students in university-level courses often perceive using VR technology for teaching and learning purposes can be beneficial to the course experience (Chung et al., 2020; 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 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 courses often engage in weld process training (Burris et al., 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?

Context of the Study

The semester-long, university-level agricultural mechanics course in our study was designed to provide students with a range of knowledge and skills related to small gas engines and metal fabrication. This course met on Monday and Wednesday afternoons for a total of five clock hours per week. The small gas engines component of the course was six weeks in duration while the metal fabrication component lasted 10 weeks. As part of the metal fabrication skill training, students engaged in a variety of skill areas, including: (1) using computer-aided design (CAD) software, (2) using computer numerical control (CNC) plasma cutting systems, (3) using oxy-acetylene systems for welding and cutting metal, and (4) using the SMAW and GMAW processes to complete various welding exercises. Students were provided with a range of projects and tasks throughout this 10-week period to hone their skills.

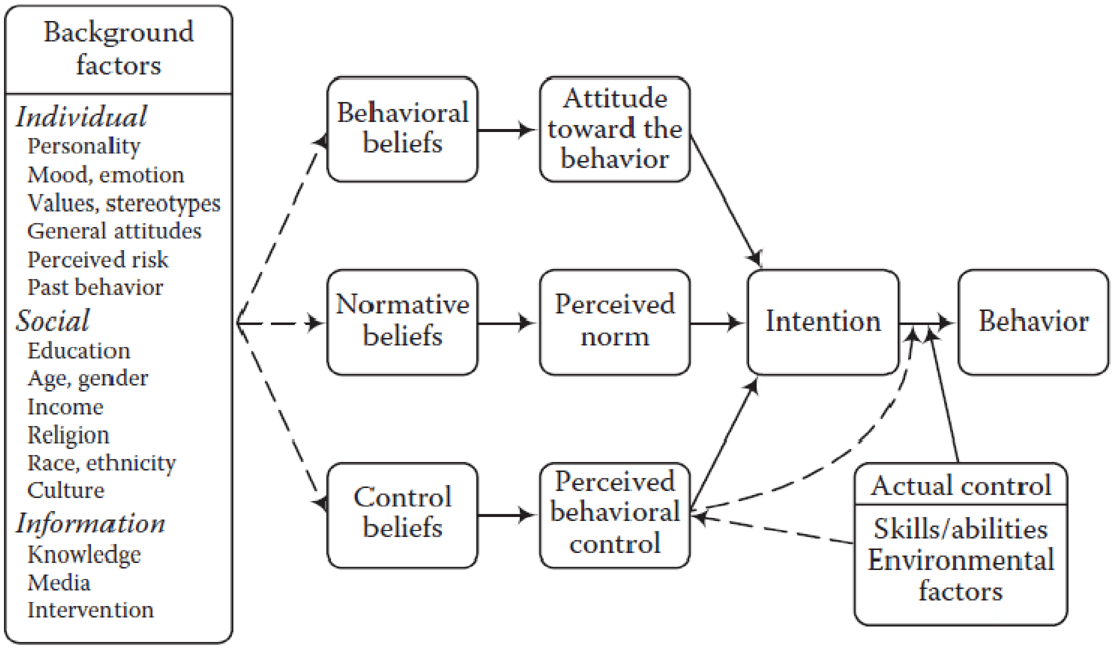
On Wednesday, February 28, 2018, three course meeting days after the metal fabrication component of the course began, all 18 students were introduced to the VR welding system used in the course and in our study. The students received instruction on its functions and applications and the how it was incorporated into the course structure as a series of graded assignments. To provide opportunities for the students to develop the welding-related psychomotor skills necessary to successfully meet the course objectives, the course instructor (i.e., the lead researcher) selected four different welds (two welds using the SMAW process and two welds using the GMAW process) for students to complete using the VR welding system. These four welds were selected prior to the February 28, 2018 course meeting and each closely aligned with the physical welds students were required to perform using the welding equipment in the Iowa State University (ISU) agricultural mechanics laboratory.

During the February 28, 2018 course meeting, all 18 students received the opportunity to initially use the VR welding system to practice welding virtually at least once. Having all the students demonstrate using the VR welding system allowed the course instructor to work one-on-one with each student and to answer any questions simultaneously. This process also ensured all students were capable of properly using the VR welding system with minimal assistance. Near the conclusion of the February 28, 2018 course meeting and after all 18 students had used the VR welding system, the course instructor informed the students that they were allowed to use the VR welding system at their own pace so long as they completed all four required virtual welds prior to April 25, 2018. This approach provided the flexibility needed to accommodate the course activities scheduled for the remainder of the semester and alleviated potential bottlenecks that could occur due to the 1:18 student-to-VR welding system ratio. As the semester progressed, the students gradually completed their four welds using the VR welding system. The majority of the 18 students completed all four virtual welds by early April.

Theoretical Framework

We used Fishbein and Ajzen's (2010) reasoned action model to underpin our study and to guide the analysis and categorization of student responses. Fishbein and Ajzen (2010) indicated behaviors are driven by a variety of prerequisite factors. These factors include individual-specific factors such as attitudes and prior behaviors, broader social factors including education, and information-specific items such as previous knowledge. In accordance with the reasoned action model, each of these background 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 and abilities as well as environmental factors present in the situation, can also impact perceptions of behavioral control and influence behaviors.

Figure 1
Reasoned Action Model



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The behavior of interest in our 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 et al., 2008). Thus, understanding individual students' perspectives could help to more thoroughly define how VR technology usage can fit into 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 courses.

Research Questions and Purpose

Based on the preceding literature and Fishbein and Ajzen's (2010) reasoned action model, we used three central research questions to guide 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 our study was to explore the perspectives students enrolled in a semester-long, university-level agricultural mechanics course had on using a VR welding system for weld process training purposes. When considering the research questions, we 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). As expressed in the American Association for Agricultural Education (AAAE) National Research Agenda (NRA) Research Priority 4: Meaningful, Engaged Learning in All Environments, 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

We used qualitative research methods to achieve our research purpose, which was phenomenological in nature. 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 our 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. We followed the recommendations provided by Creswell and Poth (2018) to conduct our study, including using multiple in-depth focus group interviews with several individuals who each experienced the phenomenon and by using phenomenological data analysis procedures.

Upon ISU Institutional Review Board (IRB) approval, we followed Morgan and Krueger's (1998) participant recruitment recommendations and began to solicit student participants via e-mail and in-class announcements. We sent the recruitment e-mail 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. Our e-mail contained information about the study and a link to a Doodle poll, which we used to allow students to designate potential focus group times and dates that fit their individual schedules. We wanted to establish a common time for each focus group session to take place based on the students' availabilities. To help incentivize participation, we offered refreshments to all students in exchange for their time. To help maximize participant turn-out, we sent reminder e-mails and text messages to the students who elected to participate.

We sought to conduct at least two focus groups on the topic during the Spring 2018 semester. According to Grudens-Schuck et al. (2004) and Morgan and Krueger (1998), using multiple focus group sessions can help deepen understanding about a topic. We conducted the first focus group session, which consisted of six students, on April 11, 2018. We conducted the second focus group session, which consisted of three students, on April 12, 2018. Conducting both focus groups during mid-April allowed approximately six weeks for students to use the VR welding system to complete their assigned virtual welds and granted them time to more thoroughly reflect on using the VR welding system within the course. We 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 our study in its entirety, we provided a brief description of each participant. We used pseudonyms 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. He 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 enrolled in the course to develop mechanical skills to help maintain his family's agricultural equipment and facilities.

Walter was an undergraduate student majoring in Agricultural Studies. He 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. He wanted to either return home and farm or pursue a position in agricultural sales and service. He sought 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. She planned to become a school-based agricultural education (SBAE) teacher in the Midwest. Her career plans included teaching agricultural mechanics courses 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. He 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. She sought to pursue a position as communications specialist in the agricultural industry upon graduation. She had previously completed agricultural mechanics courses 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. His background was in production agriculture and 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 the lead researcher's prior experiences with using the VR welding system in the course, he moderated each focus group session, which lasted approximately 90 minutes based on the recommendations of Grudens-Schuck et al. (2004). Another doctoral student 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 our findings.

It should be recognized that because the lead researcher moderated the focus group sessions and was also the course instructor, concerns of potential bias and power over the 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 us. We informed the students that their participation held no consequence toward their performance in the course and their perspectives would be used to help further improve the use of VR technology in the course structure in the future. The doctoral student's presence in each focus group session served as a monitor for any bias in the phrasing of each question (e.g., using positive voice inflections on some questions, using negative tones with other questions, etc.). The doctoral student reported he detected no bias throughout the moderation of each focus group session.

The lead researcher used a printed copy of interview questions, which included the leading questions in Table 1 along with several probing questions. Using a printed interview protocol helped to reduce the risk of bias when questions were presented during each focus group session.

Table 1

Interview Questions Used During Each Focus Group Session

Interview Question	
1	What value do you perceive in using the VR weld training system as part of the course's weld training protocol?
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?
3	What benefits, from a student perspective, exist to using the VR weld training system as part of the course's weld training protocol?
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?

We developed these questions prior to the focus group sessions. We asked an SBAE teacher with previous experience using a VR welding system and a qualitative research methods course instructor at ISU whose primary research focus was educational technology in the classroom to assess these questions for face and content validity. They each made suggestions to provide greater clarity to the leading interview questions and the probing questions. These suggestions were changes in wording and sequencing of the questions. After the suggested changes to the questions were made, we submitted the questions back to them for a second review. They each subsequently determined the interview questions were both face valid and content valid and were appropriate for use in our study.

In compliance with ISU IRB protocol, we asked the students to sign an informed consent document and return it to us 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, the lead researcher began moderating the focus group sessions, taking care to follow the interview protocol and ask 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, we 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 us. We applied the assigned pseudonyms to the transcripts to protect each student's identity. After the conclusion of each focus group session, we sent all the student participants an e-mail inviting them to participate in a follow-up focus group session to discuss the activities of their respective focus group sessions. Within this e-mail, we included a link to a Doodle poll to designate potential follow-up focus group times and dates that fit their individual schedules. We sought 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, we conducted two 30-minute follow-up focus group sessions seven days after each initial focus group session. Prior to the follow-up focus group sessions, we 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.

We used the follow-up focus group sessions to serve as our 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, we "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). We did not show the student participants any transcripts, observation notes, or video evidence. We instead showed them "preliminary analyses consisting of description or themes" (Creswell & Poth, 2018, p. 262).

Regarding the data analysis process, we 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 our 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 "corroborating evidence from different sources [can be used] to shed light on a theme or perspective" (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 our 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).

We 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, we felt it was important to provide insight into our potential biases. Bracketing beliefs about teaching with VR technology helped us "take a fresh perspective toward the phenomenon under investigation" (Creswell & Poth, 2018, p. 78). Providing insight into our prior experiences, values, and biases helps to aid our study's readers understand the inquiry perspective (Creswell & Poth, 2018).

The lead researcher was the agricultural mechanics course instructor and a former SBAE teacher who taught agricultural mechanics courses in a single-teacher program at a rural high school in western Alabama. Prior to serving as the course instructor, he did not use any VR technology as part of his instructional approach. The secondary researcher is a former SBAE teacher who taught agricultural mechanics courses 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.

The doctoral student 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, we were better able to improve the trustworthiness of our 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 along with supporting quotes from the students.

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 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, “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 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, “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 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, “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, "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 some elements of the VR welding system did not fit with actually preparing to perform the welding process, expressing, “[T]he other day when I went to MIG [metal inert gas] 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, “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, “The [VR welding system] helped me with my body position[ing] [and] [a]lso with my timing." Walter further noted, "[I]t helped ease into the transition of doing it in [the] real world."

Wayne offered, "The angles and all that stuff were really compatible." Jesse felt 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, "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 acknowledged saving consumable materials was a valuable benefit to using VR technology for teaching purposes. Wayne capitalized on this part of the 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 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 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 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 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:

> 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, "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, "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 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, "[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, "I personally [believe] [using the VR welding system] didn't benefit me as much. It probably might have benefitted 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, "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 expressed:

> 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. [They get to] [s]et everything up, calibrate everything. 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 using the VR welding system hindered their performance when using actual welding equipment. Coulter opined, "[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, "[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, "[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." Similar to Ryan, Jesse stated, "[T]here's kids [other 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 some degree of alignment existed between VR welding and live welding activities, VR technology could serve as a tool for teaching and learning purposes, and 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 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 our study indicated 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 VR technology could serve practical roles in developing the welding-related psychomotor skills of students enrolled in university-level agricultural mechanics courses, most notably when introducing students to new skills associated with course objectives. Our findings indicate 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. Chung et al. (2020) likewise found that students positively view using VR technology to support the development of new welding skills. In alignment with the students' suggestions, Whitney and Stephens (2014) noted 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 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 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 university-level students do perceive 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 our 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 the process of behavioral follow-through can often be affected by such factors. Byrd (2014), Stone et al. (2011), and Wells and Miller (2020) 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 courses are advised to analyze their current instructional needs, course structures, and curricula to ensure 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).

While our study examined the efficacy of a VR technology application from students' perspectives, we recognize perspectives can be altered based on experience and the results of our study cannot be used to determine if using VR technology applications impacts psychomotor skill performance. Several students in our study believed 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.

We recognize the results of our 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. We believe the students who participated in our 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 educational experiences (McCubbins et al., 2016).

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