“Is that an Oculus?” An Investigation of Ohio Agriculture Teachers’ and Students' User Experience in a Virtual Reality Tractor Safety Experience

Dissertation

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By

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Abstract

Career and Technical Education (CTE) has become a mainstay in public schools, which evolved from various bills such as the Smith-Hughes Act giving rise to Agricultural Education programs (ACTE, 2022). Agricultural Education uses a combination of classroom and laboratory instruction, experiential learning, and leadership education to prepare students for jobs in industry (Roberts, 2006; NAAE, 2022).

The foundation of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), are based on an artificial and digital environment provided by a computer and in which a user's actions determines what happens in the environment. This technology is an option for teachers who wish to incorporate experiential learning and give students real experiences who otherwise might not have the opportunity (Liarokapis et al., 2004; Johnson et al., 2010; Domingo & Bradley, 2018). Virtual Reality has been used across many industries as a form of training, such as medicine, pedestrian safety, construction, manufacturing, military training programs, tractor and machinery operation (McComas et al., 2002; Aggarwal et al., 2006; Tichon & Burgess-Limerick, 2011; Sacks et al., 2013; Namkoong et. Al., 2022).

Agriculture is one of the most hazardous industries in the U.S. for all workers, and even more so for young workers (U.S. Department of Labor, 2020). Research has

shown that educators and students are unaware of basic farm safety information, or where to find the necessary information. In the United States, legislation prescribes training for youth under the age of 16, working in hazardous situations in production agriculture. Specific to tractor and machinery operation, one national curriculum is the National Safe Tractor and Machinery Operation Program. It includes comprehensive lessons around equipment safety, and evaluates students' competencies though a skills checklist and a driving course.

The purpose of this mixed-methods study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students and teachers in tractor and machinery safety operation lessons. A mixed-method approach was utilized with Ohio student and teacher participants using survey research, semi-structured interviews, and performance scores to explain user experiences. Data were triangulated within the teacher population to determine if a relationship existed between the measured variables.

Objective 1 sought to describe how students (n =38) performed in the VR program. On average, students accrued a high number of points across the precheck questions and the driving course, which resulted in low performance.

Objective 2 sought to describe if there was a difference between a traditional tractor training and a tractor training with a VR intervention. The passing rates of the two groups (n = 42) that completed the tractor operation program were evaluated and found that there was no significant difference between the two groups. It can be concluded that the VR intervention had no significant effect over the traditional training in this one case.

Objective 3 and 4 used a quantitative survey to describe the 10 constructs of the user experience model. The constructs were Presence, Immersion, Engagement, Flow, Skill, Usability, Emotion, Judgement, Experience Consequence, and Technology Adoption. The survey measured the constructs on a 10-point Likert scale.

Objective 3 sought to describe students' (n = 132) user experience from the VR program. Every construct had a mean score over neutral; the Experience Consequence and Technology Adoption constructs scored the highest, while the Flow and Usability constructs scored the lowest. This concludes that the students' user experience towards this program was positive.

Objective 4 sought to describe teachers' (n =13) user experience from the VR program. Every construct had a mean score over neutral except for Flow; the highest constructs were Experience Consequence and Engagement, while the Flow and Skill constructs were the lowest. This concludes that the teachers' user experience towards this experience was positive.

In Objective 5, teachers (n = 11) participated in semi-structured interviews to describe their user experience. Two themes and 9 sub-themes emerged from those results. Three main barriers that impede VR adoption were identified as classroom and resource management, technology barriers, and negative emotions. When these are present, it is challenging for students and teachers to see the benefits of integrating VR into their skill-based activities. However, the benefits of a VR program can still have a positive effect in classroom applications. This conclude s that teachers had a valuable and positive experience.

In Objective 6, teachers (*n* = 11) participated in semi-structured interviews to describe their sense of realism in the program. It was concluded that teachers had a semi-realistic experience as they described their movements while interacting with the virtual environment.

Objective 7 sought to explore if there was a relationship between teachers' user experience scores and teachers' quantified realism scores and determine if the user experience instrument could be an indicator of realism. It was concluded that the relationship was negligible between the teachers' realism and user experience.

The findings from this study identified three main factors that influence the integration of VR into Agricultural Education. The implications of these finding suggest VR can provide a supplemental training method for tractor and machinery programs. By ensuring that teachers and students have positive user experiences, addressing students' performance, and providing a realistic interpretation of a hands-on activity VR can be successfully integrated into skill-based education.

Both students and teachers expressed excitement about a new teaching method for a traditional topic that has experienced little change over the years. This study will contribute to the body of literature to further the integration of virtual reality into educational environments.

Dedication

I am dedicating this dissertation to Maw and Uncle David, I know they would be proud to see everything that I have accomplished and where I am today. I am also dedicating this to my Paw Paw who passed a couple weeks before my defense. I know he couldn’t wait until I made it back home, but I know he is proud that I have finished and back home.

Acknowledgments

First and most importantly, to Jon, I could not have done any of this without you. You have been there for me through the ups and downs, and everything that has stressed me out or upset me. I appreciate everything that you have sacrificed for me to complete this degree, I do this for you, and I hope that I continue to make you proud. Te amo mucho mi amor.

To my family, thank you for supporting me in moving out of state to continue school. I know I said that I would never do anymore school, but I am officially done with being a student! Hopefully we can get Everleigh to be become a Tarleton Texan in time!

To my advisors Drs. Jepsen & Kitchel, thank you for your guidance and understanding. I have learned so much under both of you. I hope to make you proud with the work I will do at Tarleton State.

Lastly to my cohort, Alyssa, Colby, and Rafa. Y'all have certainly made the three years fly by and I would not have asked for anyone else to share an office. I wish Alyssa and Rafa the best as they begin their faculty careers, and Colby as he starts his dissertation.

Vita

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Major Field: Agricultural Communication, Education, and Leadership

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CHAPTER 1: INTRODUCTION

"Workforce education and development is the key to promoting individual learning and skill training" (O'Lawrence, 2017 p. 6). Since the early 19th century, workforce education has strived to produce workers with hands-on skills necessary for certain trades through individual learning experiences and classroom instruction (ACTE, 2022). Career and Technical Education (CTE) has become a mainstay in public schools, which evolved from various bills such as the Smith-Hughes Act giving rise to Agricultural Education programs (ACTE, 2022).

Agricultural Education uses a combination of classroom and laboratory instruction, experiential learning, and leadership education to prepare students for jobs in industry (NAAE, 2022). Through a synthesis of the literature, Roberts (2006) concluded that experiential learning could be defined "as a process or by the context in which it occurs" (p. 26). His model of Experiential Learning Contexts explained that experiential learning could occur across four dimensions: the level, duration, intended outcome, and the setting (Roberts, 2006).

The foundation of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), are based on "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment" (Merriam-Webster, 2022).

Virtual Reality uses a fully immersive environment and technology to engage the user in the experience. Augmented Reality is the least immersive of the three and uses technology such as a smartphone to overlay an environment that can be interacted with through the phone. Mixed Reality is a mixture of the other realities; it allows the user to interact with accurate equipment in an immersive environment, such as a driving simulator.

This technology is an option for teachers who wish to incorporate experiential learning and give students real experiences who otherwise might not have the opportunity. Johnson stated that "AR has strong potential to provide both powerful contextual, on-site learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world" (Johnson et al., 2010, p. 22). In one study, students were immersed in a virtual learning environment before the start of an online literacy course. Through their experience, students reported positive perceptions and valued the use of the virtual environment (Domingo & Bradley, 2018). Liarokapis et al., (2004) demonstrated that AR can make complicated mechanisms and difficult theories in higher education accepted and understood by students.

Virtual Reality has been used across many industries as a form of training, such as medicine, pedestrian safety, construction, manufacturing, and military training programs. For example, experienced surgeons who had prior experience with VR training were significantly faster and used significantly less contrast fluid than the inexperienced group (Aggarwal et al., 2006). McComas et al. (2002) used a desktop VR program to teach the four main lessons of pedestrian safety to students, who displayed increases in the gain mean scores. Another training program used in the construction industry reported that workers showed a significant difference between pre and post-tests in hazard ID and prevention (Sacks et al., 2013). The mining industry has tested VR, primarily around safety practices, in attempts to reduce the number of injuries that happen on the job. As a result, a range of equipment simulators including dozers, draglines, haul trucks, shovels, and continuous miners are available commercially (Tichon & Burgess-Limerick, 2011).

Studies have shown that when an experience is not sufficiently realistic it detracts from the students' ability to learn. Kavanagh et al. (2017) found that in a synthesis of research, 20% of the studies analyzed reported issues related to systems providing an insufficiently realistic experience. This accounted for 26.9% of the total output problems reported (Kavanagh et al., 2017). Other studies reported that users of the VR systems found their implementations to be insufficiently realistic, and authors worried that this may detract from the learning experience (Huang et al., 2010; Lee et al., 2014). Schwaab et al. (2011), for example, designed a VR system to simulate mock medical emergency oral examinations. While most of the students reported they preferred the VR system to the traditional approach, several also claimed it did not really reflect their practical experience and would therefore provide limited benefit to their learning. In addition to limitations to the realism provided by the virtual environments, there can also exist visual and graphic limitations to the devices providing them like low pixel density, image latency, and other limiting sensory factors (Cuccurullo et al., 2010; Hsiaoa et al., 2010).

The benefits of VR curricula allow students to experience potentially hazardous and stressful situations. As noted above, VR has widespread application to technical training programs, including machinery operation. Allowing students to engage with these situations in a realistic and safe environment can allow students to learn the necessary skills to be successful with the real experience. One safety education-based study showed 3D VR was more effective than a lecture-only delivery method and equally comparable to a lecture with a physical laboratory (Nakayama, 2014).

If the purpose of a workforce development program is to provide students with realistic experiences to prepare them for jobs in industry, then virtual reality has the potential to benefit CTE. Making these experiences as realistic as possible, VR can be used in wider training applications, including the fields of agricultural safety.

Agriculture is one of the most hazardous industries in the U.S. for all workers (U.S. Department of Labor, 2020). For young workers, the dangers of agricultural environments are even higher. According to the National Children's Center (2022), approximately 15 children die from an agricultural event per 100,000 full-time equivalent workers (FTE). The leading cause of fatalities for all youth are machinery (25%), motor vehicles including ATVs (17%), and drownings (16%) (National Children's Center for Rural and Agricultural Health and Safety, 2019). Injuries in youth populations follow fatality rates where youth are 7.8 times more likely to be fatally injured on farms and ranches (National Children's Center for Rural and Agricultural Health and Safety, 2022). Livestock and crop farms are particular sources of high injury rates for youth, with 11,943 youth ages 19 and below reporting injuries in 2014 (Centers for Disease Control and Prevention, 2018).

Youth working and living on farms and ranches are an all-too-common occurrence across the country. For the year 2014, about 893,000 youth lived on farms and more than half (51%) worked on their farm (National Children's Center for Rural and Agricultural Health and Safety, 2019). The Department of Labor's publication, *Child Labor Bulletin 102*, states that minors under the age of 12 can "be employed outside of school hours with parental consent on a farm where employees are exempt from the federal minimum wage provision" (U.S. Department of Labor Wage and Hour Division, 2016, p. 3). At age 16, there are no restrictions to youth employment on farms and ranches. To provide protection during these occurrences, it is important that educational resources be continuously developed and provided to young workers to improve their safety knowledge, enhance their skills, and overall increase their awareness for agricultural dangers; likewise, training resources directed towards agricultural educators, parents and supervisors of young workers should be readily available to adult trainers (Jepsen, 2011).

Research has shown that educators and students are unaware of basic farm safety information, or where to find the necessary information. For example, of the 24 surveyed agricultural educators, only 30% knew that the farm tractor is the leading cause of occupational fatality in agriculture in the study's pre-test (May & Scofield, 2005). In another study, 52% of respondents of Iowa agriculture teachers felt they weren't knowledgeable about where to find agricultural safety and health resources if they needed them and 60% didn't believe they taught it enough in class (Rudolphi & Retallick, 2015). Of 933 Agricultural Education students, approximately 96.1% (*n* = 893) thought safety was important, but only 40% (*n* = 377) felt that their level of managing safety or quality of safety in agricultural environments was somewhat high or high (Ramaswamy & Mosher, 2015). Vincent et al. (2019) found that high school students who participated in a cost-effective rollover protective structure curriculum showed a significant difference in improved attitude, knowledge, and skills between the pre and post-tests. Ultimately safety education has two purposes. It provides a method to train workers and other individuals to engage in self-protective behaviors, and it serves as the foundation for safeguards and supervision strategies. A popular injury prevention model used in the agricultural industry is the 3-E Model (Aherin et. al., 1992). This model suggests Education is an effective strategy for curbing occupational injuries along with the other two E's of Engineering and Enforcement. According to Murphy (1992) "The educational option has always been a high priority for those concerned about agricultural safety and health." (p. 113) While education has its place to promote safety and health concepts, program evaluation data reports varying degrees of effectiveness depending upon a wide range of contributing variables. These findings support incorporating more engaging curricula and interactive technology to improve students' safety knowledge and skills.

Problem Statement

Career and Technical Education teachers, which includes agriculture teachers, are instrumental in developing workforce development, occupational, and technical skills in youth to prepare them for industry (O'Lawrence, 2017). Current jobs for young workers require no more than basic literacy and experience that is picked up simply by being on-the-job. Basic workplace literacy refers to the terminology, knowledge, and skills within the context of the job. The experience should come from practice and simulated real-world activities to prepare workers for the specific job. As technology improves and becomes more available, more advanced occupational skills will be needed from our workers (U.S. Department of Labor, 2008). Students can be successful in real-world experiences and their careers if provided with experiential learning activities (ACTE, 2022).

Virtual Reality can provide an alternative medium for learners to gain and practice new skills (Johnson et al., 2010; Liarokapis et al., 2004,). The use of AR and VR can be traced back to the 1960s, and has become cheaper to acquire (Lee, 2012). Virtual Reality can be an efficient tool for K-12, colleges, and universities to provide their students with knowledge and skills of complex mechanisms and theories (Lee, 2012). Training programs that incorporate VR can be an effective method of training students, as it opens the door to provide a tangible context and realism to a situation that is not normally safe (Stredney et al., 2008).

There is a need for farm and ranch safety concepts to be included in youth workforce development training programs (Hard & Myers, 2006). Programs of multiple types have been developed to help train and educate students in safe tractor operation; programs range from traditional methods to more creative approaches, such as implementing a cost-effective rollover protective structure (CROPS) curriculum or teaching tractor rollover and stability concepts using LEGO Mindstorms (Vincent et al., 2019; Koc et al., 2012;). Despite the collective efforts that have been implemented to increase safety awareness, less than 1% of the youth who operate tractors or other hazardous machinery actually participate in a tractor certification training (Heaney, et al., 2006).

Cognizant that hazardous situations can occur during training programs, educators believe VR can be used as a supplemental training tool to teach machine safety (Kizil et al., 2001). The need for more realistic simulations creates the opportunity for a study to incorporate VR as an alternate means of training students and workers. As such, a VR tractor and machinery training program will be developed, and a study will be designed to measure user experience from the students' and teachers' perspective. An Ohio-based population will be used to integrate the virtual experience into Agricultural Education classrooms, which will provide the platform to evaluate future virtual experiences. Through this study, it will be possible to address the question "Can virtual reality provide a realistic experience and supplemental option for skill-based education?" specifically in the context of agricultural machinery operation.

Purpose of the Study

The purpose of this mixed-methods study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students and teachers in machinery safety operation lessons.

Research Question and Objectives

The central question guiding this study was "Does virtual reality provide a realistic experience and supplemental option for skill-based education?" The study incorporated a mixed-methods approach of quantitative and qualitative methods to answer the research questions; the study was guided by seven research objectives. A mixed-method approach was utilized with student and teacher participants using survey research, semi-structured interviews, and performance scores to explain user experiences. Data were triangulated within the teacher population to determine if a relationship existed between the measured variables.

Quantitative Objectives

1. Describe the virtual reality program performance of agricultural education students from Ohio.
2. Describe the difference in Ohio agricultural education students' performance between a traditional tractor safety training and a tractor safety program with VR.
    - H_0: There will be no difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.
    - H_1: There is a difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.
3. Describe the user experience (UX) of Ohio agricultural education students.
4. Describe the user experience (UX) of Ohio agricultural education teachers.

Qualitative Questions

5. What was the lived experiences Ohio agricultural education teachers' who implemented a virtual reality experience into their curriculum?

6. What was Ohio agricultural education teachers' sense of realism in the virtual reality program?

Convergent Parallel Mixed Methods Objective

7. Explore the relationship between Ohio agricultural education teachers’ user experience (UX) and the realistic nature of the VR program.

Limitations of the Study

1. The results of this study are focusing on teachers and students who participate in machinery safety classes and may not be generalized to the larger population of agricultural education teachers, extension educators, or students in agricultural education programs and extension programs who provide youth safety training.
2. Due to the nature of VR, teachers and students may experience adverse physical effects related to VR usage and may not be able to complete the program.

Basic Assumptions

1. Teachers presented the VR program as an educational tool and included it within their classroom curriculum.
2. Students willingly completed the VR program.
3. Participants responded truthfully to the questions regarding their experiences.
4. Participants do not have a significant or strong bias for or against the use of VR.

Definitions of Terms

- Augmented Reality: A variation of a virtual environment where technologies superimpose a computer-generated image over a user's view of the real world (Azuma, 1997).
- Emotion: A component defined as the feelings (of joy, pleasure, satisfaction, frustration, disappointment, anxiety) of the user in the VE. The Achievement Emotions Questionnaire (AEQ) created by Pekrun measures the emotion component (Pekrun et al. 2011). It identifies the emotion experienced in achievement situations.
- Engagement: A component defined as the "energy in action, the connection between a person and its activity consisting of a behavioral, emotional and cognitive form." The Presence Questionnaire (PQ) created by Witmer and Singer measures presence and engagement (Witmer et al. 1998), it identifies the degree to which individuals experience presence and engagement in a virtual environment.
- Experience Consequence: A component defined as the symptoms (e.g., the "simulator sickness," stress, dizziness, headache) the user can experience in the VE. The Simulator Sickness Questionnaire (SSQ) created by Kennedy measures the experience consequence component (Kennedy et al. 1993). It identifies the negative consequences the user can have while using the IVE.
- Flow: A component defined as "a pleasant psychological state of sense of control, fun, and joy" that the user feels when interacting with the VE. The Flow4D16

questionnaire created by Heutte measures the flow component (Heutte et al. 2010). It identifies the degree to which the user is absorbed by his task.

- Judgment: A component defined as the overall judgment of the experience in the VE. The AttracDiff questionnaire created by Hassenzahl, Burmester, and Koller (2003) measures the judgment component. It identifies the user's attraction in a pragmatic and hedonic way towards the system.
- Immersion: A component defined as the "illusion" that "the virtual environment technology replaces the user's sensory stimuli by the virtual sensory stimuli." The Immersion Tendency Questionnaire (ITQ) created by Witmer and Singer (1998) measures immersion, it identifies the tendency of individuals to be immersed.
- Presence: A component defined as the user's "sense of being there" in the VE. The concept of presence can be divided into two categories: physical presence in the virtual environment and social presence in the collective or collaborative virtual environment (Pallot et al. 2013). Most measures of presence try to address both.
- Q (#): Operational name of each variable for the questions from the user experience survey.
- Skill: A component defined as the knowledge the user gains in mastering his activity in the virtual environment. The Computer Self-Efficacy (CSE) questionnaire created by Murphy et al. (1989) measures the skill component. It identifies the attitude of a user toward computer technology, and the degree to

which one feels comfortable with a computer. This questionnaire is a reference in the education field to evaluate adult students' computer skills.

- Technology adoption: A component defined as the actions and decisions taken by the user for future use or intention to use the VE. The Unified Technology Acceptance and Use of Technology (UTAUT) questionnaire created by Venkatesh and al. (2003) measures the technology adoption component. It identifies the degree to which the user will adopt and use the system, in other words, the likelihood of success for new technology introduction.
- Usability: A component is defined as the ease of learning (learnability and memorizing) and the ease of using (efficiency, effectiveness, and satisfaction) the VE. The System Usability Scale (SUS) created by Brooke (1996) measures the usability component. This scale has been created on a base of 50 usability questionnaires. It identifies "the appropriateness of a purpose" in other words, it identifies if the way we propose to use our VE is appropriate.
- User Experience (UX): A model that is defined by the different components of the experience (Tch-Tokey et al., 2016).
- Virtual Environment (VE): The artificial environment that the user may interact with inside virtual reality (Steuer, 1992).
- Virtual Reality (VR): Can be defined as an "alternate world filled with computer-generated images that respond to human movements." (Steuer, 1992, p. 75)

Significance of the Problem

With the integration of virtual reality into multiple industries for safety and training purposes, VR curriculum has demonstrated its application as a supplemental training medium. Its ability to provide hands-on educational experiences in a safe and controlled environment will allow for integration into career and technical education. With more workers needed in skill-based professions, virtual reality can provide a medium in which students can be trained to go into these skill-based professions.

CHAPTER 2: LITERATURE REVIEW

This chapter presents literature focused on Career and Technical Education (CTE) and Agricultural Education and their collective role in developing hands-on skills through education. Virtual Reality constructs, and opportunities to use virtual reality in training settings, will be discussed. A review of agricultural safety strategies will be presented as they relate to curbing injuries in youth worker populations using the 3E Model. And finally, a theoretical framework describing the user experience model and the constructs that will be measured by students and teachers within the study.

Workforce Development and Career and Technical Education

The driving force behind a nation's ability to improve productivity and technology are trained and educated workers (O'Lawrence, 2017). The social efficiency doctrine as explained by Camp (1982) is that an efficient society could create an environment so that individuals could prosper, also that public schools were a part of this system and had a responsibility to prepare a well-trained and compliant workforce. This push to create a trained workforce became the main focus of what we call Career and Technical Education (CTE) (Scott and Sarkees-Wircenski, 2004). Scott and Sarkees-Wircenski (2004) defines Career and Technical Education (CTE) as a program "that serves the purpose of providing learning experiences that help students explore career areas, prepare for employment, and independent living" (p. 1).

Over CTE's history, several learning theories were applied. Behaviorism became the main learning theory within CTE at the beginning of the 1900s (Dobbins, 1999), but as times changed, local CTE shifted towards a competency-based curriculum focused on industry needs and standards (Doolittle & Camp, 1999). Through the technology changes of the 1990s and 2000s, constructivism was proposed into CTE's theoretical framework. Constructivism is a learning theory that states users construct knowledge from one's own neurological, social, and cultural experiences (Fosnot, 1996).

CTE is home to several programs designed to prepare students for careers in areas such as agricultural education, business, family and consumer sciences, marketing, health, trade and industry, and technical/communication (Scott & Sarkees-Wircenski, 2004). CTE programs work to build skills in students through a hands-on environment, and through these experiences, students can practice skills and apply them to real-world situations (Scott & Sarkees-Wircenski, 2004).

Career and Technical Education in Agriculture

Historically, agricultural education has been grounded in a combination of learning theories as a process for students to engage with the material learned, practice it in controlled environments, and apply it to real-life situations. The Three-Circle Model utilized by Agricultural Education focuses on classroom/laboratory instruction, experiential learning (SAE), and leadership education (FFA) (NAAE, n.d.). Focusing on the classroom/laboratory instruction, Piaget and Dewey were instrumental in the development of constructivism through their theories of childhood development and education that is continuously used today (Ackerman, 2001). Based on these principles, constructivism focuses on the processes by that learners mentally build structures when interacting with an environment; it is task-oriented, hands-on, and self-directed activities oriented towards design and discovery (Conole et al., 2004).

Another constructivist, Papert, modified Piaget's theory arguing that intelligence should be studied in a situated and connected environment called constructionism (Ackerman, 2001). Constructionism is defined as "Learning as 'building knowledge structures' through progressive internalization of actions… It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sandcastle on the beach or a theory of the universe" (Papert, 1991, p. 1).

Kolb (1984) describes experiential learning theory as a "holistic integrative perspective on learning that combines experience, perception, cognition, and behavior." (p. 21). Models of experiential learning benefit the learner by engaging them in an initial concrete experience, an observation/reflection, formation of abstract concepts or generalizations, and testing of those concepts in a new situation (Dewey, 1938; Kolb, 2014). For example, traditional machinery safety education involves the introduction of safe machine operation procedures followed by opportunities for the student to practice those procedures on the machine. This is followed by the student reflecting on the experience and continuing to practice which leads to a certification exam (Fetzer et al., 2019). A Kentucky agricultural programs targeting tractor roll-overs have been shown to alter and create positive attitudes towards the new information (Tingle et al., 2018).

There are challenges with experiential learning applications. Lin et al. (2011) determined that current pedagogical methods and tools are not capable of providing authentic and practical safety experiences. Saleh and Pendly (2012) found that safety programs in construction safety have had limited effectiveness; and while they are important programs, they are not taught on a large enough scale to have an impact.

As educators develop hands-on and self-directed learning experiences, there are possibilities for students to be introduced to risks related to occupational tasks. Educators have found these inherent risks challenging to address. More creative means may be necessary to introduce students to hazardous tasks without placing them in dangerous situations.

Virtual Reality Used as an Educational Tool

The Virtual Reality Society (2017) defines VR as an alternative environment that allows the user to explore and interact with objects virtually. A virtual environment is one that allows a user to become immersed in an alternate reality. Users can walk around, interact with other objects, and maintain social presences with other users' avatars. Environments that are generated can be real-world places or fictitious locations created by the developer. Virtual Reality goes back to the 1960s, but as technology has advanced, it has become more commonplace and cheaper to acquire (Lee, 2012).

Virtual Reality is often categorized into three groups: Immersive VR, Semi-Immersive, and Augmented Reality. Immersive VR replaces the real world with a computer-generated environment that is anchored to the user's head and hand movements; this type of technology uses headsets and hand controllers like Oculus or

HTC. Semi-immersive is often what we see in training simulators where the user sits at a control station and interacts with a screen or projection. The AR group is less immersive but blends the user's real-world environment and a virtual environment. Games like Pokémon Go are an example of AR, where the virtual work is laid over the real environment and the user interacts with it through a phone, glasses, or gloves (Gandhi & Patel, 2018).

A review of immersive VR research indicated that out of 41 studies, 76% used high-end head-mounted displays (HMD) (Oculus/HTC), 20% used mobile VR (Google Cardboard), and 2% used enhanced VR (racing wheel) to control the environment (Radianti et al., 2020). Even though HMDs are different from mobile VR technology, there seems to be no difference between presence, usability, and satisfaction but there was a higher level of immersion with the HMD (Papachristos et al., 2017). With the 2013 release of the Oculus, VR HMD and soon after the HTC Vive, there was a renewed interest in developing sophisticated AR, VR, games, and other media for commercial and educational purposes (Psotka, 2013).

Virtual Reality has been described as an efficient tool for K-12, colleges, and universities to provide their students with knowledge and skill of complex mechanisms and theories (Lee, 2012). Virtual Reality can be used as an alternative training tool (Kizil et al., 2001); and Kneebourne (2005) stated that VR “should allow for sustained, deliberate practice within a safe environment, ensuring the recently acquired skills are consolidated within a defined curriculum which assures regular reinforcement” (pg.

552;). Dalgarno and Lee (2010) identified five affordances that VR can provide to learning environments by facilitating learning tasks that lead to:

- The development of enhanced spatial knowledge representation of the domain.
- Increased intrinsic motivation and engagement.
- Improved transfer of knowledge and skill to real situations through the contextualization of learning.
- Richer and or more effective collaborative learning than is possible with 2-D alternatives.
- Facilitate experiential learning tasks that would be impractical or impossible to undertake in the real world.

Virtual learning environments that have included positive features of immersion, ease of use, and help-seeking have shown to have positive effects on students' perceived cognition through learning languages in VR (Chen, 2016; Davis, 1989). Others have reported features such as using full-body interaction in a virtual environment to promote students' active learning (Maes et al., 1997); use of storytelling to improve user involvement and engagement (Cavazza et al., 2004); promotion of psychomotor development by allowing users to practice dismantling a crane (Li et al., 2018); and promotion of skill transfer by learning to juggle in VR (Kahlert et al., 2015; Sportillo et al., 2015). The VR technology has shown to be an effective method for training students compared to other traditional methods, as it provides a tangible context and realism to a situation that is not normally safe or requires a more realistic experience than others (Stredney et al., 2008).

Educational Virtual Reality Applications

Currently, VR is used as an educational training method in the Army, Air Force, engineering education, surgical training, industrial safety training, and pedestrian safety training (Aggarwal et al., 2006). Virtual Reality applications have found uses in other industries for training and education uses as well. In engineering education, VR is currently being used to make cost-effective decisions in the early design stages of products, while giving a more complete view during the design stage, and to help reduce time and cost factors (Kaminska et al. 2019). It is being used to create online labs to help promote electrical engineering, allowing students to perform simple exercises that can be done at home or at work (Valdez et al., 2015). Dinis et al. (2017) used a VR experience to engage with young students interested in civil engineering; while Hurtado et al. (2010) developed a robotics simulation to train lab workers on equipment procedures.

Medical training has also shown success in training new surgeons using VR training simulators (Gorski et al., 2017; Riva, 2003). Nurses, physicians, and medical students can be given real-life situations to hone skills when interacting with patients (Ellinan et al., 2016); surgeons can practice procedures to develop or hone psychomotor skills (Harrison et al., 2017; Radia et al., 2018; Vankipuram et al., 2014; Wang et al., 2016).

Virtual Reality can provide low-cost options for most general education settings and provide students with a semi-immersive experience (Brown & Green, 2014; Thomas et al., 2014). Applications from Google Expeditions to Google Cardboard (Blyth, 2018) can provide a 360-degree video shot of different locations for virtual field trips. Head mounted displays can also be used to improve the immersive quality of an experience and get students engaged and more active (Zhang & Liu, 2016).

Other experiences can be useful in training participants in safety practices in the industrial workplace (Li et al., 2018; Velosa et al., 2018), in case of injuries (Pena & Ragan, 2017), or disasters (Meiliang & Qiaoming, 2012). Virtual learning environments can even be used to teach welding skills to beginners as well as experts (Bryd et al. 2015; Bryd et al. 2014). Construction engineering education is an area that has a large VR usage in the training of workers, managers, and students (Guo et al., 2012; Jeelani et al., 2017; Li et al., 2012).

There have been attempts to create VR training experiences within industrial machinery and agricultural equipment operations. Tichon & Burgess-Limerick (2011) conducted a review of VR simulations in the mining industry, where they identified VR experiences were created for dozers, draglines, haul trucks, shovels, continuous miners; however, these experiences did not have performance evaluations completed. A study by Swadling & Dudley (2001) found that operators' performance in a Load-Haul-Dump vehicle virtual simulation compared to their subsequent performance was an effective training tool and was predictive of their subsequent performance.

In agricultural applications a VR experience was developed to allow students to practice tractor operation and avoid rollover hazards (Namkoong et al., 2022). At the conclusion of their study, students were better able to recognize threats of tractor rollover and in turn improve their behavioral intentions. Another tractor safety simulator was developed and evaluated for realism amongst 99 mid-western farm equipment operators

(Faust et al., 2020). After driving the simulator for 10 minutes, these operators rated the realistic appearance of the simulation a 4.5 of 6 on.

To ensure virtual experiences have been created with the correct purpose in mind, a focus on evaluation should be considered. Radianti et al. (2020) found that 46% of the articles they reviewed did not specify a learning outcome. The articles that used methods such as questionnaires or activities while they were in the experience, were assessed against certain usability criteria. They explained that the focus of evaluation has been on the usability (Holden & Rada, 2011; Virvou & Katsionis, 2006; Zaidi et al., 2018) and the user experience of immersive VR experiences (Kaminska et al., 2017; Tcha-Tokey et al. 2018). Kaminska et al. (2019) argued that as new educational content is developed priority must be given first, to the story or content, and then to the pedagogy.

Barriers to Implementation

Studies reviewed by Jenson and Konradsen (2018) identified barriers such as a lack of educational content, technical skills needed to operate, and equity and access to the equipment. Production of VR content is expensive to develop, so currently it is limited to VR production companies for gaming and entertainment, this leads to technology designed for gaming that drives the price up and makes it out of the reach of educational institutions (Jensen & Konradsen, 2018). Headsets can often cost between $299-$499 for one headset, so getting a classroom setting on a budget is challenging (HTC, n.d.; Oculus, n.d.).

Another significant barrier of using VR in education is the realism of the experience and failing to provide a realistic experience in a simulation. This not only provides for a weakened learning experience but could negatively impact the student (Kavanagh et al, 2017). Students can become overwhelmed by the virtual environment and not notice information that is being given to them. Moesgaard et al. (2015) found that a low-interaction virtual experience had a slight advantage over traditional instruction.

A final challenge of using VR in the educational setting is having a defined pedagogical underpinning that influences the design, use, and evaluation of these technologies and experiences (Fowler, 2015). Systematic reviews have found that most studies do not mention or do not refer explicitly to a learning theory, nor do they measure the amount of knowledge gained during the experience (Mikropoulos & Natsis, 2011). Evaluations of VR technology is predominantly focused on usability and user experience, (Farra et al., 2018; Radianti et al., 2020; Zhang et al., 2017).

Overall, VR has been able to provide students with the opportunity to explore complicated and complex topics in a safe environment. The use of VR has created an educational medium in areas such as medical, engineering, and safety education.

Farm Injuries Among Youth in Agriculture

Agriculture is a dangerous industry in the United States. In 2019, the agriculture, forestry, fishing, and hunting industry reported 167 direct fatalities and an additional 573 injuries that led to fatalities all from contact with objects or equipment (U.S. Department of Labor, 2020). During this same year, 84 youth ages 19 and below suffered fatal injuries, and 15 of those fatalities resulted from contact with an object or equipment (U.S. Department of Labor, 2020). In 2014, it was reported that approximately 11,942 youth were injured on U.S. farms with 3,381 injuries coming from vehicles and 773 injuries from machinery (Hendricks et. al., 2021).

A specific review of Ohio youth-related agricultural fatalities, during the years 2009 - 2018, revealed 22 fatalities were to youth under 20 years of age (Ohio State University, 2022). In a nearby state, Gorucu et al. (2021) analyzed Pennsylvania nonfatal, agricultural injury data collected from emergency departments from 2015-2019. This study found 62,079 patients received medical treatment, with 30.34% (*n* = 18,839) of the patients being youth aged 0-17 years old; more specifically, an estimated 10% of the total youth injured had an average age of 9-10 years old. Vehicles were reported as the primary source of injuries with tractors being a major injury causing agent.

Previous research analyzing media reports, report similar rates of youth injuries and fatalities with the tractor as the primary source of injuries to youth (Gorucu et al., 2015; Hard & Myers, 2006; Kica & Rosenman, 2020; Nour et al., 2021; Scott & Dalton, 2021; Weichelt et al., 2019; Wright et al., 2013). In 2011, researchers determined that injuries to youth on farms from 2001 to 2006 cost society an estimated $1.423 billion; 86% of the fatalities were not work-related and machinery was one of the primary sources (Zaloshnja et al., 2011). These findings show just how vulnerable youth who live and work in production agriculture can be. Goldman et al. (2004) found that youth, many times under direct supervision, are more than seven times more likely to be killed at work than non-farm youth workers. The family farm is still the most common place to see the entire family involved in the production process (Stoneman & Jinnah, 2016).

Strategies to Reduce Injuries

Pate and Gorucu (2020) outlined four prevention strategies to mitigate youth injury rates. These strategies include environment modifications to limit hazard interactions; legislation, or law enforcement to promote behavior modifications; awareness, or prevention education to promote behavior modifications; and safety devices or engineering design to limit hazard interactions. Aherin et al. (1992) referred to the Three E Model which consisted of enforcement, engineering, and education as an effective model for injury prevention. This model was coined as the common-sense approach and stemmed from improving work conditions and the formalized safety and health education programs in industrial settings (Murphy, 1992). Further discussion of the 3E Model and its application to youth injury prevention is presented in the following sections.

Enforcement to Promote Behavior Modifications

The enforcement branch of the 3 E Model focuses on safety and health practices that can be applied in either production agriculture or the industrial workplace. In 1938 Child Labor Bulletin 102 was published to ensure that when youth work, they work safely without jeopardizing their health. Child Labor Bulletin 102 states that youth "under 12 may be employed outside of school hours with parental consent on a farm where employees are exempt from the federal minimum wage provisions" (p. 5) and "minors who are at least 16 years of age may perform any farm job, including agricultural occupations declared hazardous by the secretary of labor, at any time, including during school hours" (p. 5). This bulletin also allows for a parental exemption for a child of any age to be employed by his/her parent at any time in any occupation on a farm owned or operated by that parent, meaning youth 16 years or younger, may work on farms with parental consent. (U.S. Department of Labor Wage and Hour Division, 2016).

The Hazardous Occupations Orders for Agricultural Employment (HO/As) is the legislative document that identifies agricultural tasks that are deemed hazardous for youth younger than 16 years of age. These activities include:

1. Operating a tractor over 20 power-take-off (PTO) horsepower, or connecting or disconnecting an implement or any of its parts from that tractor.
2. Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any activity involving physical contact associated with the operation) any of the following machines:
    - Corn picker, cotton picker, grain combine, hay mower, forage harvester, hay baler, potato digger, mobile pea viner;
    - Feed grinder, crop dryer, forage blower, auger conveyor, or the unloading mechanism of a non-gravity-type self-unloading wagon or trailer; or
    - Power post hole diggers, power post driver, or non-walking type rotary tiller, trencher, earthmoving equipment, potato combine, or chainsaw.
3. Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any activity involving physical contact associated with the operation) any of the following machines:
    - Trencher or earthmoving equipment;
    - Forklift;

- Potato combine; or
- Power-driven circular, band, or chain saw.

4. Working on a farm in a yard, pen, or stall occupied by a:
   - Bull, boar, or stud horse maintained for breeding purposes;
   - A sow with suckling pigs, or a cow with a newborn calf (with an umbilical cord present).
5. Felling, bucking, skidding, loading, or unloading timber with a butt diameter of more than 6 inches.
6. Working from a ladder or scaffold (painting, repairing, or building structures, pruning trees, picking fruit, etc.) at a height of over 20 feet.
7. Driving a bus, truck, or automobile when transporting passengers or riding on a tractor as a passenger or helper.
8. Working inside:
   - A fruit, forage, or grain storage designed to retain an oxygen-deficient or toxic atmosphere;
   - An upright silo within 2 weeks after silage has been added or when a top unloading device is in operating position;
   - A manure pit; or
   - A horizontal silo while operating a tractor for packing purposes.
9. Handling or applying toxic agricultural chemicals (including cleaning or decontaminating equipment, disposal or return of empty containers, or serving as a flagman for aircraft applying such chemicals). Such toxic chemicals are

identified by the word “poison” or “warning” or are identified by a “skull and crossbones” on the label.

10. Handling or using a blasting agent, including but not limited to, dynamite, black powder, sensitized ammonium nitrate, blasting caps, and primer cord; or
11. Transporting, transferring, or applying anhydrous ammonia. (U.S. Department of Labor Wage and Hour Division, 2016, pp. 4-5)

The Agricultural Hazardous Occupations Orders do not apply to youth employed on farms owned or operated by their parents. Further exemptions can apply for youth employed on farms when they are enrolled in a vocational agricultural education program under a written agreement that coordinates the on-farm training with the school. Vocational and 4-H programs are identified in the legislation as educational entities who can provide exemptions for 14- and 15-year-old youth to obtain certification that would allow them to operate tractors higher than the 20 PTO horsepower requirement and most harvesting equipment (U.S. Department of Labor Wage and Hour Division, 2016).

Engineering Design to Limit Hazard Interaction

The engineering branch of the 3 E Model focuses on the comprehensive discipline of engineering, specifically as it affects a human’s ability to interact with hazardous machines or systems. Within the agricultural industry, safety engineering controls are numerous. A specific engineering safety device for tractors is a roll-over protection system (ROPS), which includes a seat belt. When used correctly, ROPS can prevent injuries and fatalities from rollovers which are one of the most common events in tractor operation (Gorucu et al., 2015; Ohio State University, 2022).

Some studies have used rebate programs to help convince farmers to install ROPS on open-station tractors to reduce injuries on those older tractors (Stone et al., 1998). Lundqvist (1996) found a 22% decrease in injury rate through a program that provided farmers funding to make physical and technological improvements in the farm environment. Other small-scale devices such as installing side mounting mirrors, backup cameras, and having youth wear reflective vests have been observed as injury prevention practices, especially effective in youth safety trainings (Muhollem, 2017; Mulhollem, 2018; Wright et al., 2013).

Prevention Education to Promote Behavior Modifications

The last branch of the 3E Model focuses on education to change behavior and promote safe practices. Efforts have been made to increase parents' and youths' awareness of farm safety and the potential for injuries. A family farm is often a place that involves everyone, the father, mother, and youth even though responsibilities are divided by gender. Fathers were found to be more responsible for machinery-related tasks, and supervising youth tractor work, and were more likely to teach youth about tractor safety than mothers (Jinnah & Stoneman, 2016; Stoneman et al., 2017; Summers et al., 2018). Although fathers were reported to be higher risk-takers than mothers, mothers perceived less farm injury risk to the youth than fathers did (Stoneman et al., 2017). It has also been reported that unsafe farm behaviors of fathers and youth were correlated and that parents with a more lax-inconsistent disciplining style had a youth that indulged in unsafe behaviors (Jinnah & Stoneman, 2016). Andersson & Lundqvist (2014) found that as women have become more involved in the farm there has also been a rise in injuries to women. More injuries were reported to occur in men with machinery than in women, and they found that women often feel less control over their work and work situation.

Programs of multiple types have been developed to address the wide range of workers in the agricultural industry. There are specific programs designed to help train and educate students in safe tractor operation and bring awareness to farm and tractor safety. Programs from traditional methods to more creative methods such as implementing a cost-effective rollover protective structure (CROPS) curriculum or teaching tractor rollover and stability using LEGO Mindstorms (Koc et al., 2012; Vincent et al., 2019,). One such program involved fathers in a training program with the youth and found that fathers in the parent-led group were more likely to begin using seatbelts and believe that their youth could be injured if not wearing a seat belt than in the staff-led and control groups (Jinnah et al., 2013).

Specific to tractor and machinery operation training, there are currently three predominate curricula used in the U.S. These include the National Safe Tractor and Machinery Operation Program (NSTMOP), AgSafety4u, and Gearing Up for Safety. It is important to note the Department of Labor does not sanction or approve any training, they just state that training must be provided (U.S. Department of Labor and Wage Division, 2016).

The National Safe Tractor and Machinery Operation Program includes a curriculum designed around tractor safety and operation, a driving course for students to practice and test on, and a certification test (Murphy, 2020). AgSafety4u is an online course designed for youth, new and beginning farmers, and for employers and employees of agricultural operation looking to enhance their knowledge and to provide training with a heavy emphasis on tractors and machinery (Fetzer et. al., 2019). Despite the programs that have been implemented to increase safety awareness, less than 1% of the youth who are operating tractors or other hazardous machinery have participated in tractor certification training (Heaney et al., 2006).

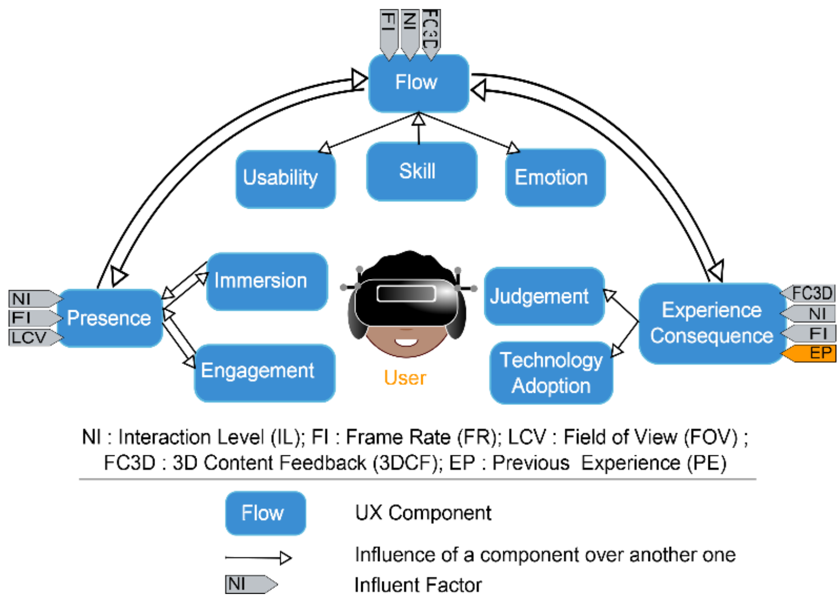
Theoretical Framework

The theoretical framework chosen for this study is the user experience (UX) model developed by Tcha-Tokey in 2016. The model was defined by a variety of different components depending on the field the experience is lived in (Tcha-Tokey et al. 2016). The components that make up this model are Presence, Immersion, Engagement, Flow, Usability, Skill, Emotion, Judgement, Technology Adoption, and Experience Consequence, as shown in Figure 1. These components were also used as constructs within our questionnaire.

Presence is a component defined as the user's "sense of being there" in the VE. The concept of presence can be divided into two categories: physical presence in the virtual environment and social presence in the collective or collaborative virtual environment (Pallot et al., 2013). Most measures of presence try to address both.

Figure 1

User Experience Framework



Engagement is a component defined as the "energy in action, the connection between a person and its activity consisting of a behavioral, emotional and cognitive form". The Presence Questionnaire (PQ) created by Witmer and Singer measures presence and engagement (Witmer et al., 1998), it identifies the degree to which individuals experience presence and engagement in VE.

Immersion is a component defined as the "illusion" that "the virtual environment technology replaces the user's sensory stimuli by the virtual sensory stimuli". The Immersion Tendency Questionnaire (ITQ) created by Witmer and Singer measures immersion (Witmer et al., 1998), it identifies the tendency of individuals to be immersed.

Flow is a component defined as "a pleasant psychological state of sense of control, fun, and joy" that the user feels when interacting with the VE. The Flow4D16 questionnaire measures the flow component (Heutte et al., 2010). It identifies the degree to which the user is absorbed by his task.

Skill is a component defined as the knowledge the user gain in mastering his activity in the virtual environment. The Computer Self-Efficacy (CSE) questionnaire created by Murphy measures the skill component (Murphy et al., 1989). It identifies the attitude of a user toward computer technology, and the degree to which he feels comfortable with a computer. This questionnaire is a reference in the education field to evaluate adult students' computer skills.

Emotion is a component defined as the feelings (of joy, pleasure, satisfaction, frustration, disappointment, anxiety …) of the user in the VE. The Achievement Emotions Questionnaire (AEQ) measures the emotion component (Pekrun et al., 2011). It identifies the emotion experienced in achievement situations.

Usability is a component defined as the ease of learning (learnability and memorizing) and the ease of using (efficiency, effectiveness, and satisfaction) the VE. The System Usability Scale (SUS) measures the usability component (Brooke, 1996). This scale has been created on a base of 50 usability questionnaires. It identifies "the appropriateness of a purpose", in other words, it identifies if the way we propose to use our VE is appropriate.

Technology Adoption is a component defined as the actions and decisions taken by the user for future use or intention to use the VE. The Unified Technology Acceptance and Use of Technology (UTAUT) questionnaire measures the technology adoption component (Venkatesh et al., 2003). It identifies the degree to which the user will adopt and use the system, in other words, the likelihood of success for new technology introduction.

Judgment is a component defined as the overall judgment of the experience in the VE. The AttracDiff questionnaire created by Hassenzahl, Burmester, and Koller (2003) measures the judgment component. It identifies the user's attraction in a pragmatic and hedonic way towards the system.

Experience Consequence is a component defined as the symptoms (e.g. the "simulator sickness", stress, dizziness, headache …) the user can experience in the VE. The Simulator Sickness Questionnaire (SSQ) measures the experience consequence component (Kennedy et al., 1993). It identifies the negative consequences the user can have while using the IVE.

This model applies to this study by focusing on the user experience of the students and the teachers. The UX model focuses on combining the above constructs to describe the experience of users in virtual environments. The above studies have focused on how improved scores in the presence, immersion, engagement, skill and flow can boost effectiveness in VR experiences, so these constructs will be applied to our experience. Usability, technology adoption, and symptoms are also the main component that should be considered when designing VR experiences, these constructs were used to determine how our experience affects users.

Summary of Literature

In summary, CTE is a critical lynchpin that is designed to work with public schools to provide training for individuals that wish to enter the workforce (Scott & Sarkees-Wircenski, 2004). Through different programs, learning experiences, and competency-based education combined with the real-world situation, students can be prepared to satisfy the needs of industry (Scott & Sarkees-Wircenski, 2004). Education and training research have shown how important experiential learning is to agricultural education and the effects it has on students in the learning environment (Baker, & Robinson, 2017; Smith, & Rayfield, 2019). Kolb stated that experiential learning is a combination of factors such as experience, cognition, and is beneficial for introducing learners to new experiences that they can develop and practice. (Kolb, 2014).

Educational VR experiences have been evaluated on their usability but not so much on their learning outcomes in the application domain (Fowler, 2015; Jensen & Konradsen, 2018; Kavanagh et al., 2017). Even though research has shown that it's important to look at the usability and the experience of the user, it also needs to consider the pedagogical underpinning and learning outcomes of the experience (Radianti et al., 2020). Technology such as virtual reality has been around for decades but is now finally within reach of the educational setting and has been incorporated in multiple areas, including medicine, pedestrian safety, construction education, engineering education, and general education settings.

Literature has shown that injuries and fatalities are occurring to youth whether they are living or working on the farm, and identify tractors as being the biggest contributor (Centers for Disease Control and Prevention, 2018; Goldcamp et al. 2004; Gorucu et al., 2015). Despite legislation like Child Labor Bulletin 102 that outline hazardous occupations for youth, parents, and youth still seem unaware of the hazards and safety procedures that youth can encounter on the farm. Programs have shown some success in changing youths' perceptions and intentions toward unsafe behaviors by using a variety of tools and pedagogical methods (Andersson & Lindqvist, 2014; Heaney et al., 2006; Jinnah et al., 2014; Vincent et al., 2019).

The following study was conducted to evaluate students' performance and user experience of a VR training program for tractor and machinery operation. Agricultural Education students participated in an VR tractor safety experience and was evaluated on their performance on a practice driving course. Agricultural Education teachers and their students reported their user experience in the VR environment. The teachers participated in a semi-structured interview to explore their lived experiences of integrating VR into a classroom lesson and the realism of the program. This study will contribute to the body of literature by exploring the use of VR in an educational environment for skill-based training of tractor and machinery operation.

CHAPTER 3: METHODS

The study was conducted using a mixed methods design. This chapter describes the protocol taken to describe students' performance within the VR experience, describe students' and teachers' user experience, determine the teachers' sense of realism, and examine the relationship between the teachers' user experience and realism.

Objectives

The overarching question of this study was, "Does virtual reality provide a realistic experience and supplemental option for skill-based education?" For this study, *skill-based education* is related to safe tractor and machinery operation. This study used the following objectives to help answer the question:

Quantitative Objectives

1. Describe the virtual reality program performance of agricultural education students from Ohio.
2. Describe the difference in Ohio agricultural education students' performance between a traditional tractor safety training and a tractor safety program with VR.
    - H_0: There will be no difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.

- H_1: There is a difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.

3. Describe the user experience (UX) of students from Ohio in the virtual reality program.
4. Describe the user experience (UX) of Ohio agricultural education teachers.

Qualitative Questions

5. What is Ohio agricultural education teachers' user experience (UX) in the virtual reality program?
6. What was Ohio agricultural education teachers' sense of realism in the virtual reality program?

Convergent Parallel Mixed Methods Objective

7. Explore the relationship between Ohio agricultural education teachers' user experience (UX) and the realistic nature of the VR program.

Virtual Reality Safe Tractor Experience

The virtual reality program utilized for this study was a curriculum resource developed with USDA-NIFA funding under the Youth Farm Safety and Education Program, titled Safety in Agriculture for Youth (SAY). This tractor safety simulation was designed at The Ohio State University using software services of Victory Enterprise, Inc. The software program operates on the Oculus Quest/Quest 2 VR headsets which comes with a right and left controller and uses a USB-C cable to connect to the computer. The

VR program was based on the skills and driving courses within the National Safe Tractor and Machinery Operation Program (NSTMOP). Throughout the development process, the experiences received reviews from a content advisor and three extension representatives who have taught and certified students through the NSTMOP program. It was pilot tested with 15 college of agricultural students enrolled at Ohio State University.

In the virtual environment, participants can move freely between three different areas. Upon entry, the area to their left has a barn and stationary model tractor. Users can interact with the tractor to review safety content related to their classroom curriculum. Moving around this tractor they can call out specific safety information related to that area of the tractor. Users can stay in this area for as long as needed to prepare themselves for the skills and driving course.

The skill testing area is outside of the barn. This experience was designed to represent the skills test portion of the DOL certification program. Here, the users interact with a stationary tractor's PTO, hydraulic connections, and implement hitch. A hay mower is present for the users to connect the implement to the tractor, and connect the PTO shaft, and hydraulic hoses. Users may also enter the cab of the tractor and answer a few informational questions related to connecting PTOs and hitching implements.

The final area is a virtual driving course. This course was modeled after the NSTMOP driving course and satisfies the DOL certification criteria. Users are required to answer questions that are intended to represent pre-operational checks they would conduct on a real tractor before they drive it. Users will accumulate penalty points if they answer a question incorrectly or skip over a question. Once the checks have been completed, users must safely mount the tractor, fasten the seatbelt, start the tractor, engage the correct gear, and successfully drive the course. Points are accumulated if users brush, strike, or knock over an object or mount the tractor incorrectly. If users accumulate too many points, the course may be reset to try again. There is one situation where a user can automatically fail the program and that is if the user tries to start the tractor without engaging the seatbelt. In this situation, the program will automatically fail them and ask them to reset the experience.

It is important to note that this VR program is not meant to replace the in-person tractor driving component but to act as a supplemental resource for the live offering of the course. This will allow students the opportunity to practice in a classroom setting prior to their real tractor operation. The VR program provides teachers a resource for occupying students' time while they attend to student operators on the real tractor course. Teachers can also provide the VR program as a class supplement while students are at home during weather events, learning at a distance, or to accommodate social distancing and COVID requirements.

As users engage with the skills and driving areas on the course their scores are recorded on the VR headset. Teachers were provided with the proper cables to connect the headset to their computer to retrieve and save student scores for grading.

For this study, an Oculus headset with instructions on how to use the headset, and steps for completing the program were sent to agricultural education teachers who consented to be a part of this study. As a licensed teacher, Agricultural Education teachers are identified in the DOL legislation as qualified instructors to teach agricultural related topics including tractor and machinery safety. The NSTMOP curriculum is one of several curricula that teachers can use to teach tractor and machinery safety. As headsets were delivered by the researcher, teachers were instructed on the use of the of the technology and provided a video link with the same information. Teachers were instructed to teach their machinery curriculum and allow students to use the virtual experience for two weeks.

Research Design

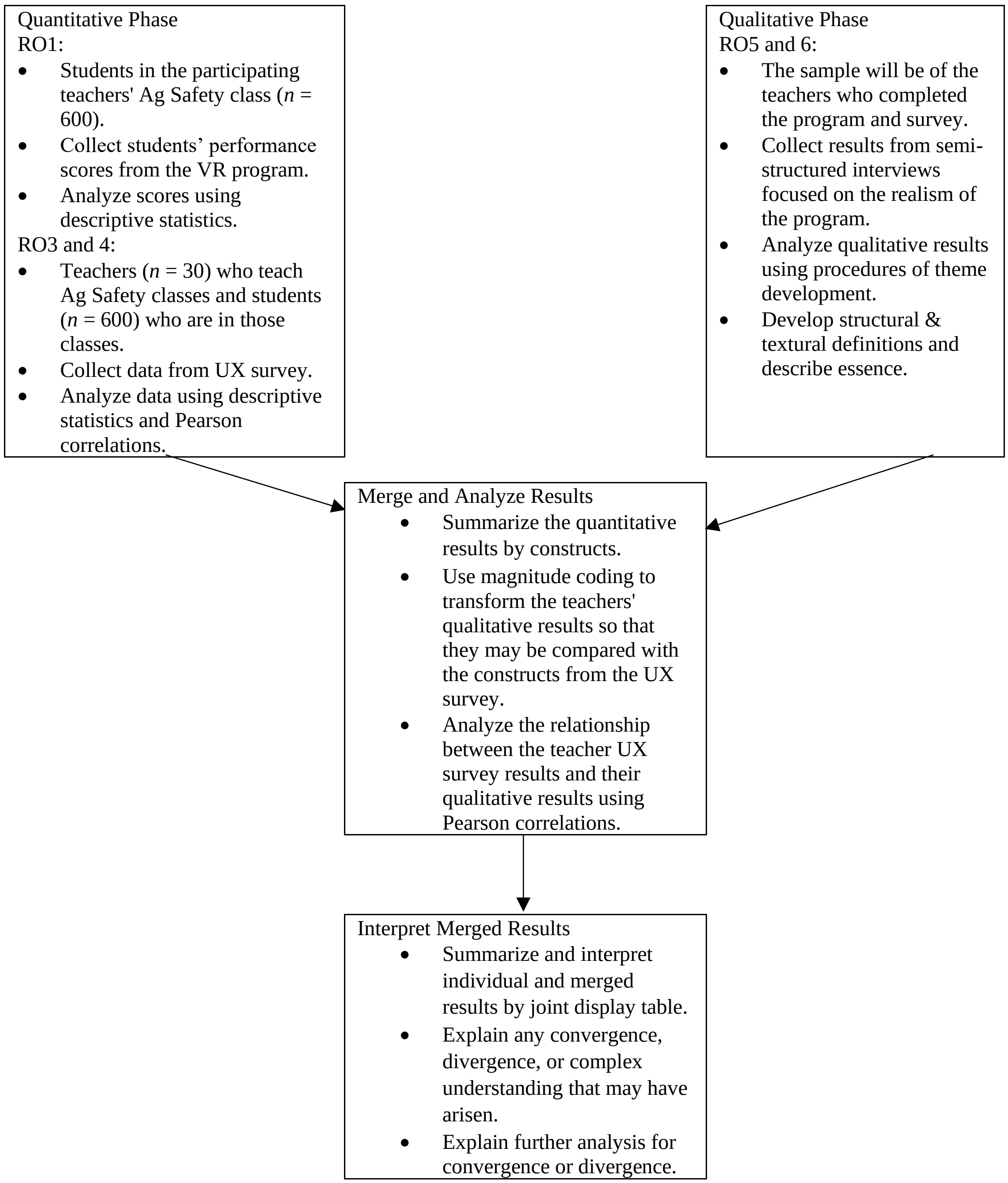
Convergent Mixed Methods

This study utilized the convergent mixed methods design where the quantitative phase occurred at the same time as the qualitative phase (quant. + qual.). The definition of mixed methods research, as defined by Greene et al. (1989), are those designs “that include at least one quantitative method (designed to collect numbers) and one qualitative method (designed to collect words), where neither type of method is inherently linked to any particular inquiry paradigm” (pg. 256). The convergent mixed methods design intends to obtain data from the same source that complements each other (Creswell & Plano-Clark, 2018; Morse, 1991). This study is the parallel variant of convergent designs, in which the two strands of data are collected and analyzed independently and brought together during the integration stage (Creswell & Plano-Clark, 2018). The problem that this study falls under is a need to obtain more complete and corroborated results (Creswell & Plano-Clark, 2018). Using mixed methods for a complex problem allows for a better understanding by using a quantitative method for a more general understanding and the qualitative method for a more detailed and richer understanding. After students and teachers were immersed in a virtual environment, it was important to get detailed information about their UX and the realistic nature of the experience.

The purpose of this convergent parallel mixed-methods design study was to explore if there is a relationship between the teachers' quantitative user experience (UX) results and the teachers' opinions of the realistic nature of the program. The quantitative results were analyzed independently and then combined into their constructs presence, immersion, engagement, flow, skill, emotion, usability, judgment, technology adoption, and experience consequence. The qualitative results were transcribed and analyzed for recurring and emerging themes. Data were transformed using magnitude coding, which is used to add value, intensity, frequency, direction, presence, or evaluative content to be compared with the UX constructs from the quantitative phase (Saldana, 2021). Data and themes related to teachers' opinions of realism were transformed to a scale of one to 10. The UX constructs and the transformed qualitative data were compared using Pearson correlations. The data were then interpreted for signs of convergence or divergence and displayed in a joint display table. The study is outlined in Figure 2.

Figure 2

Procedural Diagram



Descriptive

The quantitative objectives focused on describing the performance of Ohio Agricultural Education students. The scores were obtained by how well the students completed the VR experience such as answering questions correctly and driving properly and safely. Participants received scores from their activities in the VR program, items such as the final driving course score, mounting/dismounting the machine correctly, how many times they struck/grazed an object, and incorrect responses to questions were recorded within the headset. Performance data were analyzed using descriptive statistics to provide the mean of these infractions. The user experiences (UX) of Ohio agriculture education teachers and their students were described. The students' user experiences were based on the constructs from Figure 1. Teachers and students answered questions related to their experience in the program; constructs focused on presence, immersion, engagement, flow, skill, usability, emotion, judgment, experience consequence, and technology adoption.

Quasi-Experimental

Objective 2 was designed to be a simple two-group quasi-experimental design that compared the passing rate of Ohio agricultural education students that participated in a traditional tractor safety training course to students that participate in a tractor safety training with an integrated VR component. Experimental studies are considered more powerful than other designs by uncovering causal relationships between variables (Spector, 1981). The two-group design involves two independent variables, a training program with VR intervention, and a dependent variable, student certification rates. This objective compared students' performance from both training methods to determine if one is more effective than the other.

As a quasi-experimental design, mortality and compensatory or resentful demoralization may arise as threats to the internal validity of this study (Creswell & Creswell, 2017). Mortality is when participants may have to drop out of the experiment, in this case, students may experience severe side effects related to virtual reality such as headaches, nausea, dizziness, or lightheadedness. Participants were given time to acclimate to the virtual environment and were given breaks to reduce the chance of experiencing side effects. Compensatory or resentful demoralization is where one group may view receiving the treatment as unequal; here one group will be using the VR intervention to train, and the other group will not. The group that doesn't use it in the experiment will be given access to use the VR intervention after the experiment has been conducted.

External validity may be affected by the interaction of selection and treatment, setting and treatment, and history and treatment. The interaction of selection, setting, history, and treatment addresses the fact that the researcher cannot generalize to other individuals that do not have the characteristics of the participants, individuals in other settings, and individuals before and after situations. To address these threats the researchers should conduct future experiments with individuals that have other characteristics in other settings.

Phenomenology

The qualitative objectives were completed by using a transcendental phenomenology design, which is meant to reduce the individual experiences with a phenomenon to a description of the universal essence (Creswell, 2007; Creswell & Poth, 2018; Yin, 2016). The phenomenon, in this study, is the VR experience that the teachers are participating in and the essence of that experience. According to Moustakas (1994), the procedures consist of selecting a phenomenon, fleshing out one's experiences, and collecting data from several people who have experienced the phenomenon. The data were then analyzed by reducing the information to significant statements or quotes and combining the statements into themes producing a textural and structural description of the experiences to convey the essence of the experience (Creswell, 2007). Polkinghorne (1989) recommends that researchers interview 5 to 25 individuals who have experienced the phenomenon.

Quantitative Methods

Population and Sampling

Non-probabilistic sampling methods were used to identify a volunteer sample from the frame of agricultural education teachers in Ohio (Creswell & Plano-Clark, 2018). To identify teachers for this study, recruitment materials were sent to the entire base of agricultural educators (n = 524) in the state of Ohio. Recruitment materials asked for teachers who taught machinery operation and safety as a part of their curriculum. Of the 524 teachers recruited, 55 teachers responded and elected to participate in the study (Creswell et al., 2018). Teachers were asked to supply a letter of approval from the administration; of the 55 teachers who responded, 28 provided the letter of approval. Of the 28 teachers who provided their letter of approval, 20 were able to complete the study. The participating teacher then recruited students from their courses that have machinery operation and safety content to participate in the VR experience. The beginning sample was approximately 132 agricultural education students. The headsets were distributed to the teachers based on the order of sign-up, location in the state, and proximity to other participating schools. When a teacher received the headset, they were given personal instructions for setting up the headset, which included locating the application within the headset and a walkthrough of the experience. They also received a 40-minute video of these same instructions for later reference if needed. It was recommended in recruitment that teachers try out the VR program first, teach their machinery operation and safety curriculum next, and then recruit students to use the headset.

Sampling for the quasi-experimental design in Objective 2 consisted of a random sample of two agriculture classrooms from the volunteer sample of agriculture teachers who did not receive the headset in the prior objectives. Randomization was not able to be ensured. Two classes of freshmen students were identified at a participating school and completed the experiment across four weeks. The intervention schedule for the two participating classrooms is outlined in Figure 3. The teacher was provided access to the online AgSafety4u curriculum and was instructed to have students complete the two modules related to Tractors and Implements during week one. During week two, the teacher selected one of the classes to use the safe tractor VR experience for students to practice in an immersed environment, while the other class continued to work on additional safety modules within the online course that did not relate to tractors and implements. A real tractor was provided for both classes during week three for students to practice their driving skills. During week four, students drove the tractor through the NSTMOP driving course requirements. A local extension representative responsible for certifying students in the driving course was present to provide passing/failing certifications along with the Agricultural Education teacher.

Figure 3

Quasi-Experimental Virtual Reality Intervention Schedule

Week	Group with no VR Tasks	Group with VR Tasks
Week 1	Students were to complete the Tractors & Implements modules of the AgSafety4U curriculum.	Students were to complete the Tractors & Implements modules of the AgSafety4U curriculum.
Week 2	Students could continue to work on other areas of the AgSafety4U curriculum.	Students were to practice the driving course through the VR headset.
Week 3	Students were to begin practicing driving a real tractor through the driving course.	Students were to begin practicing driving a real tractor through the driving course.
Week 4	Students drove the real tractor through the course for certification.	Students drove the real tractor through the course for certification.

Instrumentation and Data Collection

Data for Objective 1 were collected after the student completed the program and was retrieved through the saved score files on the headset. Data included the final scores which consisted of how many times an object was lightly touched (1 pt. each), hit (2 pts. each), mounting or dismounting correctly (1 pt. each), and how many times a specific question was missed. Questions were about the oil, battery, coolant, fuel, tires, ROPS, hitch, and debris; and for each question answered incorrectly or not answered at all 1 point was added to their final score. Data for Objective 2 included the same data as mentioned above but also included students' passing rates so the VR intervention training can be compared to the traditional NSTMOP training.

Data for Objectives 3 and 4 were collected through a survey after the teacher and student completed all of the tasks in the VR program. Table 1 outlines the original questionnaires and their authors.

Table 1

User Experience Original Questionnaires and Authors

Component	Original Questionnaire	Authors of the original questionnaire
Presence	PQ	
Engagement	PQ	Kennedy et al. 1993
Immersion	ITQ	
Flow	Flow4D16	Heutte et al. 2010
Usability	SUS	Lewis et al. 2009
Skill	CSE	Murphy et al. 1989
Emotion	AEQ	Pekrun et al. 2011
Experience Consequence	SSQ	Bailenson et al. 2006
Judgment	AttracDiff	Hassenzahl et al. 2003
Technology Adoption	UTAUT	Venkatesh et al. 2003

The survey consisted of 10 constructs and 79 questions pulled from previously published surveys. The original surveys consisted of 10 constructs presence, engagement, immersion, flow, skill, emotion, usability, technology adoption, judgment, and experience consequence. Each of the constructs is measured on a 10-point Likert scale, with Strongly Disagree (1) and Strongly Agree (10).

The instrument was constructed and validated with 116 French participants ranging from 18 to 63 years old, all with careers in Information and Communications Technology or Computer Science. Reliability was established by Tcha-Tokey (2016) as shown in Table 2 below, the questions were pulled from the previously published original studies and show moderately high alphas ranging from .71 to .9, which was considered acceptable according to Devellis, (2003).

Table 2

Cronbach Alpha Coefficients of Questionnaires Used and Original Questionnaire

Component	Current Study 2022		Pilot Study in Spring 2021	Tcha-Tokey et al. 2016	Original Questionnaire
	Students	Teachers			
Presence	.88	.92	.92	0.75	0.88
Engagement	.85	.97	.92	0.75	
Immersion	.85	.73	.79	0.76	0.81
Flow	.85	.74	.89	0.82	0.84 – 0.86
Usability	.39	.96	.34	0.46	0.92
Skill	.91	.96	.97	0.82	0.95
Emotion	.60	.46	.53	0.71	0.78 – 0.93
Experience Consequence	.92	.94	.92	0.90	0.71
Judgement	.93	.94	.94	0.80	0.73 – 0.90
Technology Adoption	.90	.91	.89	0.78	0.87 – 0.91

Tcha-Tokey et al. (2016) reported a low alpha on the Usability construct, this could be attributed to the low question count (n = 3) of that construct. It was important to include this construct in the survey so that the usability of the headset and program could be assessed. Although this instrument has been validated, it was done so in another country and with participants of different professions and age ranges. For this study, post-hoc reliability will be reported to ensure accurate results.

A pilot test of the instrument was conducted in the spring of 2021 with 15 college-level agricultural systems management and agricultural education students. College-level agricultural systems and agricultural education students were chosen because they were close to the age of the high school students that this would be used, and the agricultural education students were preparing to become teachers. All constructs had α > .7, except for Emotion (α = .53) and Usability (α = .34), these could have been attributed to the low number of students participating in the pilot study.

Of the responses collected from the students (*n* = 132), 41.66% (*n* = 55) students answered all questions, and the completed surveys were used to report students' summated user experience. Immersion originally reported as an alpha of .32, after removing Q25 it was raised to .67, and Q24 was removed to raise reliability to .85. I was unable to remove any questions from both the Emotion (α = .60) and Usability (α = .39) construct. Therefore, they were removed from the final user experience construct due to low reliability, all other constructs reported high alphas α < .8 and were included.

Of the responses collected from the teachers (*n* =13), 6 teachers answered all questions, and the complete surveys were used to report teachers' summated User Experience. Immersion originally reported an alpha of .52, after removing Q25 it was raised to .73. I was unable to remove any questions from the Emotion (α = .46) construct. Therefore, it was removed from the final user experience construct due to reliability, all other constructs reported high alphas α < .7 and were included.

Objective 2 used a posttest-only with nonequivalent groups design, in which the control group was the students who went through the traditional AgSafety4u curriculum, practiced driving the tractor, and completed the skills, drove the course, and completed the skills test. The intervention group went through the same curriculum at the beginning of the program but were given the VR headset before practicing on the real tractor and skills test. Both groups, after practicing, drove the certification course on the real tractor. Passing rates of both groups were collected to determine if the VR intervention had any effect on students passing the driving course and skills test.

Data Analysis

Student performance data from Objective 1 were analyzed using descriptive statistics to describe the mean and standard deviation of their final score, questions missed, objects lightly touched, struck, and mounted or dismounted.

Data collected for Objective 2, from the two groups, were analyzed by a paired-samples *t*-test to compare the means of students' certification rates in the traditional training group and the VR integrated training group (Field, 2017). Assumptions were not met due to a procedural error; only pass or fail data were recorded for students in both groups. To report this nominal data, a chi-square test was used to analyze the difference between the two groups (Field, 2018).

Data collected for Objectives 3 and 4 were analyzed using descriptive statistics. To ensure construct reliability they will be analyzed using Cronbach’s Alpha. Once validated, data were analyzed using descriptive statistics to determine the mean and standard deviations of the constructs and then were combined to describe the overall mean user experience.

Qualitative Methods

Population and Sampling

The population used for the qualitative methods was the same Ohio SBAE teachers who were recruited for the quantitative objectives. For the teachers to participate in the interview they needed to complete the VR program. Teachers who were sent a headset were provided with a notecard to sign up for a semi-structured interview. Once the teacher signed up and consented to the interview, a zoom call was scheduled with the teacher. Interviews will be conducted until results reach saturation. Polkinghorne (1989) recommends that researchers interview 5 to 25 individuals who have experienced the phenomenon.

Data Collection

After the teacher completed the virtual experience and the UX survey, a semi-structured interview ensued. Eleven teachers completed the semi-structured interview. Participants were asked to describe and explain their experiences as related to the UX survey constructs of presence, immersion, engagement, skill, flow, emotion, usability, technology adoption, experience consequence, and judgment. The participant was then asked about the realism related to those specific constructs. Questions were also asked about their opinions of using VR in agricultural education classrooms. The interviews ranged from 25 minutes to 45 minutes in length and participants were asked about 20 questions total.

Data Analysis

Moustakas (1994) recommends that a phenomenology follow the structured method of describing the personal statements, developing a list of significant statements, grouping the statements, creating a description of “what” participants experienced, drafting a description of “how” the experience happened, and write a composite description of the phenomenon. The qualitative data were transcribed for significant statements, sentences, or quotes that provide an understanding of the experience. Those items were highlighted and developed into initial codes, then into meaning units, and then into themes. Those themes were then used to create the textural and structural description of the users' experience (Creswell & Poth, 2018; Moustakas, 1994). This was a valuable method to gather data from the teachers because the teachers are helping the students through the experience, so therefore they have a different perspective that we would like to tap into. For validation of the qualitative data, member checking was used. Three to five members were randomly selected from the participants and will be sent the outline of themes gathered from the interviews to determine if that is what was truly discussed. Member checking was used to ensure the validation of the qualitative data. Three to five members were randomly selected from the participants and sent the outline of themes gathered from the interviews to determine if that is what was truly discussed. Member checking is considered to be the most critical technique for establishing credibility (Lincoln & Guba, 1985). Reliability was ensured by obtaining detailed field notes and descriptive transcripts. The interview data were coded by one person, so intercoder agreement was not a priority. An external audit was done with a faculty member to examine the process and the product to assess accuracy (Creswell, 2007).

Convergent Data

Data Analysis

To prepare the data for triangulation, the qualitative data and themes related to realism were coded using magnitude coding, which is used to add value, intensity, frequency, direction, presence, or evaluative content to be compared with the quantitative UX constructs (Saldana, 2021). Data and themes related to teachers' opinions of realism were transformed into a one to 10 scale. Pearson correlations were used to determine if there is a relationship between the Ohio SBAE teachers' UX data and the quantified themes of realism from their interviews. Assumptions were not met due to lack of participation from the teachers results in Objective 4. To analyze these data, a nonparametric Spearman Rho correlation was calculated. Both strands of data were analyzed for converging or diverging concepts, along with the results from the integrated analysis. A joint display table is used to display the UX results, the untransformed qualitative results, and the results from the integrated analysis.

Demographics

A sample of 13 agriculture teachers completed the study, of which 46.15% (n = 6) were female, 30.77% (n = 4) were male, and 23.08% (n = 3) did not identify. The average age of participating teachers was about 38 years old (M = 38.11, SD = 12.36), with the youngest at 23 years old and the oldest at 55 years old. Of those that participated, 38.46%

(*n* = 7) were certified in the A0 Agriculture, Food, and Natural Resources pathway, and 7.69% (*n* = 1) identified themselves as a commercial lender. The VR experience was used in classes such as Ag Business, Capstone, Ag Technology Independent Study, 8^{th}-grade Intro to Ag., Animal and Plant Science, Agronomy, Mechanical Principles, and Agronomic Systems. Of the courses listed above, teachers reported that they do not teach machinery safety in Ag Business, Capstone, 8^{th}-grade Intro to Ag., and Mechanical Principles.

A sample of 132 agricultural education students participated in this study, of which 40.91% (*n* = 54) identified as male, 36.36% (*n* = 48) identified as female, 21.97% (*n* = 29) did not identify a gender, and .76% (*n* = 1) chose not to answer. All levels of high school were represented with 2.27% (*n* = 3) from 8^{th} grade, 22.73% (*n* = 30) from 9^{th} grade, 17.42% (*n* = 23) from 10^{th} grade, 14.39% (*n* = 19) from 11^{th} grade, 19.70% (*n* = 26) from 12^{th} grade, and 23.48% (*n* = 31) did not provide their grade level. The average of participating students was about 16 (*M* =16.34, *SD* = 2.83) years old with the youngest age of 13 years old and the oldest age of 19 years old. Students identified tractors, skid steers, combines, grain carts, backhoes, ATVs, dump trucks, pickup trucks, balers, and mowers as the equipment they have operated anywhere from a single experience to 10 years of experience.

CHAPTER 4: RESULTS

The purpose of this study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students and teachers in machinery safety operation lessons. Quantitative methods were used to describe students' performance and user experience; mixed methods were used to describe teachers' user experience and explore their opinions of the realistic nature of the program.

Objective 1: Describe the virtual reality program performance of agricultural education students in Ohio.

Objective 1 sought to describe how agricultural education students in Ohio performed in the virtual reality experience. Of the 132 students who participated in this study, 38 saved their performance data to the headset. Table 3 below reports the descriptive statistics of the 38 students' performance data.

Table 3

Ohio Agricultural Education Students' Performance Scores (n = 38)

Question	Frequency	Percent
Oil Question		
Correct	16	42.11%
Incorrect	12	31.58%
Not Answered	10	26.32%

Continued

Table 3 Continued

Fuel Question		
Correct	27	71.05%
Incorrect	1	2.63%
Not Answered	10	26.32%
Battery Question		
Correct	23	60.53%
Incorrect	5	13.16%
Not Answered	10	26.32%
Coolant Question		
Correct	27	71.05%
Incorrect	1	2.63%
Not Answered	10	26.32%
Tire Question		
Correct	23	60.53%
Incorrect	2	5.26%
Not Answered	13	34.21%
ROPS Question		
Correct	16	42.11%
Incorrect	1	2.63%
Not Answered	21	55.26%
Hitch Question		
Answered	27	71.05%
Not Answered	11	28.95%
Checking for Debris		
Moved Debris	16	42.11%
Did Not Move Debris	22	57.89%
Mounting		
Used Handle	29	76.32%
Didn’t Use Handle	9	23.68%
Dismounting		
Used Handle	28	73.68%
Didn’t Use Handle	10	26.32%
	M	*SD*
Number of Light Touches on an Object	7.92	4.31
Number of Obstacles Hit	7.57	5.62
Total Points	24.55	14.82

The fuel question focused on what the letter on top of the fuel cap stood for and was answered correctly by 71.05% (n = 27) students, incorrectly by 2.63% (n =1), and not answered by 26.32% (*n* = 10). The coolant question focused on when coolant should be checked and was answered correctly by 71.05% (*n* = 27) students, incorrectly by 2.63% (*n* =1), and not answered by 26.32% (*n* = 10). The oil question focused on how often the oil should be checked; this question was answered correctly by 42.11% (*n* = 16) of students, incorrectly by 31.58% (*n* = 12) of students, and 25.32% (*n* = 10) of the students did not answer .The ROPS question focused on if the seatbelt should be used with the ROPS; the question was answered correctly by 43.11% (*n* = 16) of students, 2.63% (*n* = 1) answered incorrectly, and 55.26% (*n* = 21) did not answer. Students were required to move around the tractor and move a crate before they drove, only 42.11% (*n* = 16) of the students moved the debris while 57.89% (*n* = 22) of the students did not move the debris.

Students were required to use the handle when mounting and dismounting the tractor, but there was an option to jump on the tractor by selecting the floorboard. When mounting the tractor 76.32% (*n* = 29) of students used the handle and 23.68% (*n* = 9) did not use the handle. When dismounting, 73.68% (*n* = 28) used the handle and 26.32% (*n* = 10) did not use the handle to dismount. The driving course tracked the times a student lightly touched or struck an object. Students lightly touched obstacles an average of 7.92 (*SD* = 4.31) times and hit obstacles an average of 7.57 (*SD* = 5.62) times. On average, the students had a mean score of 24.55 (*SD* = 14.82) on the pre-check questions, mounting, driving, and dismounting the tractor in the driving course of the experience.

Objective 2: Describe the difference in Ohio agricultural education students' performance between a traditional tractor safety training and a tractor safety program with VR.

Objective 2 sought to describe the difference between agricultural education students' performance between a traditional tractor safety training and a tractor safety training with a VR intervention. The following hypotheses were used to accomplish this objective.

- H_0: There will be no difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.
- H_1: There is a difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.

A Chi-Square test was used to determine differences once it was determined that assumptions would not be met for a paired t-test. It was expected that at least 90% of students would pass the training program. Table 4 describes the students' pass and fail rates as well as the results of the chi-square analysis.

Table 4

Ohio Agricultural Education Students' Passing Rates and Chi-Square

Group	Frequency	Percent	Chi-Square	*p*
With no VR			.55	.45
Pass	18	85.70%		
Fail	3	14.30%		
Total	21	100%		
With VR			.55	.45
Pass	18	85.70%		
Fail	3	14.30%		
Total	21	100%		

A total of 42 students in two classes completed the program and of those students who completed the driving portion of the program, Group 1 did not use the VR intervention and had 85.70% (n = 18) pass rate with 14.30% (n = 3) students failing. Of the second group that used the VR intervention 85.70% (n = 18) passed and 14.30% (n = 3) failed. Results of the chi-square test reported a non-significant (X^2 = .55, p > .5) score between students that passed and failed from both groups. Because both groups had the same number of students that failed the driving portion of the program, it can be concluded that there was no significant difference between the two groups' passing rates. Therefore, the research hypothesis was rejected.

Objective 3: Describe the user experience (UX) of Ohio agricultural education students.

Objective 3 sought to describe Ohio agricultural education student user experience scores. The UX survey recorded 132 responses from students, with 41.66% (n = 55) complete responses. Each question was scored on a scale of Strongly Disagree (1) to Strongly Agree (10) and negatively worded questions were reverse coded to not negatively affect reliability. For the complete table of students' mean scores see Appendix D.

Question mean scores ranged from 4.90 to 8.00, with the majority of scores ranging between 6.00 and 7.90; therefore, questions with a mean score above 7.90 were considered to be high, and questions with a mean score lower than 6.00 were considered to be low. Described below are the questions with the highest and lowest mean scores.

The Experience Consequence construct had the most questions with high averages, of which all questions were negatively coded (1 = 10 and 10 = 1). For Question 56, which gauged if students felt an increase in salivation during their experience, the mean score of 8.06 (*SD* = 2.67), with 68.10% (*n* = 90) of the students reporting experiencing a minor increase of salivation. For Question 61, which gauged if students experienced any symptoms of vertigo during the experience, the mean score of 8.09 (*SD* = 2.63) with 68.10% (*n* = 90) of the students reporting experiencing minor symptoms of vertigo. The Engagement construct had the second-highest number of questions with a high score. For question 17, which gauged how involved students were with the experience, the mean score of 8.08 (*SD* = 2.11) with 75.70% (*n* = 100) of the students reporting being involved in the virtual environment.

The following questions were the lowest scoring questions from the instrument; mean scores below 6 were considered low. The Flow construct had the highest number of questions with a low score. For question 28, which gauged if students knew what to do at each step, the mean score of 5.62 (*SD* = 2.54), with 76.50% (*n* = 101) of the students neither agreeing nor disagreeing about what they should do at each step. For question 31, which gauged if students felt like time sped up while they were in the experience, the mean score of 5.38 (*SD* = 2.83), with 75% (*n* = 99) of the students neither agreeing nor disagreeing that sped up. For question 32, which gauged if students felt like they were losing sense of time, the mean score of 5.74 (*SD* = 3.06), with 74.20% (*n* = 98) of the students neither disagreeing nor agreeing that they felt a loss of time. For question 37, which gauged if students felt the need to share emotions that they were feeling, the mean score of 5.30 (*SD* = 2.95), with 73.40% (*n* = 97) of the students neither agreeing nor disagreeing with the need to share those emotions. The Usability construct had the second-highest number of low-scored questions; for question 48, which gauged if students felt there was too much inconsistency between the training resources and the virtual environment, the mean score of 5.63 (*SD* = 2.53), with 73.40% (*n* = 97) of the students neither agreeing nor disagreeing that there was too much inconsistency. For question 49, which gauged if students felt like the Oculus headset and controllers were cumbersome to use, the mean score of 5.39 (*SD* = 2.90), with 73.40% (*n* = 97) of the students neither disagreeing nor agreeing with this statement. The Immersion construct only had one question that was considered low. For question 25, which gauged if students became so involved with the experience that they lost track of time, the mean score of 4.94 (*SD* = 3.06), with 72.70% (*n* = 96) of the students reporting a slightly below neutral level of involvement to the point they lost track of time. Table 5 shows the 41.60% (*n* = 55) of completed scores that will make up the students' summated UX.

Table 5

Ohio Agricultural Education Students User Experience (Summated) (n = 55)

Construct	Number of items	*M*	*SD*	Range
Presence	12	7.12	1.59	1.92-9.25
Engagement	3	7.30	1.94	1.33-10.00
Immersion[a]	5	6.52	2.04	1.00-10.00
Flow	11	6.05	1.64	1.00-9.45
Emotion	3	7.53	1.86	3.00-10.00
Skill	3	7.18	2.34	2.33-10.00
Usability	3	6.10	1.82	2.33-10.00
Judgement	9	6.90	2.11	1.00-10.00
Experience Consequence	9	8.01	2.06	1.56-10.00
Technology Adoption	7	7.51	1.84	3.14-10.00
User Experience[b]	8	7.07	1.38	4.41-9.47

[a] The Immersion construct had Q24 and Q25 removed.
[b] The Emotion and Usability construct was not included in the User Experience construct.

Of the responses collected from the students (*n* = 132), 41.60% (*n* = 55) students answered all questions within the construct section; the complete surveys were used to report students' summated user Experience. Due to low reliability in the Emotion (α = .60) and Usability (α = .39) construct, those constructs were removed from the final user experience construct, all other constructs reported high alphas $\alpha < .8$ and were included.

On a scale of 1-10, Strongly Disagree (1) and Strongly Disagree (10), students reported they agreed (*M* = 7.12, *SD* = 1.59); they felt present within the experience and agreed (*M* = 7.30, *SD* = 1.94); and they felt engaged throughout the experience. Students slightly agreed (*M* = 6.52, *SD* = 2.04) the experience felt immersive. Students also slightly agreed (*M* = 6.05, *SD* = 1.64) about how well the experience flowed. Students agreed (*M* = 7.53, *SD* = 1.86) that they enjoyed learning with and using the headsets, but the environment did slightly scare them because they did not fully understand it. Students agreed (*M* = 7.18, *SD* = 2.34) that they had a moderate skill when it came to understanding and using the Oculus headset and controllers but slightly agreed (*M* = 6.10, *SD* = 1.82) about the usability of the Oculus headset and the experience. Students reported an agreeable (*M* = 6.90, *SD* = 2.11) judgement of the experience. Experience Consequence is a negative construct, in which students reported minor experiences (*M* = 8.01, SD = 2.06) such as eye strain, headache, nausea, and dizziness. Students agreed they would (*M* = 7.51, SD = 1.84) want to use this experience again and think that it would make learning more interesting. Ultimately, students' reported user experience was a 7.07 (*SD* = 1.38) indicating a positive user experience.

Objective 4: Describe the user experience (UX) of Ohio agricultural education teachers.

Objective 4 sought to describe Ohio Agricultural Education teacher UX. The UX survey provided *n* = 13 responses with *n* = 6 complete responses. For the complete table of teachers' mean scores for each question please see Appendix F.

Questions reported average scores ranging from 4.90 to 8.00, with the majority of the scores between 6.00 and 7.90, therefore questions with a mean score above 7.90 were considered to be high, and questions with a mean score lower than 6.00 were considered to be low. Described below are the questions with the highest and lowest mean scores.

The Experience Consequence construct had the two questions that scored the highest, which were negatively coded. For question 56, which gauged if teachers felt they had an increase in salivation, the mean score of 8.33 (*SD* = 2.69), with 75.00% (*n* = 9) of the teachers feeling they had a minor increase in salivation. For question 57, which gauged if teachers felt an increase in sweat during the experience, the mean score of 8.1 (*SD* = 2.80), with 75.00% (*n* = 9) of the teachers feeling like they had a minor increase in sweat. The Presence construct had the next two highest-scoring questions. For question 5, which gauged if teachers felt they could actively survey their environment, the mean score of 8.33 (*SD* = 1.80), with 75.00% (*n* = 9) of the teachers agreeing that they could actively survey their environment. For question 6, which gauged if teachers felt they could closely examine nearby objects, the mean score of 8.00 (*SD* = 1.80), with 75.00% (*n* = 9) of the teachers agreeing that they could examine nearby objects closely. The Technology Adoption construct had one question that scored high and was reverse coded. For question 66, which gauged if teachers thought using the Oculus headset and controllers was a bad idea, the mean score of 9.10 (*SD* = 1.10), with 76.90% (*n* = 10) of the teachers reporting that it was not a bad idea to use the Oculus headset and controllers.

The following questions were the lowest scoring questions from the instrument, where mean scores below 6 were considered low. The Flow construct had the highest number of low-scoring questions. For question 27, which gauged if teachers could perfectly control their actions, the mean score of 5.15 (*SD* = 2.07), with 100.00% (*n* = 13) of the teachers neither disagreeing nor agreeing that they could control their actions. For question 28, which gauged if teachers knew what to do at each step, the mean score of 4.50 (*SD* = 2.22), with 76.90% (*n* = 10) of the teachers slightly disagreed that they knew what to do at each step. For question 30, which gauged if teachers felt that time flowed differently, the mean score of 5.60 (*SD* = 2.75), with 76.90% (*n* = 10) of the teachers neither disagreeing nor agreeing that time flowed differently. For question 31, which gauged if teachers felt that time seemed to speed up, the mean score of 4.90 (*SD* = 2.51), with 76.90% (*n* =10) of the teachers slightly disagreeing that time seemed to speed up. For question 32, which gauged if teachers felt like they were losing sense of time, the mean score of 3.60 (*SD* = 2.06), with 76.90% (*n* = 10) of the teachers disagreeing with the statement. For question 36, which gauged if teachers felt that this experience gave them a sense of accomplishment, the mean score of 5.80 (*SD* = 1.93), with 76.90% (*n* = 10) teachers neither agreeing nor disagreeing that this experience gave them a sense of accomplishment. For question 37, which gauged if teachers felt like they had emotions to share from the experience, the mean score of 4.80 (*SD* = 1.39), with 76.90% (*n* = 10) of the teachers slightly disagreeing with the statement. The Immersion construct had the second-highest number of questions that score low. For question 20, which gauged if teachers were so involved that they were not aware of things going on around them, the mean score of 5.80 (*SD* = 2.39), with 76.90% (*n* = 10) of the teachers neither disagreeing nor agreeing with the statement. For question 22, which gauged if teachers felt so involved it was as if they were inside a course rather that manipulating a controller and watching a screen, the mean score of 5.60 (*SD* = 2.83), with 76.90% (*n* = 10) teachers neither disagreeing nor agreeing with the statement. Question 25 gauged if teachers felt that they lost all track of time, the mean score of 5.60 (*SD* = 2.79), with 76.90% (*n* = 10) of the teachers neither disagreeing nor agreeing with the statement. The Presence construct also had two questions that had low scores. For question 9, which gauged if teachers felt distracted by the visual display quality while performing tasks, the mean score of 5.78 (*SD* = 2.58), with 75.00% (*n* = 9) of the teachers neither disagreeing nor agreeing that the display caused a distraction. For question 10, which gauged if teachers felt distracted by the device while performing tasks, the mean score of 5.89 (*SD* = 2.89), with 75.00% (*n* = 9) of the teachers neither disagreeing nor agreeing that the device cause any distraction. The Technology Adoption construct had one question that reported a low score. For question 70, which gauged if teachers had the financial resources to acquire an Oculus headset, controllers, and the experience, the mean score of 3.30 (*SD* = 2.40), with 76.90% (*n* =10) of the teachers disagreeing with the statement. The Judgement construct had one question that reported a low score. For question 51[1], which gauged if teachers thought the experience was confusing or clear, a mean of 5.54 (*SD* = 2.40), with 100% (*n* = 13) of the teachers neither disagreeing nor agreeing with the statement. The Skill construct had one question that reported a low score. For question 45, which gauged if teachers felt confident in describing the functions of the Oculus headset and controllers for use in a virtual reality environment, the mean score of 5.70 (*SD* = 2.21), with 76.90% (*n* = 10) of the teachers neither disagreeing nor agreeing with the statement. The Experience Consequence construct had one question that reported a low score. For question 55, which gauged if teachers experienced eyestrain from their interaction with the virtual environment, the mean score of 5.89 (*SD* = 2.84), with 75% (*n* = 9) of the teachers neither agreeing nor disagreeing that they experienced eyestrain from their interaction. Table 6 describes the teachers' summated UX scores from the valid responses (*n* = 6).

Table 6

Ohio Agricultural Education Teachers User Experience (Summated) (n = 6)

Construct	Number of Items	*M*	*SD*	Range
Presence	12	7.40	1.89	4.75-9.17
Engagement	3	7.88	1.95	5.33-10.00
Immersion[a]	7	6.47	2.06	4.83-9.67
Flow	11	5.78	1.28	4.27-7.36
Emotion	3	7.05	1.90	4.00-9.67
Skill	3	6.05	2.13	3.67-9.00
Usability	3	6.50	2.33	3.00-9.67
Judgement	9	6.98	2.09	4.00-9.33
Experience Consequence	9	7.94	2.34	3.44-10.00
Technology Adoption	10	6.96	1.80	4.60-9.50
User Experience[b]	9	6.88	1.65	4.81-8.80

[a] The Immersion construct had Q25 removed.
[b] The Emotion construct was not included in the User Experience construct.

Of the responses collected from the teachers (n = 13), 6 teachers answered all questions within the construct section; these complete surveys were used to report teachers' summated user experience. Due to low reliability in the Emotion (α = .46) construct, it was removed from the final user experience construct. All other constructs reported high alphas $\alpha < .70$ and were included.

On a scale of 1-10 teachers reported they agreed (M = 7.40, SD = 1.89) that they felt present within the experience and teachers agreed (M = 7.88, SD = 1.95) that they felt engaged throughout the experience. Teachers slightly agreed (M = 6.47, SD = 2.06) when it came to the immersiveness of the experience. Teachers neither agreed nor disagreed (M = 5.78, SD = 1.28) about how well the experience flowed. Teachers agreed (M = 7.05, SD = 1.90) that they enjoyed learning with and using the headsets, but the environment did slightly scare them because they did not fully understand it. Teachers slightly agreed

(*M* = 6.05, *SD* = 2.13) that they had skill when it came to understanding and using the Oculus headset and controllers. Teachers also slightly agreed (*M* = 6.50, *SD* = 2.33) that the usability of the Oculus headset and the experience were high. Teachers judged the experience a 6.98 out of 10 (*SD* = 2.09). Experience Consequence was reverse coded, teachers reported minor experiences (*M* = 7.94, *SD* = 2.34) such as eye strain, headache, nausea, and dizziness. Teachers slightly agreed (*M* = 6.96, *SD* = 1.80) that they would want to use this experience again, and think that it would make teaching more interesting, but indicated that they did not have the financial resources to acquire the headset. Ultimately, teachers' user experience reported an average of 6.88 (*SD* = 1.65), indicating a positive user experience.

Objective 5: What is Ohio agricultural education teachers' user experience (UX) in the virtual reality program?

Objective 5 sought to describe agricultural education teachers' user experience in the virtual reality program through semi-structured interviews. From these interviews, two major themes emerged, with 9 sub-themes. The two major themes emerged from the data were that teachers' thought the experience provided valuable benefits, and they experienced new challenges brought on by new technology. See Figure 4 for all sub-themes.

Figure 4

Teachers' User Experience Themes and Sub-Themes

Theme	Sub-Themes
The experience provided valuable benefits.	1. It used unique content to provide unattainable experiences. 2. It provided enhanced engagement through technology and social collaboration. a. Students' real-world experience determined their experience in the VR program. 3. It was a positive educational experience with future implications. 4. It caused little to no symptoms related to VR immersion. 5. Positive contextual emotions.
New technology brought new challenges.	1. Teachers had little experience with VR, and it required them to experiment and practice. 2. Challenges with classroom and resource management. 3. Technology barriers impeded learning, due to lack of experience. 4. Negative contextual emotions.

Theme 1: The experience provided valuable benefits

Theme one emerged from the benefits that the teachers described from the experience. All of the teachers shared that this experience helped them provide an experience the teacher could not provide, an experience that a student was unlikely to have, or even helped them alleviate nervousness or fear around machinery. Teacher #2 said that "That the fear factor wasn't there, so they could actually try driving without getting on the equipment. We saw that with some of the kids, so I was impressed with what I saw teaching it."

Most of the teachers said that they saw an increased level of engagement from students who do not usually engage with the class and that this promoted a higher level of social collaboration. Teacher #6 said that "It was kind of neat to watch the kids who typically are not like the straight-A, really engaged kids, they were the ones who were teaching." This engagement depended on the previous experience that students had with VR and machinery operation and could often be used to identify students that did not have any driving experience. Teacher #2 saw that one of her students had prior VR experience and that held her back a little bit, "She was also one of them that does VR a lot, so she was trying to walk, like physically walk, around the tractor. I was like, no, no, you have to stand still."

Most of the teachers mentioned that this was a positive, fun, and educational experience that still has a lot of potential for safety training, as well as other areas in agriculture. They also mentioned that there were minimal symptoms, common with VR, that were experienced by them and their students. This led to positive emotions from both the students and teachers. Teacher #3 said:

> I don't think this is something that just one-to-one replaces (the way you teach), I think it takes it to the next step. Which is what you always want in education, you want to figure out what you're currently doing and how the students can improve their knowledge and skills. I think that VR could be something that you could do with those students.

The proceeding sections break this theme into more descriptive sub-themes.

Sub-Theme 1: Using unique content engagement to provide unattainable experiences

Almost all teachers shared that this experience allowed them to provide students with an experience that they would not normally get or allow them to practice an activity that they do not have equipment for. Teacher #4 said she usually just teaches the safety curriculum but because her students come from a more urban area, she understands that they don't have that experience: "Because again a lot of my kids are not going to have that opportunity to get on a tractor or to have, they may be on a small lawn tractor." Teacher #5 was in a similar situation where she also did not have the equipment available to teach her students and understood that this was a "kind of like a low stakes way to teach people, and I could see this being used in the training field outside of a classroom setting." Teacher #11 stated that "For like an urban agriculture class like mine that kind of virtual experience I think it's really, really cool because I cannot provide that to my students because I don't have that equipment, it's not in my community." While most teachers echoed these sentiments, Teacher #8 has a program that manages a large school farm and while he felt like the experience was good for giving experience it wasn't a good fit for him: "I teach a program where we manage a [large] school farm, so we have real tractors that we drive operate, real combines, so in fairness, to that, it's never going to compare to the real thing."

Sub-Theme 2: Enhanced engagement through technology and social collaboration

Teachers saw enhanced engagement in their students while they participated in this experience. Teachers noted that students who were previously more reserved became more engaged because this was a technology they knew and understood, it allowed them to help both other students and teachers who didn't have experience with this technology.

Teacher #4 said, “That was unintentional, was the teamwork of it so as one kid was struggling, and they were watching on a TV another one coming beside them and started to coach them.” Related, Teacher #6 said, “it was kind of neat to watch the kids who typically are not like the straight-A really engaged kids, were the ones who were teaching the other students.” Students were overall highly engaged through the activities in the experience, Teacher #1 said that “I think the opportunity to use brand new technology and do it in this setting was really, really engaging for kids and they were fully immersed in the experience.”

Over half of the teachers stated that depending on the students’ previous real-world experience, their experience in the program was different than what was expected. Most teachers found that their students with no farm experience did better in the experience than students that had farm experience. Teacher #8 noticed that his students “were more frustrated like I was because the program itself just wasn't responding like they felt it should. It wasn't that they couldn't do it, but they wanted to be able to do the physical motions.” Other teachers dealt with frustration and tried to coax students through the experience when they wanted to quit. Teacher #8 said “They would get really frustrated and they would just want to stop, and they won't even want to finish the course and I had to really do some coaxing.” Teacher #2 said:

> I would say it definitely helps the kids that haven't driven tractors their whole lives and aren't used to it, I have some kids that work on some pretty big machinery for their farms and the dairy farms like they're out pulling choppers, manure spreaders, and everything like that on a daily

> basis and they're driving skids loaders like the best of us. So, I mean some of the kids that definitely haven't driven before, they picked up on it, and a lot faster. They kind of did, I don't want to say, better than the kids that have driven a tractor before, but they picked it up better in this setting.

Due to the students that had more real-world practice struggling with the VR experience, it allowed students who had VR experience or who picked up the driving easy the opportunity to help others.

Sub-Theme 3: A positive educational experience that has future implications

An emergent theme from the teachers was that this experience was positive, provided sensible educational content, and has plenty of potential for future use. Teacher #4 described VR as so important for future education that the adoption of VR was non-negotiable to her, "So the adoption of this is a non-negotiable in my mind, I just wish there were more experiences, that would open the door to more options for our kids." Teacher #8 saw that while it was applicable for him at this moment, he could see the potential that an experience like this could provide for students, "I understand this at the beginning, so I think there's a lot of potential there." Teacher #6 thought that getting to use the VR technology in the classroom was the exciting component that brought students into it:

> I think, overall, it was a positive experience, and I think anytime that you add a novel experience like this, kids don't always get to use virtual reality, and especially in the classroom, I think that brings a level of excitement for anyone because it is something different.

Teachers were able to see the potential that VR has in the educational setting. Teacher #6 went as far as to say she wishes "there was more valid experience like this one available" and that she "would love to incorporate more experiences like this one" into her classroom.

Sub-Theme 4: Mostly no symptoms were experienced except minor motion sickness and dizziness

Almost all of the teachers reported that this experience did not produce any negative symptoms that common VR experiences might cause. Only a couple of teachers said they experienced motion sickness, but not to the point they needed to quit using the headset, "I don't know if it was just the closeness and all that stuff that, I just wasn't used to the motion sickness yet." While teacher #11 said he did not like the feeling of coming out of the headset and getting reoriented to the real world "When I came back out of the virtual reality environment, especially in the longest session I did find that my eyes took a little bit of time to readjust to real-world lighting and real-world spatial dynamics." Other teachers reported no side effects of using the VR experience, Teacher #2 said she did not experience anything personally, but did notice that the students:

> Went out and had fun and played with the barrels …… I think it was the kids' extra time spent in the headset, but I would say the kids did just the test, and then the driving test itself we're fine.

For the most part, teachers described few instances where they experienced motion sickness while in the headset and little to no other symptoms.

Sub-Theme 5: The experience brought out the users' positive contextual emotions.

This sub-theme breaks down the positive contextual emotions experienced by the teachers and students, which focused on collaboration, excitement, and competitiveness. Teacher #1 said:

> I really liked it, it was honestly fun, it made learning fun is what it did, and I know this is all about tractor safety which is definitely not one of the most engaging topics, but I think it was good that it was done over a non-engaging topic.

Teacher #2 saw that her students:

> Had a lot of fun, I think a lot of the kids really enjoyed trying to at least, and even if it wasn't necessary to do the test, like the safety tests, they just wanted to drive the tractor.

Teachers described the students as “excited” that they got to try something new like VR in class, and expressed gratification that it made an “not so interesting topic interesting again.”

Theme 2: New technology brought new challenges.

The second theme emerged from the challenges that arose from trying to use new technology like a VR headset in the classroom. All of the teachers mentioned they had little to no VR experience, and to practice and experiment with the headset on their own. Teacher #8 felt that “Just for having it a couple of months I wasn't extremely familiar with it, so it took me a lot of time to figure it out.”

Some of the teachers dealt with the challenge of trying to manage the classroom with only one headset and making sure all of the students stayed on task. Teacher #3 felt that the teacher "needs to be invested in VR" before trying to integrate it into their classroom. Teacher #5 felt that because he used it as a "side activity" students were not able to see the benefit of using it as an educational tool.

All of the teachers described technological issues of some kind. Teachers had issues with navigating and using the technology, connecting to their school computers, and trying to cast the experience to their projectors. Teacher #9 said:

> The biggest struggle that we had was trying to get the students trained through it. Then our technology doesn't always work with all the other technology out there, our school pretty much locks down our computers, I can't download programs, I can't do anything. So, the casting part did not work for us.

The proceeding sections break this theme into more descriptive sub-themes.

Sub-Theme 1: Teachers have little experience of virtual reality and it required necessary practice and experimentation.

As echoed by all teacher participants starting to use the VR technology, they encountered learning curves and technology barriers that inhibited them from learning how to use the technology. Teacher #4 stated, "I had to go back and watch the YouTube video that you provided so that I was sure that I walked through the process correctly, and again I think that's a generational thing probably." Teacher #5 stated:

> Knowing what buttons to push, the instructions; I don't know, I don't think it was as easy as it could have been you know moving forward and I have

> the same issues with my virtual welder so I’m not saying it was just that thing.

Some teachers went as far as to have their students help them work through the technology. Teacher #2 stated that:

> Coming in, not knowing anything was really cool, but my students were able to kind of talk me through it. I have a couple (of kids) that's what they do for games is that's all they have is the VR, so they could kind of talk me through it.

Some teachers had technology or gaming experience, but while they had that experience, they did not have experience with VR technology. Teacher #2 also stated she was always interested in virtual reality but never really “had the opportunity to use it” or determine if she wanted to get it. Teacher #11 described himself as “top of the game” when it came to technology: “People would come to me and be like …. how do I do this thing and I’d solve it” but VR always seemed to be “way beyond” what he usually does and was a “bit of a jump” to learn how to operate it.

Sub-Theme 2: Virtual reality requires teachers to be thoughtful about classroom and resource management

Teachers identified time as one of the biggest factors toward making the most of implementing the experience in their classrooms. It was often stated that it took too much time for the students to get through the experience. Teacher #1 said, “the biggest challenges I had was getting the kids involved with it and doing so in like a timely manner because I didn't do this with every class.” Related, Teacher #3 said, “It takes up a lot of time, so you'd have to get three or four going at the same time." Teacher #3 wished he had more headsets to allow students to use them simultaneously and that other students would have something to do while others are busy. Related, Teacher #5 said his biggest challenge was teaching his whole class with just one piece of equipment. Teacher #4 noted the FFA chapter owned a VR headset, but could not get the experience downloaded onto their headset to have another one to use.

Sub-Theme 3: Technology barriers to experience and learning

This sub-theme focused on teachers who brought up different barriers that prohibited them from using this technology correctly such as this experience feeling more like a game than a learning tool and not having the ability to cast what was on the headset to their computers. Teacher #5 said he felt his students "saw it more as a fun activity versus a learning activity" and Teacher #8 compared this to a welding simulator that they had used in the past:

> We used a welding simulator and I felt like it was pretty accurate, your position had to be held right and your materials were right here. You actually had to set some things up like you would really be welding, whereas this you just kind of put this on like you do a video game.

Other teachers focused on technological issues such as casting or Wi-Fi issues. Teacher #11 said, "we had a variety of issues with casting from either getting the headset connected to the school's Wi-Fi or the Wi-Fi not being strong enough to be able to support the casting or just having the content blocks." Teacher #5 stated "he couldn't really teach those students because it was hard to teach it without looking at it, so I was trying to remember the steps to guide the students."

Sub-Theme 4: The experience brought out the users' negative contextual emotions

This sub-theme breaks down the negative emotions experienced by the teachers, the negative emotions focused on apprehension, being overwhelmed, and feeling frustrated. The biggest negative emotion experienced was related to frustration, Teacher #3 experienced frustration around not being able complete certain actions in the experience which led to restarting the experience "Doing with that with students can be very frustrating, though, when the things want to kick you off, and you have to completely shut down." Teacher #5 and his students got frustrated when they could not figure out what to do next or which buttons to click: "I think lots of them are getting frustrated and they're like I don't I don't know where I'm going or I don't know what I'm clicking, and which button do I click." Teacher #2 stated she felt some nervousness around teaching with new technology and a new content area such as this:

> There was definitely, like I had a little bit of nervousness about teaching it just because to do something completely out of my, like real, out of my comfort zone not only the VR but teaching some of the kids who have never driven a tractor before.

Objective 6: What was Ohio agricultural education teachers' sense of realism in the virtual reality program?

Objective 6 sought to describe agricultural education teachers' sense of realism in the virtual reality program through semi-structured interviews. Teachers were asked on a scale of 1-10 how realistic was the experience and then asked to go into detail about why they thought it was that realistic. From these interviews, one theme emerged from their responses, as shown in Figure 5.

Figure 5

Teachers' Sense of Realism Themes and Sub-Themes

Theme	Sub-Themes
The experience provides a semi-realistic interpretation of a hands-on activity.	1. The program did not allow for instinctive actions due to the limitations of VR. 2. Presence and sense of space was realistic.

Theme 1: The experience provided a semi-realistic interpretation of a hands-on activity

All of the teachers interviewed described some parts of the experience to be realistic. Teacher #1 described driving the tractor:

> I would steer with the controllers, but I would also like move my hands in that direction, so I don't know if that was just like a me thing, but it felt really realistic, even though I consciously knew that I was watching a video or like playing a video game it felt really real.

Teacher #2 described it as realistic enough that she went to reach for the steering wheel, "I also have caught myself like actually taking my hand and trying to move the wheel, instead of the joystick". Teacher #5 described the VR tractor:

> You got on the tractor, and it looks exactly what it looks like when you get on a real tractor, the steps you have to use, put the seatbelt on, push the clutch, and you know that sort of thing, starting and all that.

Sub-Theme 1: The program did not allow for instinctive action due to the limitation of VR.

While the experience did provide some realistic features for the teachers to experience, some instinctive actions weren’t as realistic as they could be. Teacher #1 described the prechecks that students had to do more like checking a box, “The prechecks weren't as realistic because it's like if you were doing a precheck you'd actually have to go and like look at the thing, instead of here where you just checking a box.” Teacher #9 described it as imperfect as of yet, “It's not quite like how it is in real life, but it does give them a feel for it. It's not perfect, not yet at least.” For example, users had to click on the handle to mount the tractor. Teacher #6 felt that “getting on the tractor and moving some of the controls weren't as realistic, but I’m not sure that they could be more realistic either.” Teacher #8 shared he or she expected to be able to do different things:

> You could do things like a front-end loader, and running a joystick on the loader because I struggle with a lot of kids understanding the plus sign. You know right tilts, left curls, and hooking up attachments. It just seemed like he got on and even though they were stressing the points about the seat belt, it's almost like he just kind of threw it in drive and took off. There was no clutching, breaking, no power reverser. I think those little

> details, with the type of tractors and equipment, are important to make it applicable.

Comments like these show that in creating educational experiences like this, you need to make sure that every conceivable piece is incorporated in that can be. Realistic experiences can provide more relatable content for participants and in turn, can build knowledge off of this experience. Teacher #8 also said that:

> I felt like it would be more acceptable for somebody with a compact tractor, maybe a residential person. More so than what we would do in production agriculture, but it almost seemed a bit generic compared to what we would be using.

Sub-Theme 2: The presence and sense of space was realistic.

The second sub-theme emerged from teachers speaking about how realistic, present and immersed they felt within the experience. There were certain components that teachers felt were realistic, such as the driving course. Teacher #4 said the experience:

> Was really good, like the concept of knowing how to touch the key and turn that on, how to unbuckle or buckle the seat belt, and how to step up onto the tractor. So, from an immersive experience I like that, things looked real.

Although Teacher #5 did not have a positive experience with the program, he still felt that it had some realistic components, especially where all the parts were located. He said:

> It was really detailed when you look, you're sitting on a tractor, the word seatbelt was where the location was, where the seatbelt is. You know to turn the key, it was down in the bottom right there, and that was very accurate.

Objective 7: Explore the relationship between Ohio agricultural education teachers' user experience (UX) and the realistic nature of the Virtual Reality program.

Objective 7 sought to explore if there was a relationship between the teachers' user experience score and their sense of realism that was quantified from their qualitative results. Table 5 displays how the teachers rated the realism of the VR experience.

Table 5

Teachers' Quantified Realism Scores

Teacher Number	Realism Score[a]
1	7
2	7
3	5
4	6
5	7
6	7
7	6
8	4
9	6
10	7
11	7

[a] Realism scores are out of a 10-point scale

Table 6 describes the mean and standard deviation of the teachers' realism scores. On a scale of 1-10, one being the lowest and 10 being the highest, teachers reported having an average of 6.2 (*SD* = 1.0). Scores ranged from 4, as the lowest, and 7, as the highest, ratings of the experience.

Table 6

Mean Score of Teachers' Quantified Sense of Realism

Category	*M*	SD	Range
Teachers Realism	6.23	1.05	4.00-7.00

To explore if there was a relationship between the realism score and the user experience score, correlations were calculated. Assumptions were checked and while the data met the assumptions for independence and linearity, it did not meet the assumptions for related pairs, normality, and levels of measurement. Because assumptions were not met, a nonparametric Spearman Rho correlation was calculated (see Table 7).

Table 7

Spearman Rho Correlation of Teachers' User Experience (n = 6) to Teachers' Realism (n = 11)

Category	*r*	R^2	*p*	CI Lower	CI Upper
Teachers User Experience to Teachers Realism	-.16	.02	.74	-.94	.94

The relationship between teachers' user experience and the teachers' quantified senses of realism was found to be non-significant, negative, and low in magnitude (r = -.16, R^2 = .02, $p > .01$, 95% CI: -.94 to .94). A non-significant, negative, and low magnitude relationship would suggest that there is not a relationship between the teachers' user experience and realism.

CHAPTER 5: DISCUSSION

The overarching question of this mixed-methods study was to determine "Does virtual reality provide a realistic experience and supplemental option for skill-based education?" The purpose of this study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students and teachers in machinery safety operation lessons. I described how students performed in a grant-funded VR tractor safety experience. I sought to determine if there was a difference between two classrooms of students, one of which used the VR experience as an intervention, specifically involving a tractor safety program. I described both teacher and student user experience scores from the VR experience. I used thematic analysis to analyze qualitative data from semi-structured interviews about teachers' user experience and sense of realism in the VR experience, through which 3 themes emerged. I explored the relationship between teachers' user experience and their quantified sense of realism. I begin this chapter by interpreting the findings from the seven research objectives that guided this study.

In this section I will relate the findings to my seven research objectives:

1. Describe the virtual reality program performance of agricultural education students from Ohio.

2. Describe the difference in Ohio agricultural education students' performance between a traditional tractor safety training and a tractor safety program with VR.
    - H_0: There will be no difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.
    - H_1: There is a difference between students passing rates who participated in the training with the VR intervention and students who participated in the training with no VR intervention.
3. Describe the user experience (UX) of students from Ohio in the virtual reality program.
4. Describe the user experience (UX) of Ohio agricultural education teachers.
5. What is Ohio agricultural education teachers' user experience (UX) in the virtual reality program?
6. What was Ohio agricultural education teachers' sense of realism in the virtual reality program?
7. Explore the relationship between Ohio agricultural education teachers' user experience (UX) and the realistic nature of the VR program.

Conclusions, Implications, and Discussion

Objective 1

Objective 1 sought to describe how students performed in the VR program. I found, on average, students are accruing a high number of points across the precheck questions and the driving course. In the context of this experience, students should have gotten a score as close to zero as possible. Students scoring a high number of points can be considered poor performance. This poor performance included a high number of questions that were not answered by the students. This could be attributed to them not reading or following the instructions correctly. This could also be contributed to the context in which the teacher presented the experience, which led to them not taking it seriously. It can be concluded that students reported poor scores in the VR program.

Currently, VR-integrated welding training has shown some promise in creating a positive transfer of knowledge from the training to real-life activities (Stone et al., 2011). Wells and Miller (2020) found that of 101 university agricultural sciences students, the ones that participated in a 100% VR welding training held the highest mean score between the welding training groups. While this does not directly support the findings in this study, students who completed all of the questions seemed to do better in the experience than students who did not complete all the questions. Perhaps, because they took the experience more seriously than the other students.

In other areas of education, McGovern et al. (2020) found VR helped students assess their presentation skills, and practice upgrading those skills. Yang et al. (2021) found that students in a VR-guided writing group had higher scores that those in a traditional setting. Buchanan (2004) found that first-year dental students learned faster and arrived at the same level of performance as students in their traditional labs. Syed et al. (2019) found that VR-based learning materials were effective in improving laboratory safety and confidence. In their interviews, teachers described seeing their anxious students become less anxious about possibly driving a machine like a tractor and an increase in students willing to try new technology.

Madden et al. (2020) found that video game experience can be a factor that predicts students' performance outcomes. Lee et al. (2010) found that presence, usability, and VR features can all be significantly related to learning outcomes, and it can explain a small amount of variance in student performance. Possibly other factors including personal goals, cognitive styles, and computer attitudes may affect performance. Getting a better score is not necessarily the goal of all students (Lee et al., 2010; McGill & Klobas, 2009).

Based on previous research, it can be implied that internal and external factors impeded students' performance in the VR experience in this current study, and more work should be done to determine what factors affect student performance. In this study, teachers were instructed to use the VR experience as a part of their current curriculum. Due to the casual nature of testing this experience, less emphasis was placed on this experience as a learning tool, and was viewed as a side activity with little ties to the curriculum. Although, how teachers present this experience may seem trivial, this could have larger implications for other virtual experiences. While some of the performance could be attributed to students not taking the VR experience seriously, some teachers explained that students became competitive as they watched other students complete the program. Teachers said that students would compete with each other to get the lowest score and would keep a scoreboard on the whiteboard. So, while students completed the program with different purposes in mind, students did complete the program as intended.

They were noted saying that this was a cool experience and saw the educational purpose of it. These findings have important implications for the broader domain of Agricultural Education. As different components of education move to virtual format, will be important to address how these students perform and what factors are affecting their performance.

Objective 2

Objective 2 sought to describe if there was a difference between a traditional tractor training and a tractor training with a VR intervention. The passing rates of the two groups that completed the tractor operation program were evaluated and found that there was no significant difference between the two groups. It can be concluded that the VR intervention had no significant effect over the traditional training.

While research has shown that significant differences existed between writing groups and virtual reality classrooms (Liou & Chang, 2018; Yang et al., 2021); this study aligns with Stone et al. (2013) and Wells and Miller (2020) when they found no significant differences between traditional, full, and 50/50 VR welding groups. Since VR has shown positive differences between traditional trainings and VR trainings, it can be implied that other variables affected students' performance. Time in between using the VR intervention and the official driving, and the emphasis placed on the experience as a learning tool should be looked at as potential variables affecting performance.

Stone et al. (2013) found no significant interactions between groups using VR welding training while completing different welds in different positions. Wells and Miller (2020) also found no significant differences between full VR, full live welding, and 50/50

VR and live welding groups. In other areas of education, Yang et al. (2021) found significant differences between experimental writing groups; the group trained in VR had significantly higher scores than the control group. Liou and Chang (2018) found that a virtual reality classroom showed better motivation, learning outcomes, and positive impacts on students learning scores. While VR has not shown significant differences between groups of students in Agricultural Education, it has shown differences between groups in other areas of education. This could be due to the experiential and hands-on nature of Agricultural Education; two teachers described that students would rather be doing the real activity instead of a VR version of it. Lack of structure and resources could also describe the lack of differences between our two groups.

While there were no significant differences found between the groups, it implies that the VR intervention is just effective as the traditional training without the VR intervention. Ultimately, the implications of these finding are important because it found the VR experience did not perform worse than the traditional training. The impact educational VR experiences could have on the domain for both students and teachers would be beneficial for not only Agricultural Education but other areas as well.

Objectives 3 and Objective 4

Objective 3 sought to describe students' user experience from the VR program. I found that every construct had a mean score over neutral, concluding that the students' user experience towards this experience was positive. Unfortunately, both the Emotion and Usability constructs were excluded from the students' summated user experience score due to low-reliability estimates. This aligns with research reporting positive user experiences in educational settings (Dirin, 2020; Tcha-Tokey et al., 2017).

Currently, in Agricultural Education, there have been no studies related to user experience in VR experiences with students. This study will begin to bridge the gap in literature for VR integration. In other areas of education, Dirin (2020) developed a mobile VR application and saw changes in students’ perceptions of the new technology through their user experience. Tcha-Tokey et al. (2017) found that students showed a difference in pre and post-test knowledge in an edutainment application while reporting a slightly positive experience. The results from this objective implies that students had a positive user experience in this VR program. These matters because understanding students’ user experiences of educational experiences allows us to work on the specific areas that are deficient.

Objective 4 sought to describe teachers' user experience from the VR program. I found that every construct had a mean score over neutral except for flow. Therefore, I conclude that the teachers’ user experience towards this experience was positive. Unfortunately, the Usability construct was excluded from the teachers’ summated User Experience score due to low reliabilities.

Like the students’ user experience, there have been no previous studies regarding user experience in Agricultural Education, and this will begin to bridge the gap in the literature and open other opportunities for future research. In other areas, user experience helped Alenazi and Demir (2019) determine design and engagement problems with a virtual tour. Mikropoulos et al. (2020) created an AR system that allowed parents, special educators, and therapists of children with autism and sensory overload to experience the same effects. It was found to be convincing, comfortable, and user-friendly (Mikropoulos et al., 2020). Virtual Reality was used as a one-on-one tutoring method in an anatomy course, users reported feeling immersed in the environment, and said that actions felt natural and intuitive (Saalfeld et al., 2020).

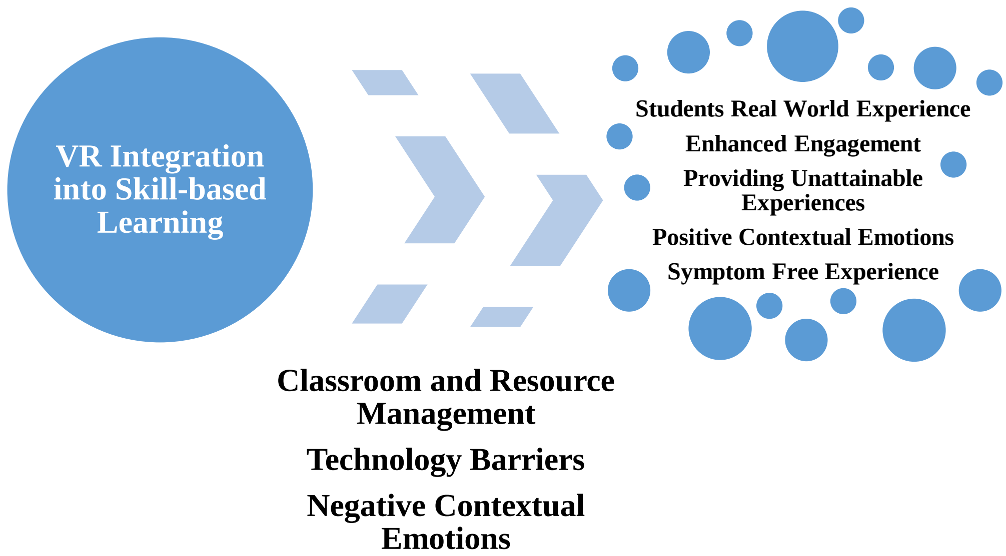
These conclusions will have significant applications in the development of future digital educational experiences. Understanding how students perceive experiences through the user experience model will be instrumental in designing content directed towards them. Allowing teachers to understand user experience will not only be beneficial to them when they design or help design experiences, but it will allow them to understand what areas students need help in.

Objective 5

In Objective 5, Agricultural Education teachers participated in semi-structured interviews to break down their user experience. Two themes and 9 sub-themes emerged from those results, concluding that teachers had a valuable and positive experience. To describe the essence of these results it’s important to look at these results as two separate groups, benefits of VR integration and barriers facing VR integration. Figure 6 displays how the barriers prevent students and teachers from seeing the benefits of integrating VR into skill-based learning.

Figure 6

Barriers of VR Integration Influence on Benefits



This figure graphically articulates the three main barriers that impede VR adoption. These were identified as classroom and resource management, technology barriers, and negative emotions. When these are present, it will be challenging for students and teachers to see the benefits of integrating VR into their skill-based activities. Even though these barriers are present, that does not mean that some of the benefits of VR adoption cannot still be experienced. Teachers mentioned in their interviews that while they still felt frustrated at the casting technology, they were still able to provide students with a unique experience that they would have not been given otherwise. Teachers were provided with one VR headset to use in their classrooms. Because of this, some wished they had more than one headset and teachers took longer to train their students because of having one headset.

As data were analyzed, a new question emerged that replaced the previous one guiding this objective. Instead of describing the teachers' user experience, emerging themes described teachers' experience of integrating virtual reality into their classrooms. Overall, from the emerging themes, it can be concluded that this experience was positive and able to provide an engaging and unique experience; but more importantly themes described the valuable benefits that VR can provide as well as the barriers that are impeding VR's integration.

Wells and Miller (2020) found fairly agreeable opinions among Iowa teachers related to the integration of SBAE programs, which align with some of the positive items' teachers identified in their interviews. It also showed that the teachers were unsure that the benefits would outweigh the potential costs. This supports the findings from the teachers' interviews regarding this experience providing valuable experiences for students. It also echoed some of the concerns that teachers voiced regarding its use in the classroom as an educational tool. Although these barriers may seem trivial, it is in fact crucial for the successful implementation of VR in the classroom. This implies that until we attempt to alleviate the challenges and remove the barriers in place, teachers will only have semi-successful experiences with VR in their classrooms.

Objective 6

I conclude that teachers had a semi-realistic experience. Teachers went as far as to try to grab the steering wheel and other levers as if they were real. In addition, their bodies would move with the tractor as they drove and would respond to the movements and motions as if they were actually driving a tractor. Teachers also reported that not being able to do more instinctive actions like checking the oil or grabbing the steering wheel took away from the realism of the experience.

Lamb and Etopio (2019) found that a VR versus real-life condition where pre-service teachers had the opportunity to confirm, extend, or disconfirm their prior knowledge about how they will react in the classroom resulting in the construction of new knowledge, skills, and strategies was not significant. The study did find that it can promote learning from modeled real-life situations for the transfer of theory into practice. Lombard and Ditton (1997) argued that when a user is not familiar with something, like virtual reality, that unfamiliarity promotes a lower presence score and in turn can't be a realistic experience. Gisbergen et al. (2019) found that even though differences in realism were observed they did not have an effect on experience or behavior. They found that there might be other variables that can affect the whole experience to essentially "obliterate" the effects of a better sense of presence and realism (Gisbergen et al., 2019). It implies realism is important to the users' experience as well as making a successful integration of VR into a classroom or curriculum and can allow them to see the potential uses that VR can provide. Also, other factors of the experience can negatively affect the users' experience and detract from the realistic nature. By ensuring that educational experiences are as realistic as possible, it will make the experience more transferable to real-life situation so students can make those connections.

Objective 7

Objective 7 sought to explore if there was a relationship between teachers' user experience scores and teachers' quantified realism scores and determine if the user experience instrument could be an indicator of realism. Based on the results, the relationship is negligible between the teachers' realism and user experience.

As mentioned above, there has been no research conducted in Agricultural Education on user experience. Research has shown that presence is one of the main variables of realism. Other studies have shown that between conditions of a virtual environment and a real one, both presence and user experience were partially correlated (Brade et al., 2017). From the results, this implies that there is no relationship between the two variables, although research points to a potential relationship between user experience and realism, more research should be done to confirm this. This may have been affected by the response rate of the teachers that caused assumptions to not be met for the original analysis. Understanding the relationship between user experience and realism is important, because if one influences the other then by addressing one variable we could be improving the other.

Limitations

Several limitations emerged from this study such as student and teacher participation, low reliabilities, and external weather factors during the experiment. Of the 132 students that participated, 38 provided usable performance data, and 55 fully completed the user experience survey. Of the 19 teachers that participated, 11 participated in the semi-structured interviews, and six fully completed the user experience survey. This should be replicated and more effort to control the response rate, as well as providing an incentive to participate should be built into the design of the study.

Two constructs had low-reliability estimates (Usability and Emotion) due to these constructs using three questions and the low response rate from above. More questions should be pulled from the original questionnaires and be re-tested with another group of agriculture teachers and their students.

Several internal and external threats to validity limited the impact of the quasi-experimental Objective 2. This experiment was designed to take place over 4 weeks, but due to weather issues, was implemented over two months. External threats consisted of several delays, spring break occurred during this time, and they had six or more two-hour fog delays, as well as multiple days with rain that prevented them from practicing outside. Internal threats arose from not receiving the correct data which led to the data received not meeting assumptions and a change of data analysis. A confounding variable arose from the data in the form of prior experience. In their interviews, teachers said that students who had prior experience driving a tractor struggled more with the VR headset than the students with no prior experience. This experiment should be replicated in a more controlled environment to avoid these issues. The reader should be cautioned that the data reported is not representative of the entire agriculture teachers and their students of Ohio and applies only to the teachers and students that participated in this study. Some reservations may exist amongst teachers who viewed this as a game and not quite as a learning experience. While this study had its limitations, the positives outline the potential that VR could have by integrating this technology into Agricultural Education classrooms.

Recommendations for Research

Because this study was limited in the number of classrooms, teachers, and students that were able to use and complete the VR experience, the results are not representative of the Agricultural Education teacher and student populations. Further research needs to be conducted in a more structured setting to see the true effect that VR can bring to the classroom. There is a small body of knowledge regarding the integration of VR into Agricultural Education, currently focused on VR welding experience, the recommendations presented here will add to this body of knowledge. Further work should be done to improve the VR experience and continue to evaluate the performance of students to improve their experiences.

Performance

There is a gap in related literature in Agricultural Education, the only research presented so far has focused on VR welding skills. Efforts should be taken to develop more agricultural VR experiences that expand across all of the content areas of agriculture. Students' views of activities used in the classroom largely depend on how it presented to them by the teacher and if the educational benefits can be seen by the students (Cukurbasi & Kiyici, 2018). Further research should be conducted to assess teachers’ opinions of using VR in the classroom and if they feel it is a novelty or a useful tool. From our findings, teachers described some of their students as having VR experience, so more research should also be done with them to see how they view VR technology. Replication in a more structured environment is needed to determine if the poor scores of students reported in this study are consistent and determine how to improve student performance. This will allow for procedural errors that arose to be rectified while students are in the experience

Traditional Setting vs VR Intervention

This specific VR experience should continue to be tested for effectiveness against the traditional live version of the training program. Further research needs to be conducted to develop an implementation program for teachers implementing a VR experience like this into their curriculum. The procedural issues that arose could be alleviated by providing teachers with a structured implementation guide. While no significant differences were found within the groups in this study, this experiment should be replicated in a more controlled setting and focus more on individual variables such as questions answered, objects struck, etc. Research needs to be done as well on how students and teachers view the seriousness of the training and how a tractor operation certification is perceived.

User Experience

There have currently been no studies measuring user experience amongst teachers or students in Agricultural Education. The user experience model should be used to evaluate current digital experiences. While the development and implementation of new virtual and digital experiences should continue while using the user experience model to evaluate how students and teachers respond to it. Understanding how teachers experience educational activities is important to understand. If teachers do not have a good experience, it’s less likely that they would introduce the experience into their curriculum. Additional research should be conducted to determine the reliability of the two deficient constructs that emerged in this study.

Themes of User Experience

More qualitative work should be conducted to explain teachers’ perceptions of VR and how they view it as an educational tool. Work could also be done with administrations about their view of VR and what potential it could have for students as an educational tool. More work should be done with teachers to determine if the emerged themes are present amongst other teachers across the state. Research should also be done to determine what other barriers may exist that hinder the implementation of VR in educational settings. Work should also be done about teachers' perceived barriers to implementing VR technology into the classroom with a focus on teachers who have utilized the technology and teachers who have only seen it being used.

Themes of Realism

Realism is a concept that is not directly measured by the constructs of the user experience model, but the constructs of Presence and Immersion do relate to realism (Lamb & Etopio, 2019). Other qualitative work can be done to discover barriers that cause an experience to be unrealistic. Quantitative work can also be done to discover potential relationships between the constructs of the user experience model and realism.

User Experience and Realism

More research should also be conducted to determine if there is a relationship between participants' user experiences and their perceived realism of the experience. Several constructs such as presence and immersion, have been shown to influence the realistic nature of a VR experience (Goncalves et al., 2022). So, more research should be conducted to determine if any of the constructs of user experience have a relationship or effect on the realism of an experience.

Recommendations for Practice

This study provides a starting point for individuals who are interested in developing or integrating virtual reality experiences into a classroom setting. This study introduces the user experience model and explains how the different components can influence the experience of users in a virtual environment. It is recommended that state staff, administration, and teachers address potential issues before integrating the technology. Addressing these issues beforehand can relieve a lot of frustration in the future.

State Staff

State staff should try to provide continuing education opportunities for pre and in-service teachers to interact with new technologies, such as VR. Other opportunities at professional development conferences should be developed to allow teachers to see what is available and interact with the technologies if possible. State agencies could also provide opportunities or incentives for districts to adopt VR technologies through funding opportunities such as grants or incentives.

Teacher Educators

Teacher educators should provide an opportunity for pre-service teachers to experience using VR technology in an educational setting. Pre-service teachers should also be made aware of funding opportunities to supply their classrooms with VR technology. The opportunity to work with new technology can open up collaboration opportunities with other departments across campus to provide pre-service teachers access to new instructional technology.

Administration

Some teachers described in their interviews that their administration wanted to stay at the forefront of technology by having the newest equipment available, but most of the teachers disagreed that they had the financial support to purchase this technology. Administrations should be made aware of the available technology, and the value it provides for the teachers. Administrators should make themselves available to see teachers try out new technology in their classrooms. Some teachers said their principals came by the class while they were using the headsets and even tried it out themselves.

Teachers

This specific experience is tied to a supplemental piece of curricula that is tied to the National Safe Tractor and Machinery Operation Program and should be used with similar tractor and machinery certification programs. Teachers can use it with their curriculum but need to be aware of the content in the experience to ensure transferability between their curriculum and the experience. Therefore, teachers should make it a priority to integrate a potential VR experience into their curriculum and not use it as a side activity in the classroom. This will allow students to see it as the educational component it was designed as, and not as a game. Teachers should make sure they have properly reviewed the instructions and practiced the experience before introducing it to the students. Teachers should make sure they have used technology enough to feel comfortable using it in front of their students and to talk them through the basic steps.

Developers

Developers that wish to create educational VR experiences should consider working with educational specialists or teachers within the applicable content area. This will help the developers understand the educational requirement that an experience will need. It also gives developers an idea of where to focus their effort when designing educational experiences. It is recommended that individuals who are designing educational VR experiences use this user experience model to evaluate how students and teachers are responding to your experience.

Summary

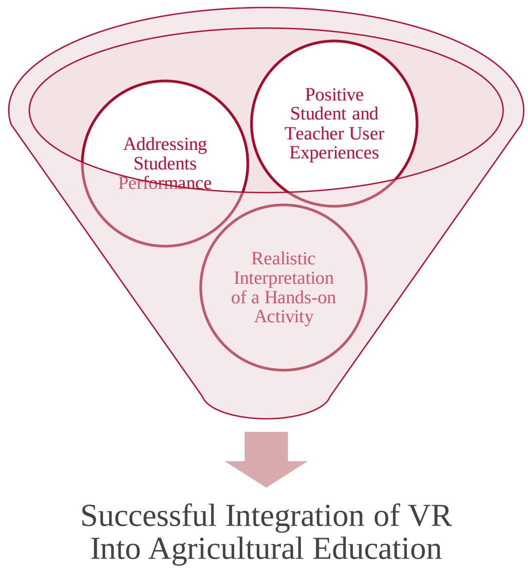
The purpose of this mixed-methods study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students and teachers in machinery safety operation lessons. The central question guiding this study was "Does virtual reality provide a realistic experience and supplemental option for skill-based education?" Due to the depth of the question, multiple methods were used to answer the question.

Descriptive methods were used to analyze students' performance, student user experience, and teachers' user experience. Which found that students reported scores that could be considered poor, this implies that they may not have taken the experience seriously. Students reported user experience scores indicating a positive experience. Teachers also reported user experience scores that indicated they had a positive experience.

Semi-structured interviews were used to describe the teachers' views of the VR phenomenon. Three themes emerged from the teachers’ interviews, teachers thought the experience provided valuable benefits, brought on new challenges, and that it provided a semi-realistic interpretation of a hands-on activity. To accomplish the mixed methods objective of this study, teachers described how realistic they thought the experience was. The data were quantified and triangulated with the teachers’ user experience scores. It was concluded that in this context there was a negative relationship between the two. Figure 7 visually depicts the three main factors that seem to influence the successful integration of VR into Agricultural Education.

Figure 7

Successful Integration of Virtual Reality into Agricultural Education Model



By ensuring that teachers and students have positive user experiences, addressing students' performance, and providing a realistic interpretation of a hands-on activity we can see VR successfully integrated into Agricultural Education. Both students and teachers expressed excitement about a new teaching method for a traditional topic that has experienced little change over the years. Based on the results of this study, it can be concluded that virtual reality has the potential to supplement skill-based education. This study will contribute to the body of literature to further the integration of virtual reality into educational environments for skill-based education.

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Appendix A. Teacher Recruitment Letter

Greetings Teacher Participant,

You are being sent this letter because you fall within the scope of a prospective research study being conducted by The Ohio State University on integration of virtual reality in tractor and machinery operation. We are developing a Virtual Reality (VR) training program to teach proper machinery operation procedures and safe practices. I am inviting you to participate in this voluntary study.

As a teacher being recruited for this study, if you agree to participate, we ask that you read the student recruitment letter that will be supplied to you for your students' recruitment into the study. The goal of this study is gain insights on your perceptions of this VR program.

This is a two-step study, the first is utilizing an Oculus headset provided to you. Using this headset, you will complete the safety training, which includes an informational area on tractor safety and driving a VR tractor down a prescribed course. You will be in this VR environment for approximately 15 minutes.

The second step, once you have completed the program you will be asked to complete a 15-minute survey on your experience. We want to know your perceptions of the VR experience related to usability and technology adoption.

There are no known risks to your participation in completing this questionnaire. Your participation is voluntary. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision to participate will not affect your future relationship in [current class]. There is no cost to you except your time. You may answer some or none of the questions. Your results will be kept confidential; your name will not be associated with your responses.

Additionally, if you would like to participate in an interview about your experience with the VR program a notecard will be included with the headset for you to provide your contact information.

If you are interested in participating in the study, please click on the link below to consent to the study and provide your mailing information for the headset.

[Insert Survey Link]

If you have any questions regarding the documents sent to you or the study [IRB #] in general, please contact me at pulley.25@osu.edu or Dee Jepsen at Jepsen.4@osu.edu.

Thank you very much for your participation with this important study.

Sincerely,

Justin Pulley,
Ph.D. Student

Appendix B. Student Recruitment Letter

Greetings Student Participant,

You are being sent this letter because you fall within the scope of a prospective research study being conducted by The Ohio State University on integration of virtual reality in tractor and machinery operation. We are developing a Virtual Reality (VR) training program to teach proper machinery operation procedures and safe practices. I am inviting you to participate in this voluntary study.

If you are interested in completing the study, please talk to your teacher to set up a time to consent and complete the research.

As a student being recruited for this study, if you agree to participate, we ask that you complete the steps below. The goal of this study is to gain insights from your experience on the usability and functionality of this VR program.

This is a two-step study, the first is utilizing an Oculus headset provided to you. Using this headset, you will complete the safety training, which includes an informational area on tractor safety and driving a VR tractor down a prescribed course. You will be in this VR environment for approximately 15 minutes.

The second step, once you have completed the program you will be asked to complete a 15-minute survey on your experience.

There are no known risks to your participation in completing this questionnaire. Your participation is voluntary. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision to participate will not affect your future relationship in [current class]. There is no cost to you except your time. You may answer some or none of the questions. Your results will be kept confidential; your name will not be associated with your responses.

If you have any questions regarding the documents sent to you or the study [IRB #] in general, please contact me at pulley.25@osu.edu or Dee Jepsen at Jepsen.4@osu.edu.

Thank you very much for your participation with this important study.

Sincerely,

Justin Pulley,
Ph.D. Student

Appendix C. Students' User Experience Survey

Question	Construct
The virtual environment was responsive to actions that I initiated.	Presence
My interactions with the virtual environment seemed natural.	Presence
The device that controlled my movement in the virtual environment seem natural.	Presence
I was able to actively survey the virtual environment.	Presence
I was able to examine objects closely.	Presence
I could examine objects from multiple viewpoints.	Presence
I felt proficient in moving and interacting with the virtual environment by the end of the experience.	Presence
The visual display quality distracted me from performing assigned tasks.	Presence
The device that controlled my movement distracted me from performing assigned tasks.	Presence
I could concentrate on the assigned tasks rather than on the device's controller.	Presence
I correctly identified sounds produced by the virtual environment.	Presence
I correctly localized sounds produced by the virtual environment.	Presence
The visual aspects of the environment involved me.	Engagement
The sense of moving around inside the virtual environment was compelling.	Engagement
I was involved in the virtual experience.	Engagement
I felt stimulated by the virtual environment.	Immersion
I became so involved in the virtual environment that I was not aware of things happening to me.	Immersion
I identified to the role I played in the virtual environment.	Immersion
I became so involved in the virtual environment that it was as if I was inside the course rather than manipulating a controller and watching a screen.	Immersion
I felt physically fit in the virtual environment.	Immersion
I got scared by something happening in the virtual environment.	Immersion
I became so involved in the virtual environment that I lost all track of time.	Immersion
I felt I could perfectly control my actions.	Flow

Continued

Continued

At each step, I knew what to do.	Flow
I felt I controlled the situation.	Flow
Time seemed to flow differently than usual.	Flow
Time seemed to speed up.	Flow
I was losing the sense of time.	Flow
I was not worried about other people's judgement.	Flow
I was not worried about what other people would think of me.	Flow
I felt I was experiencing an exciting moment.	Flow
This experience gave me a great sense of accomplishment.	Flow
When I think about the virtual experience, I have emotions that I would like to share.	Flow
I enjoyed the challenge of learning with the Oculus headset and controllers.	Emotion
The virtual environment scared me since I do not fully understand it.	Emotion
I enjoyed dealing with the Oculus headset and controllers.	Emotion
I feel confident understanding the terms/words relating to the Oculus headset and controllers.	Skill
I feel confident learning advanced skills within a specific virtual reality software using the oculus headset.	Skill
I feel confident describing the functions of the Oculus headset and controllers for use in a virtual reality environment.	Skill
I thought the Oculus headset and controllers were easy to use.	Usability
I thought there was too much inconsistency between training resources and the virtual environment.	Usability
I found the Oculus headset and controllers very cumbersome to use.	Usability
Personally, I would say the virtual environment is: Impractical or Practical	Judgement
Personally, I would say the virtual environment is: Confusing or Clear	Judgement
Personally, I would say the virtual environment is: Unruly or Manageable	Judgement
Personally, I would say the virtual environment is: Typical or Original	Judgement
Personally, I would say the virtual environment is: Lame or Exciting	Judgement
Personally, I would say the virtual environment is: Easy or Challenging	Judgement
Personally, I would say the virtual environment is: Amateurish or Professional	Judgement

Continued

Continued

Personally, I would say the virtual environment is: Unpresentable or Presentable	Judgement
Personally, I would say the virtual environment is: Disagreeable or Likeable	Judgement
I suffered from fatigue during my interaction with the virtual environment.	Experience Consequence
I suffered from a headache during my interaction with the virtual environment.	Experience Consequence
I suffered from eyestrain during my interaction with the Virtual environment.	Experience Consequence
I felt an increase of my salivation during my interaction with the virtual environment.	Experience Consequence
I felt an increase of my sweat during my interaction with the virtual environment.	Experience Consequence
I suffered from nausea during my interaction with the virtual environment.	Experience Consequence
My interaction with the virtual environment caused me to have a lot on my mind.	Experience Consequence
I suffered from dizziness with my eyes open during my interaction with the virtual environment.	Experience Consequence
I suffered from vertigo during my interaction with the virtual environment.	Experience Consequence
If I use the same virtual environment again, my interaction with the environment would be clear and understandable for me.	Technology Adoption
It would be easy for me to become skillful at using the virtual environment.	Technology Adoption
Learning to operate the virtual environment would be easy for me.	Technology Adoption
Using the Oculus headset and controllers is a bad idea.	Technology Adoption
The Oculus headset and controllers would make learning more interesting.	Technology Adoption
I would like learning with the Oculus headset and controllers.	Technology Adoption
I have the resources necessary to use the Oculus headset and controllers.	Technology Adoption

Appendix D. Students' User Experience Descriptive Data

Question	Number of responses per item	*M*	*SD*	Range
Q2 The virtual environment was responsive to actions that I initiated.	121	6.8	2.7	1-10
Q3 My interactions with the virtual environment seemed natural.	103	6.5	2.4	1-10
Q4 The device that controlled my movement in the virtual environment seem natural.	103	6.4	2.5	1-10
Q5 I was able to actively survey the virtual environment.	103	7.5	2.2	2-10
Q6 I was able to examine objects closely.	103	7.7	2.1	2-10
Q7 I could examine objects from multiple viewpoints.	103	7.7	2.3	1-10
Q8 I felt proficient in moving and interacting with the virtual environment by the end of the experience.	102	7.1	2.4	1-10
Q9 The visual display quality distracted me from performing assigned tasks.	102	6.3	2.7	1-10
Q10 The device that controlled my movement distracted me from performing assigned tasks.	101	6.5	3.0	1-10
Q11 I could concentrate on the assigned tasks rather than on the device's controller.	101	6.7	2.5	1-10

Continued

Continued

Q12 I correctly identified sounds produced by the virtual environment.	101	7.2	2.4	1-10
Q13 I correctly localized sounds produced by the virtual environment.	100	7.1	2.4	1-10
Q15 The visual aspects of the environment involved me.	116	6.6	2.5	1-10
Q16 The sense of moving around inside the virtual environment was compelling.	101	6.8	2.3	1-10
Q17 I was involved in the virtual experience.	100	8.0	2.1	2-10
Q19 I felt stimulated by the virtual environment.	115	6.5	2.6	1-10
Q20 I became so involved in the virtual environment that I was not aware of things happening to me.	99	6.2	2.7	1-10
Q21 I identified to the role I played in the virtual environment.	98	7.1	2.3	1-10
Q22 I became so involved in the virtual environment that it was as if I was inside the course rather than manipulating a controller and watching a screen.	98	6.4	2.8	1-10
Q23 I felt physically fit in the virtual environment.	96	6.5	2.5	1-10
Q24 I got scared by something happening in the virtual environment.	96	6.8	3.3	1-10
Q25 I became so involved in the virtual environment that I lost all track of time.	96	4.9	3.0	1-10
Q27 I felt I could perfectly control my actions.	115	6.1	2.9	1-10
Q28 At each step, I knew what to do.	101	5.6	2.5	1-10

Continued

Continued

Q29 I felt I controlled the situation.	99	6.3	2.5	1-10
Q30 Time seemed to flow differently than usual.	99	6.0	2.9	1-10
Q31 Time seemed to speed up.	99	5.3	2.8	1-10
Q32 I was losing the sense of time.	98	5.7	3.0	1-10
Q33 I was not worried about other people's judgement.	98	6.9	2.6	1-10
Q34 I was not worried about what other people would think of me.	97	6.9	2.7	1-10
Q35 I felt I was experiencing an exciting moment.	97	6.5	2.6	1-10
Q36 This experience gave me a great sense of accomplishment.	96	6.3	2.8	1-10
Q37 When I think about the virtual experience, I have emotions that I would like to share.	97	5.3	2.9	1-10
Q39 I enjoyed the challenge of learning with the Oculus headset and controllers.	108	6.8	2.8	1-10
Q40 The virtual environment scared me since I do not fully understand it.	96	6.6	3.0	1-10
Q41 I enjoyed dealing with the Oculus headset and controllers.	93	7.7	2.3	1-10
Q43 I feel confident understanding the terms/words relating to the Oculus headset and controllers.	110	6.7	2.7	1-10
Q44 I feel confident learning advanced skills within a specific virtual reality software using the oculus headset.	97	7.0	2.4	1-10

Continued

Continued

Q45 I feel confident describing the functions of the Oculus headset and controllers for use in a virtual reality environment.	96	7.0	2.5	1-10
Q47 I thought the Oculus headset and controllers were easy to use.	109	6.8	2.8	1-10
Q48 I thought there was too much inconsistency between training resources and the virtual environment.	97	5.6	2.5	1-10
Q49 I found the Oculus headset and controllers very cumbersome to use.	97	5.3	2.9	1-10
Q51_1 Personally, I would say the virtual environment is: Impractical or Practical	99	6.8	2.6	1-10
Q51_2 Personally, I would say the virtual environment is: Confusing or Clear	100	6.4	2.8	1-10
Q51_3 Personally, I would say the virtual environment is: Unruly or Manageable	97	7.1	2.5	1-10
Q51_4 Personally, I would say the virtual environment is: Typical or Original	97	6.8	2.6	1-10
Q51_5 Personally, I would say the virtual environment is: Lame or Exciting	97	7.1	2.7	1-10
Q51_6 Personally, I would say the virtual environment is: Easy or Challenging	101	6.3	2.9	1-10
Q51_7 Personally, I would say the virtual environment is: Amateurish or Professional	97	6.9	2.6	1-10
Q51_8 Personally, I would say the virtual environment is: Unpresentable or Presentable	96	7.5	2.4	1-10
Q51_9 Personally, I would say the virtual environment is: Disagreeable or Likeable	96	7.6	2.6	1-10

Continued

Continued

Q53 I suffered from fatigue during my interaction with the virtual environment.	106	7.4	2.8	1-10
Q54 I suffered from a headache during my interaction with the virtual environment.	94	7.3	2.8	1-10
Q55 I suffered from eyestrain during my interaction with the Virtual environment.	91	7.0	2.9	1-10
Q56 I felt an increase of my salivation during my interaction with the virtual environment.	90	8.0	2.6	1-10
Q57 I felt an increase of my sweat during my interaction with the virtual environment.	91	7.6	2.9	1-10
Q58 I suffered from nausea during my interaction with the virtual environment.	90	7.8	2.8	1-10
Q59 My interaction with the virtual environment caused me to have a lot on my mind.	90	7.9	2.6	1-10
Q60 I suffered from dizziness with my eyes open during my interaction with the virtual environment.	91	7.3	3.0	1-10
Q61 I suffered from vertigo during my interaction with the virtual environment.	90	8.0	2.6	1-10
Q63 If I use the same virtual environment again, my interaction with the environment would be clear and understandable for me.	105	6.8	2.70	1-10
Q64 It would be easy for me to become skillful at using the virtual environment.	92	7.4	2.4	1-10
Q65 Learning to operate the virtual environment would be easy for me.	92	7.0	2.4	1-10
Q66 Using the Oculus headset and controllers is a bad idea.	92	7.2	3.0	1-10

Continued

Continued

Q67 The Oculus headset and controllers would make learning more interesting.	92	7.6	2.4	1-10
Q68 I would like learning with the Oculus headset and controllers.	92	7.4	2.3	1-10
Q69 I have the resources necessary to use the Oculus headset and controllers.	92	7.4	2.3	1-10

Appendix E. Teachers' User Experience Survey

Question	Construct
The virtual environment was responsive to actions that I initiated.	Presence
My interactions with the virtual environment seemed natural.	Presence
The device that controlled my movement in the virtual environment seem natural.	Presence
I was able to actively survey the virtual environment.	Presence
I was able to examine objects closely.	Presence
I could examine objects from multiple viewpoints.	Presence
I felt proficient in moving and interacting with the virtual environment by the end of the experience.	Presence
The visual display quality distracted me from performing assigned tasks.	Presence
The device that controlled my movement distracted me from performing assigned tasks.	Presence
I could concentrate on the assigned tasks rather than on the device's controller.	Presence
I correctly identified sounds produced by the virtual environment.	Presence
I correctly localized sounds produced by the virtual environment.	Presence
The visual aspects of the environment involved me.	Engagement
The sense of moving around inside the virtual environment was compelling.	Engagement
I was involved in the virtual experience.	Engagement
I felt stimulated by the virtual environment.	Immersion
I became so involved in the virtual environment that I was not aware of things happening to me.	Immersion
I identified to the role I played in the virtual environment.	Immersion
I became so involved in the virtual environment that it was as if I was inside the course rather than manipulating a controller and watching a screen.	Immersion
I felt physically fit in the virtual environment.	Immersion
I got scared by something happening in the virtual environment.	Immersion
I became so involved in the virtual environment that I lost all track of time.	Immersion
I felt I could perfectly control my actions.	Flow

Continued

Continued

At each step, I knew what to do.	Flow
I felt I controlled the situation.	Flow
Time seemed to flow differently than usual.	Flow
Time seemed to speed up.	Flow
I was losing the sense of time.	Flow
I was not worried about other people's judgement.	Flow
I was not worried about what other people would think of me.	Flow
I felt I was experiencing an exciting moment.	Flow
This experience gave me a great sense of accomplishment.	Flow
When I think about the virtual experience, I have emotions that I would like to share.	Flow
I enjoyed the challenge of teaching with the Oculus headset and controllers.	Emotion
The virtual environment scared me since I do not fully understand it.	Emotion
I enjoyed dealing with the Oculus headset and controllers.	Emotion
I feel confident understanding the terms/words relating to the Oculus headset and controllers.	Skill
I feel confident learning advanced skills within a specific virtual reality software using the oculus headset.	Skill
I feel confident describing the functions of the Oculus headset and controllers for use in a virtual reality environment.	Skill
I thought the Oculus headset and controllers were easy to use.	Usability
I thought there was too much inconsistency between training resources and the virtual environment.	Usability
I found the Oculus headset and controllers very cumbersome to use.	Usability
Personally, I would say the virtual environment is: Impractical or Practical	Judgement
Personally, I would say the virtual environment is: Confusing or Clear	Judgement
Personally, I would say the virtual environment is: Unruly or Manageable	Judgement
Personally, I would say the virtual environment is: Typical or Original	Judgement
Personally, I would say the virtual environment is: Lame or Exciting	Judgement
Personally, I would say the virtual environment is: Easy or Challenging	Judgement
Personally, I would say the virtual environment is: Amateurish or Professional	Judgement

Continued

Continued

Personally, I would say the virtual environment is: Unpresentable or Presentable	Judgement
Personally, I would say the virtual environment is: Disagreeable or Likeable	Judgement
I suffered from fatigue during my interaction with the virtual environment.	Experience Consequence
I suffered from a headache during my interaction with the virtual environment.	Experience Consequence
I suffered from eyestrain during my interaction with the Virtual environment.	Experience Consequence
I felt an increase of my salivation during my interaction with the virtual environment.	Experience Consequence
I felt an increase of my sweat during my interaction with the virtual environment.	Experience Consequence
I suffered from nausea during my interaction with the virtual environment.	Experience Consequence
My interaction with the virtual environment caused me to have a lot on my mind.	Experience Consequence
I suffered from dizziness with my eyes open during my interaction with the virtual environment.	Experience Consequence
I suffered from vertigo during my interaction with the virtual environment.	Experience Consequence
If I use the same virtual environment again, my interaction with the environment would be clear and understandable for me.	Technology Adoption
It would be easy for me to become skillful at using the virtual environment.	Technology Adoption
Learning to operate the virtual environment would be easy for me.	Technology Adoption
Using the Oculus headset and controllers is a bad idea.	Technology Adoption
The Oculus headset and controllers would make teaching more interesting.	Technology Adoption
I would like teaching with the Oculus headset and controllers.	Technology Adoption
I have the resources necessary to use the Oculus headset and controllers.	Technology Adoption
I have the financial resources necessary to acquire the Oculus headset and controllers and virtual environment.	Technology Adoption
I have the knowledge necessary to use the Oculus headset and controllers.	Technology Adoption
	Continued

Continued

The Oculus headset and controllers are not compatible with other technologies I use.	Technology Adoption

Appendix F. Teachers' User Experience Descriptive Data

Question	Number of responses per item	*M*	*SD*	Range
Q2 The virtual environment was responsive to actions that I initiated.	12	7.2	2.0	3-10
Q3 My interactions with the virtual environment seemed natural.	9	7.1	2.2	4-10
Q4 The device that controlled my movement in the virtual environment seem natural.	9	7.5	1.8	5-10
Q5 I was able to actively survey the virtual environment.	9	8.3	1.8	5-10
Q6 I was able to examine objects closely.	9	8.0	2.6	3-10
Q7 I could examine objects from multiple viewpoints.	9	7.8	2.3	3-10
Q8 I felt proficient in moving and interacting with the virtual environment by the end of the experience.	9	6.6	2.0	4-10
Q9 The visual display quality distracted me from performing assigned tasks.	9	5.7	2.5	1-10
Q10 The device that controlled my movement distracted me from performing assigned tasks.	9	5.8	2.8	1-10
Q11 I could concentrate on the assigned tasks rather than on the device's controller.	9	7.0	1.6	5-10

Continued

Continued

Q12 I correctly identified sounds produced by the virtual environment.	9	7.8	2.6	4-10
Q13 I correctly localized sounds produced by the virtual environment.	9	7.5	2.2	4-10
Q15 The visual aspects of the environment involved me.	12	7.7	1.7	5-10
Q16 The sense of moving around inside the virtual environment was compelling.	9	7.8	1.6	5-10
Q17 I was involved in the virtual experience.	9	7.8	1.9	5-10
Q19 I felt stimulated by the virtual environment.	13	7.1	2.1	3-10
Q20 I became so involved in the virtual environment that I was not aware of things happening to me.	10	5.8	2.3	3-10
Q21 I identified to the role I played in the virtual environment.	10	7.3	1.8	4-10
Q22 I became so involved in the virtual environment that it was as if I was inside the course rather than manipulating a controller and watching a screen.	10	5.6	2.8	1-10
Q23 I felt physically fit in the virtual environment.	10	7.4	2.3	3-10
Q24 I got scared by something happening in the virtual environment.	10	6.9	3.5	1-10
Q25 I became so involved in the virtual environment that I lost all track of time.	10	5.6	2.7	1-10
Q27 I felt I could perfectly control my actions.	13	5.1	2.0	3-10
Q28 At each step, I knew what to do.	10	4.5	2.2	2-7

Continued

Continued

Q29 I felt I controlled the situation.	10	6.6	2.3	3-10
Q30 Time seemed to flow differently than usual.	10	5.6	2.7	1-9
Q31 Time seemed to speed up.	10	4.9	2.5	1-9
Q32 I was losing the sense of time.	10	3.6	2.0	1-7
Q33 I was not worried about other people's judgement.	10	7.0	1.8	4-10
Q34 I was not worried about what other people would think of me.	10	7.4	1.7	4-10
Q35 I felt I was experiencing an exciting moment.	10	7.2	2.0	4-10
Q36 This experience gave me a great sense of accomplishment.	10	5.8	1.9	2-8
Q37 When I think about the virtual experience, I have emotions that I would like to share.	10	4.8	1.3	2-7
Q39 I enjoyed the challenge of teaching with the Oculus headset and controllers.	13	6.8	2.0	3-10
Q40 The virtual environment scared me since I do not fully understand it.	10	6.9	2.2	4-10
Q41 I enjoyed dealing with the Oculus headset and controllers.	10	7.0	2.5	3-10
Q43 I feel confident understanding the terms/words relating to the Oculus headset and controllers.	13	6.0	1.9	3-9
Q44 I feel confident learning advanced skills within a specific virtual reality software using the oculus headset.	10	6.0	2.2	2-9

Continued

Continued

Q45 I feel confident describing the functions of the Oculus headset and controllers for use in a virtual reality environment.	10	5.7	2.2	2-9
Q47 I thought the Oculus headset and controllers were easy to use.	13	6.0	2.0	3-10
Q48 I thought there was too much inconsistency between training resources and the virtual environment.	10	6.1	1.9	2-9
Q49 I found the Oculus headset and controllers very cumbersome to use.	10	6.6	1.8	4-10
Q51_1 Personally, I would say the virtual environment is: Impractical or Practical	13	6.3	1.8	3-9
Q51_2 Personally, I would say the virtual environment is: Confusing or Clear	13	5.5	2.4	1-10
Q51_3 Personally, I would say the virtual environment is: Unruly or Manageable	13	6.1	2.6	1-10
Q51_4 Personally, I would say the virtual environment is: Typical or Original	13	7.0	1.8	5-10
Q51_5 Personally, I would say the virtual environment is: Lame or Exciting	13	6.9	2.2	3-10
Q51_6 Personally, I would say the virtual environment is: Easy or Challenging	13	6.4	2.2	3-10
Q51_7 Personally, I would say the virtual environment is: Amateurish or Professional	13	6.3	2.1	3-10
Q51_8 Personally, I would say the virtual environment is: Unpresentable or Presentable	13	6.7	2.1	3-10
Q51_9 Personally, I would say the virtual environment is: Disagreeable or Likeable	13	7.2	2.5	3-10

Continued

Continued

Q53 I suffered from fatigue during my interaction with the virtual environment.	13	7.0	2.8	1-10
Q54 I suffered from a headache during my interaction with the virtual environment.	9	6.7	3.4	1-10
Q55 I suffered from eyestrain during my interaction with the Virtual environment.	9	5.8	2.8	1-10
Q56 I felt an increase of my salivation during my interaction with the virtual environment.	9	8.3	2.6	2-10
Q57 I felt an increase of my sweat during my interaction with the virtual environment.	9	8.1	2.8	2-10
Q58 I suffered from nausea during my interaction with the virtual environment.	9	7.5	3.7	1-10
Q59 My interaction with the virtual environment caused me to have a lot on my mind.	9	7.6	3.0	1-10
Q60 I suffered from dizziness with my eyes open during my interaction with the virtual environment.	9	6.1	3.9	1-10
Q61 I suffered from vertigo during my interaction with the virtual environment.	9	7.7	3.1	1-10
Q63 If I use the same virtual environment again, my interaction with the environment would be clear and understandable for me.	12	7.0	2.5	2-10
Q64 It would be easy for me to become skillful at using the virtual environment.	10	7.1	2.0	5-10
Q65 Learning to operate the virtual environment would be easy for me.	10	7.0	1.7	4-10

Continued

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Q66 Using the Oculus headset and controllers is a bad idea.	10	9.1	1.1	7-10
Q67 The Oculus headset and controllers would make teaching more interesting.	10	7.4	2.0	3-10
Q68 I would like teaching with the Oculus headset and controllers.	10	7.1	2.3	2-10
Q69 I have the resources necessary to use the Oculus headset and controllers.	10	6.2	3.0	1-10
Q70 I have the financial resources necessary to acquire the Oculus headset and controllers and virtual environment.	10	3.3	2.4	1-8
Q71 I have the knowledge necessary to use the Oculus headset and controllers.	10	6.6	2.1	3-10
Q72 The Oculus headset and controllers are not compatible with other technologies I use.	10	7.1	1.5	5-10

Appendix G. Semi-Structured Interview Guide

The purpose of the interview to gauge teachers opinions of the VR program and to gather their perceptions of how realistic it is.
Each person will be asked the same question at the beginning of the interview:

- What were you perceptions about VR before you began this study?
- How did it feel to use this VR experience

From here, I will ask:

- On a scale of 1-10, how realistic was the program during your experience?
- Can you explain why you thought it was (number)?
- Can you describe your user experience (UX)?
- Ask them to describe each construct area
    - Probing and guiding questions will used get an accurate description of their experience.

Other questions that will be asked will be related to Usability and Technology Adoption.

- How likely are you to use this experience again?
- How easy was the headset to operate?
- Were the controls/actions in the experience confusing?

To wrap up the interview, I will ask:

- How has your perceptions of VR changed since using the experience?
- Can you explain any positives that you saw?
- What were some challenges that you experienced?