

An Evaluation of Ohio Agricultural Education Students' Performance and User Experience in a Virtual Reality Machinery Safety Experience

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Abstract

Agriculture is one of the most hazardous industries in the United States for all workers, and even more so for young workers. In the U.S., legislation prescribes training for youth under the age of 16 working in hazardous situations in production agriculture. Virtual Reality (VR) technology has become an increasingly popular means of deploying training for various disciplines. The purpose of this study was to determine the feasibility of a VR curriculum to provide a realistic and positive user experience for students in tractor and machinery safety operation lessons. The VR curriculum developed for the study was based on the National Safe Tractor and Machinery Operation Program. Ohio Agricultural Education students' (n = 132) user experience data were analyzed, and found students had a positive experience in the virtual reality training. Results indicated that students had a positive user experience from the VR experience. Performance data from agricultural education students resulted in poor scores during the precheck and driving course. Finally, two groups of students comparing traditional training versus training using the VR experience resulted in a non-significant difference between the pass/fail rates. The implications of these findings suggest VR can provide a supplemental training method for tractor and machinery programs. It is recommended that this study be replicated with a larger sample of students as well as the evaluation of other VR-based educational experiences.

Introduction and Literature Review

Youth Working in Agriculture

Agriculture is one of the most hazardous industries in the United States 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 (2020), approximately 15 children die from an agricultural event per 100,000 full-time equivalent workers (FTE), with 25% of all child-related deaths attributed to machinery (National Children's Center for Rural and Agricultural Health and Safety, 2019). Additionally,

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injuries in youth populations follow fatality rates where youth are 7.8 times more likely to be fatally injured on farms and ranches.

Youth working for hire and those living on a family farm have exposure to agricultural equipment. The Department of Labor states 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 educational resources be continuously developed and provided to young workers to improve their safety knowledge, enhance their skills, and overall increase their awareness of agricultural dangers; likewise, training resources directed toward agriculture teachers, parents, and supervisors of young workers should be readily available to adult trainers (Jepsen, 2011).

Safety Education

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 (Donham & Thelin, 2016). Research shows educators and students are unaware of basic farm safety information and where to find resources needed to stay informed (Rudolphi & Retallick, 2015; Whipp, 2018). For example, of 24 agriculture teachers surveyed, only 30% knew the farm tractor was the leading cause of occupational fatalities (May & Scofield, 2005). In another study of Iowa agriculture teachers, 52% indicated they were not knowledgeable about where to find agricultural safety and health resources and 60% did not believe they taught safety and health enough in class (Rudolphi & Retallick, 2015). Vincent et al. (2019) showed a significant difference in improved attitude, knowledge, and skills between the pre- and post-tests of high school students who participated in a cost-effective rollover protective structure curriculum. In safety education, it is important to provide an engaging and interactive curriculum to improve students’ safety knowledge and skills. The use of educational technology, such as virtual reality, could be a method to provide those engaging skills and knowledge.

Virtual Reality

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) are common types of computer technology programs based on artificial environments where users interact through their sights, sounds, and actions (Virtual Reality Society, 2017). VR uses a fully immersive environment and technology to engage the user in the experience. AR is the least immersive of the three and uses technology such as smartphones to overlay an environment that can be interacted with through a smartphone. Although AR may not be as immersive as the other three, it can provide more interactivity since there are more “real-world components” shown during experiences. MR 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. These technologies are options for teachers who wish to incorporate experiential learning and give students access to real experiences they might have the opportunity to participate in otherwise.

VR, AR, and MR have been studied some time; Johnson et al., (2010, p. 22) stated, “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” (p. 22). Lamb and Etopio (2019) found that a virtual experience for preservice teachers promoted learning from modeled real-life situations for the transfer of theory into practice. In another study, students were immersed in a virtual learning environment before the start of an online literacy course; through their experience, they reported positive perceptions and valued the use of the virtual environment (Domingo & Bradley, 2018). Liarokapis et al. (2004) demonstrated that AR can take complicated mechanisms and complex theories in higher education and make them accepted and understood by students. Positive experiences and applications have been reported in several educational settings, paving the way for VR to enter numerous disciplines as a training method.

Virtual Reality Training

VR has been used as an effective form of training across many industries, such as medicine, pedestrian safety, construction, manufacturing, military training programs, and preservice teacher preparation. In one study, experienced surgeons who had prior experience with VR training were much faster and used significantly less contrast fluid than the inexperienced group (Aggarwal et al., 2006). Another study on a VR training program used in the construction industry reported that workers who used the program showed a significant difference between pre- and post-tests in hazard identification and prevention (Sacks et al., 2013). Finally, the mining industry tested VR safety practices to reduce the number of equipment-related injuries. As a result, various simulators are available commercially, including dozers, draglines, haul trucks, shovels, and continuous miners (Tichon & Burgess-Limerick, 2009).

Agricultural machinery operation is yet another technical training program that VR could improve. One benefit of VR curricula is that it allows students to experience potentially hazardous and stressful situations in a safe, controlled environment. In this environment, students can learn the necessary skills needed to be successful in real experience without the danger of attempting trial and error in real experience. One safety education-based study showed that 3D VR was more effective than a lecture-only delivery method and equally comparable to a lecture in a physical laboratory (Nakayama, 2014). Using VR curricula in agricultural machinery operation training could, therefore, be used as a safer method to teach these concepts without the risks of a physical laboratory setting. With VR becoming more popular in other areas of education, this study will begin to bridge the gap in research on VR use in agricultural education.

Conceptual Framework

The User Experience (UX) model, developed by Tcha-Tokey et al. (2016), guided the design of this study. These components include Presence, Immersion, Engagement, Flow, Usability, Skill, Emotion, Judgement, Technology Adoption, and Experience Consequence. Each component influences the other directly or indirectly to establish the User Experience. This model combines the above ten independent components to create a personalized user experience with the technology (see Figure 1).

Figure 1

User Experience Framework Definitions

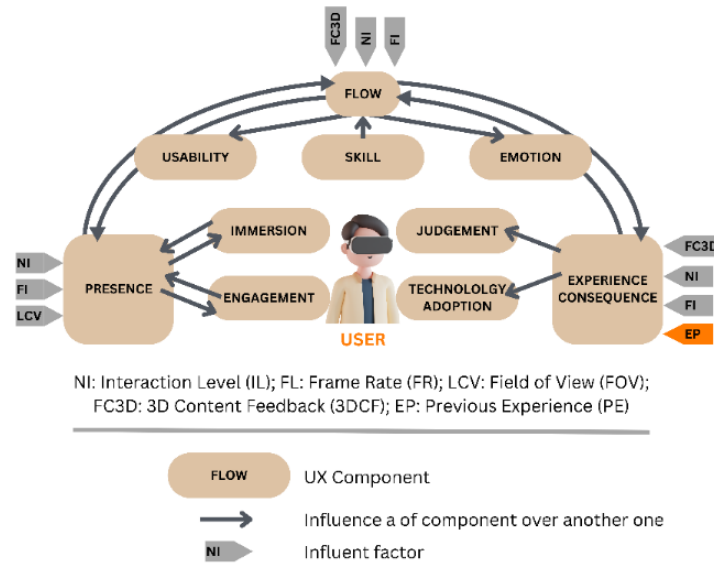
Construct	Definition	Source
Presence	Presence is the user’s sense of being in the virtual environment (VE).	Pallot et al., 2013
Engagement	Engagement is the energy in action, or the connection between a person and their activity, consisting of a behavioral, emotional, and cognitive form.	Witmer et al., 1998
Immersion	Immersion is defined as the “illusion;” the virtual environment technology replaces the user’s sensory stimuli with the virtual sensory stimuli.	Witmer et al., 1998

Flow	Flow indicates a pleasant psychological state of sense of control, fun, and joy that the user feels when interacting with the VE.	Heutte & Fenouille, 2010
Skill	Skill is the knowledge the user gains in mastering their activity in the virtual environment.	Murphy et al., 1989
Emotion	Emotion is the feelings of joy, pleasure, satisfaction, frustration, disappointment, and anxiety of the user in the VE.	Pekrun et al., 2011
Usability	Usability describes the ease of learning, as well as the ease of using the VE.	Brooke, 1996
Judgment	Judgment is the user's overall perceptions (clarity, originality, practicality, etc.) of the experience in the VE.	Hassenzahl et al., 2003
Experience Consequence (EC)	Experience Consequence comprises the symptoms or "simulator sickness," stress, dizziness, and headache the user can experience in the VE.	Kennedy et al., 1993
Technology Adoption (TA)	Technology Adoption includes the actions and decisions the user takes for future use, or intention to use, the VE	Venkatesh et al., 2003

The UX framework is a novel framework in agricultural education and has not been evaluated in the context of agricultural education-focused VR experiences before. This UX framework was used by Pulley et al. (2024) to guide semi-structured interview of school-based agricultural education (SBAE) teachers, but it has not been used to evaluate any experiences in agricultural education. The initial framework was developed and validated for an “edutainment immersive virtual environment (IVE)” (Tcha-Tokey et al., 2016). The IVE was a shooter-based experience and was validated with 116 individuals, with professions ranging from VR engineers to food service and public relations (Tcha-Tokey et al., 2016). Figure 2 graphically represents how each of the constructs are influenced by each other.

Figure 2

User Experience Framework



Based on the above diagram, at highest level of interactions Presence and Experience Consequence have two-way relationships with Flow; showing both Presence and EC can be affected by the flow of an experience. Within Presence, both Immersion and Engagement have two-way relationships with Presence, indicating the Presence can affect both Immersion and Engagement and vice versa. Flow directly affects both Usability and Emotion, but Skill directly influences the Flow. This means the flow of an experience can affect how usable an experience is as well as the positive/negative emotions of the user. The skill of the user can affect the flow of an experience, therefore indirectly influencing the usability and emotion of the user. In EC, this references the physical symptoms of the user in the VE, these symptoms can directly affect positive/negative judgement of the user’s experience and affect the likelihood of adoption.

This UX framework has been used to evaluate online systems used by different organizations (Yusof et al., 2022); to evaluate UX and risks of VR-based museum exhibits; and to evaluate mobile games specifically a mobile parkour game (Che et al., 2018). To connect this framework to this study, the User Experience framework will be used to evaluate secondary agricultural education students’ user experience as they work through a machinery safety VR experience. This experience is designed for students to work through safety and operational procedures related to machinery and tractor operation. This machinery safety experience will be compared against a traditional machinery and tractor safety curriculum.

Purpose and Research Objectives

The overarching purpose of this study was to determine if virtual reality provides 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 aligns with American Association for Agricultural Education’s (AAAE) core values, such as advancing public knowledge of AFNR systems and promoting personal responsibility and safety in AFNR systems (AAAE, 2023). This study used the following objectives:

1. Describe the user experience (UX) of Ohio secondary agricultural education students in the virtual reality machinery safety experience.
2. Describe program performance of Ohio secondary agricultural education students enrolled in a tractor and machinery course, using VR as a supplemental learning tool.
3. Describe the difference in Ohio secondary agricultural education students' pass/fail rate between a traditional tractor safety training and a tractor safety program with VR.

Methods

This quasi-experimental, descriptive study sought to evaluate the use of a VR-based educational experience. The experience was integrated into different secondary agricultural education programs and focused on collecting descriptive UX data and performance data from agricultural education students. Additionally, the VR-based experience was compared against traditional tractor operation training.

VR Experience

This tractor safety simulation was designed at The Ohio State University using the software services of Victory Enterprise, Inc. The VR experience operates on the Oculus Quest/Quest 2 VR headsets, two hand controllers, and a USB-C cable for connections to a computer. It was based on the operating skills and driving course within the National Safe Tractor and Machinery Operation Program (NSTMOP). The NSTMOP curriculum is one of several curricula teachers can use to teach tractor and machinery safety to qualify for the DOL certification. A content advisor and three Extension representatives with NSTMOP experience provided reviews during the development process. It was pilot-tested with 15 College of Agriculture students enrolled at The Ohio State University.

The VR experience was comprised of three areas: a safety content review, a skills test, and a driving course. The three areas were designed for the students to move freely between the skills and driving courses. The safety content review area was an unscored area of experience, available anytime. This component included a stationary tractor inside a barn where users could interact with "hot spots" on the tractor to review safety content related to NSTMOP content or their classroom curriculum. The skills testing area was outside of the barn. Here, a large stationary tractor and hay baler were available for students to interact with the power take-off (PTO), hydraulic connections, and implement hitch. The driving course was the center of the experience, between the review barn and the skills station. Users completed pre-operational checks, represented by questions from the specific pre-op check; if these were not completed or completed inaccurately, students received penalty points. Once the pre-checks were completed, users had to safely mount the tractor, fasten the seatbelt, start the tractor, engage the correct gear, and successfully drive the course. Points were accumulated if users brushed, struck, or knocked over an object or mounted the tractor incorrectly. The scoring of this experience required students to finish with a score as close to zero as possible, meaning no penalty points.

Population and Sample

Recruitment materials were sent to the entire base of 524 Ohio agriculture teachers in 2021. The recruitment materials contained the selection criteria which sought to identify teachers who taught machinery operation and safety as a part of their curriculum. To be qualified, teachers needed to have machinery operation and machinery safety included in their curricula. Licensed agriculture teachers are identified in the Department of Labor (DOL) legislation as qualified instructors to teach tractor and machinery safety. A volunteer sample of 20 teachers qualified and responded with interest in the study. These teachers then recruited 132 students from their courses to participate in the VR experience. Since the research team only had 10 headsets, a schedule was developed for deploying VR hardware to the programs based on the order of sign-up, location in the state, and proximity to other participating schools. Participating teachers had a two-week period, which coincided with when they taught their machinery

operation lesson, use the headset. A visit was made by a member of the research team to deliver the resources, which included an in-person training on the headset and experience. They were given personal and written instructions for setting up the headset, including locating the application and a tutorial on the experience. They also received a YouTube link to a 40-minute video of these instructions for later reference. The teachers were recommended to complete the VR program first, teach their machinery operation and safety curriculum next, and then introduce the experience to students in the class. The teachers were instructed to use the VR experiences with their machinery safety curriculum as supplemental learning activities.

Participants in Objective 3 were recruited from a single school in two different class periods, with 21 students in each class. As teachers volunteered for this study, they were asked if they were interested in evaluating the VR experience in a quasi-experimental design, one teacher responded with interest. Therefore, this teacher was purposively sampled from the 20 participating teachers above. This teacher held annual NSTMOP trainings for students in their Principles of Agriculture class, and had a reputation for conducting well led trainings. All students were in an 8th grade level Principles of Agriculture course. This teacher was given the same training as all of the previous teachers mentioned above.

Instrumentation, Data Collection and Analysis

Data for Objective 1 was collected via survey after students completed all the tasks in the VR program. The 79-item instrument consisted of 10 constructs extracted from previously published surveys, using 10-point Likert scales, with ranges from Strongly Disagree (1) to Strongly Agree (10). Table 1 outlines the original questionnaires and their authors for each construct.

Table 1

User Experience constructs by original authors and Cronbach alpha coefficients for original studies and tractor/machinery study

Component	Current Study 2022	Pilot Study in Spring 2021	Tcha-Tokey et al. 2016	Original Questionnaire	Original Authors
Component Cronbach Alphas for each Study					
Presence	.88	.92	0.75	0.88	Kennedy et al. 1993
Engagement	.85	.92	0.75		
Immersion	.85	.79	0.76	0.81	
Flow	.85	.89	0.82	0.84 – 0.86	Heutte et al. 2010
Usability	.39	.34	0.46	0.92	Lewis et al. 2009
Skill	.91	.97	0.82	0.95	Murphy et al. 1989
Emotion	.60	.53	0.71	0.78 – 0.93	Pekrun et al. 2011
Experience Consequence	.92	.92	0.90	0.71	Bailenson et al. 2006
Judgment	.93	.94	0.80	0.73 – 0.90	Hassenzahl et al. 2003
Technology Adoption	.90	.89	0.78	0.87 – 0.91	Venkatesh et al. 2003

The original instrument (Tcha-Tokey et al., 2016) 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. Table 1 also reported reliability coefficients from the original questionnaires, our pilot study, and our current study. Almost all constructs report acceptable alphas ranging from .85 to .93 (Devellis, 2021). Tcha-Tokey et al. (2016) reported a low alpha on the usability construct, which could be attributed to the low question count (3) of that construct. However, it was important to include this construct in the survey to assess the headset and program's usability.

For our study, post hoc reliability was used to test the reliability of each construct. Upon analysis, three constructs with low alphas were identified. Immersion initially reported an alpha of .32, but after removing two questions, reliability was raised to .85. Two other constructs, Emotion ($\alpha = .60$) and Usability ($\alpha = .39$), were removed due to having a low number of questions. All other constructs reported acceptable alphas ($\alpha > .80$) and were included in the summated User Experience score. Additional data collected for Objective 1 were analyzed using descriptive statistics.

Objective 1 sought to describe Ohio agricultural education students' scores on their perceptions of user experience. Once the students finished using the VR experience, they were given a QR code which led them to the survey. The UX survey recorded 132 student responses; 41.66% ($n = 55$) of students provided a usable data sample. Each question was scored on a scale of Strongly Disagree (1) to Strongly Agree (10), and negatively worded questions were reverse-coded for analysis. Data were analyzed using descriptive statistics to report mean, standard deviation, and range. Data for Objective 2 were collected after the student completed the program's driving course and retrieved through the saved score files on the headset once the headset was returned to the research team. 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 incorrectly (1 pt. each), and how many times a specific question was missed. Questions focused on oil, battery, coolant, fuel, tires, ROPS, hitch, and debris. For each question answered incorrectly or not answered at all, 1 point was added to their final score. Student performance data from Objective 2 were analyzed using descriptive statistics to describe the mean and standard deviation of their final score, questions missed, objects lightly touched, struck, and mounting or dismounting.

Data for Objective 3 were collected upon the students' completion of the program's driving course on the real tractor. Figure 3 outlines the implementation schedule followed by the teacher and students.

Figure 3

Virtual Reality Intervention Schedule

Week	Group with no VR Tasks	Class 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 working 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.	Students were to begin practicing driving a real tractor.
Week 4	Students drove the real tractor through the course for certification.	Students drove the real tractor through the course for certification.

Each teacher was provided access to the AgSafety4U online course to provide students with tractor safety content comparable to the NSTMOP curriculum. The researcher randomly chose the class to use the VR experience. Upon completing the online curriculum, students had one week to practice driving the certification course. The class that practiced with the VR experience also had one week to practice with the

experience before practicing on the real tractor. Finally, each class had one week to drive the certification course for pass/fail. Data were recorded as a pass/fail upon completion. A Chi-Square test was used to determine statistical differences between nominal and ordinal variables; once it was determined, assumptions were not met for a paired samples *t*-test to be calculated.

Results

Objective 1 sought to describe the UX of Ohio agricultural education students in the virtual reality program. Low and high categories for the UX mean were determined by the following breakdowns, 38.1% ($n = 21$) had scores below 6.00, 40% ($n = 22$) ranged between 6.00 and 7.90, and the remaining 21.8% ($n = 12$) had scores above 7.90. Therefore, constructs with a mean score above 7.90 were considered to be high, and constructs with a mean score lower than 6.00 were considered to be low. Of the 132 responses Table 2 shows the 41.60% ($n = 55$) of completed scores that make up the students' summated UX, rated on a scale of 1-10 for the whole experience, from Strongly Disagree (1) to Strongly Agree (10).

Table 2

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

Construct	Number of items	<i>M</i>	<i>SD</i>	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 two questions removed.

^[b] The Emotion and Usability construct was not included in the User Experience construct.

Students' reported User Experience was a 7.07 ($SD = 1.38$), indicating a positive user experience. The three highest (Technology Adoption, Emotion, and Experience Consequence) and lowest (Flow, Usability, and Immersion) scoring constructs are reported below. Students reported they enjoyed learning with and using the headsets ($M = 7.53$, $SD = 1.86$). Students also agreed they would want to use this experience again and think that it would make learning more interesting ($M = 7.51$, $SD = 1.84$). In Experience Consequence, a negative construct, students reported minimal minor experiences such as eye strain, headache, nausea, and dizziness ($M = 8.01$, $SD = 2.06$). Students slightly agreed the experience felt immersive ($M = 6.52$, $SD = 2.04$). Students also slightly agreed about how well the experience flowed ($M = 6.05$, $SD = 1.64$). They also slightly agreed about the usability of the Oculus headset and the experience ($M = 6.10$, $SD = 1.82$).

Objective 2 sought to describe how Ohio agricultural education students performed in the virtual reality experience. Of the 132 students participating 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	42.10		
Incorrect	12	31.58		
Not Answered	10	26.32		
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		
Did Not Use Handle	9	23.68		
Dismounting				
Used Handle	28	73.68		
Did Not Use Handle	10	26.32		
Action			<i>M</i>	<i>SD</i>
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, coolant, and hitching questions were the highest-scoring questions, with 71.05% ($n = 27$) answering correctly. The fuel question focused on what the letter was on top of the fuel cap stood for; the

coolant question focused on when coolant should be checked. The hitching question asked if implements could be hitched to other areas of the machine. The oil and ROPS questions were the lowest-scoring questions, with 42.11% ($n = 16$) answering correctly. The oil question focused on how often the oil should be checked, and the ROPS question focused on whether the seatbelt should be used with the ROPS. Additionally, students were required to explore around the tractor and move a crate before they drove; only 42.11% ($n = 16$) of the students moved the debris, while the majority, 57.89% ($n = 22$), did not.

Students were evaluated for using a handrail when mounting and dismounting the tractor. In the VR program, they could choose to select the handrail or tractor platform. When mounting the tractor, 76.32% ($n = 29$) of students used the handrail, and 23.68% ($n = 9$) did not. When dismounting, 73.68% ($n = 28$) used the handrail, and 26.32% ($n = 10$) did not use it. 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 portion of the experience. In the experience, a 0 is considered a perfect score.

Objective 3 sought to describe the difference between the two groups of students participating in the program. A non-significant difference was found between the two groups. Results of the Chi-Square test reported a non-significant ($\chi^2 = .55, p > .05$) score between students who passed and failed from both groups. 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 an 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. Table 4 outlines the results.

Table 4

Ohio Agricultural Education Students' Passing Rates and Chi-Square

Group	Frequency	Percent	Chi-Square	<i>p</i>
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%		

Conclusions, Implications, and Recommendations

The purpose of this study was to determine the effectiveness of a VR machinery safety experience, describe secondary agricultural education students' user experience, and describe the UX conceptual framework (Tcha-Tokey et al., 2016).

Students' User Experience from the VR Program.

Secondary agricultural education students had a mean score over neutral for every construct, concluding that the students' user experience was positive while acknowledging the removal of the two unreliable constructs. The results of the secondary agricultural education students align with research reporting positive user experiences in educational settings (Dirin, 2020; Tcha-Tokey et al., 2017). Currently, there have been several studies related to user experience and the use of VR experiences with students in agricultural education and agricultural mechanics courses at both the secondary and post-

secondary levels (Heibel et al., 2024; Pulley et al., 2024). This work contributes to these other studies by evaluating the use of VR in the agricultural education setting.

In other areas of education, Dirin (2020) developed a mobile VR application and reported changes in students' perceptions of the new technology through their user experience. A foundational VR study of Tcha-Tokey et al. (2017) found students showing a difference in pre- and post-test knowledge in an edutainment application while reporting a slightly positive experience. Acknowledging the removal of two constructs, Emotion and Usability, from the summated construct measurements in this study, our results imply that students had a positive user experience with the tractor and machinery VR program. These two constructs presented an issue due to both only having three questions in each construct. It is recommended to return to the original questionnaire where these questions were pulled and consider adding more question to the current questionnaire. Additionally, more work could be done to improve the usable sample size to improve reliability. The benefits of understanding students' user experiences will impact future work, targeting specific areas of concern that youth feel affect their learning experience.

Performance of Students in the VR Tractor Program

In this experience, students should score as close to zero as possible, meaning ultimate proficiency in operating a tractor with minimum errors. However, realizing the limitations, the sub-set of students using the technology received a high number of points and were, therefore, labeled as poor performers. This poor performance included many questions not answered by the students, which could be attributed to them not reading or following the instructions correctly. It was not assumed if a question went unanswered the student did not know, it was assumed they simply did not answer the question and skipped ahead to drive the tractor. It was also assumed that the students answered each question truthfully and did not guess. Additionally, a large limitation, many students from this sample simply did not save their scores to the headset as instructed. This could also be associated with the context in which the teacher presented the experience to the students, especially when it was offered as a supplemental assignment to their existing tractor safety course. Students may have simply not followed directions from the teacher as well. For these reasons, the research team believes the VR course was not presented with sufficient instructions for the students or taken seriously by the students beyond a gamified experience. This limitation could be addressed with future research around implementing VR technology into existing curricula. It is recommended to replicate this objective and provide more guided and hands-on instruction for completing the necessary steps of the experience.

Differences Between a Traditional Tractor Training and a Tractor Training with VR

The passing rates of the two groups completing the tractor operation program were evaluated, and found no significant difference between the two groups. Because both groups had the same number of students who failed the driving portion of the program, it can be concluded that there was no significant difference between the two groups' passing rates. It can also be concluded that the VR intervention had no statistically significant effect over the traditional training, meaning the VR intervention performed just as well as the traditional training in this instance. 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 and VR training, it can be implied that other variables could have affected students' performance. This should be replicated with an additional focus on identifying confounding variables. Additionally, there were no demographic data taken at the beginning of the experiment, which was a limitation. It is recommended to replicate this to determine if any demographic factors might affect the outcome.

In other areas of education, Ford et al., (2023) found significant differences between quasi-experimental when using VR to improve preservice teacher metacognitive awareness. Additionally, Michalski et al., (2022) found that VR improved real-world skills in people with disabilities and skill

transfer. While VR has not shown significant differences between groups of students in agricultural education courses, 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 and the desire of students to perform a real scenario; this is corroborated by two teachers who reported that some students would rather be doing the actual activity instead of a VR version of it (Pulley et al., 2024). The lack of structure and resources could also describe the absence of differences between our two groups. While no significant differences were found between the groups, it implies that the VR intervention was just as effective as the traditional training without the VR intervention in this instance.

The implications of these findings are important because they confirm the VR experience could provide supplemental practice to the training. Therefore, the impact educational VR experiences could have on the domain for students and teachers would benefit agricultural education and other areas. Based on previous research, it can be implied that internal and external factors, such as missed class days and weather delays, impeded students' performance in the VR experience in this current study (Pulley et al., 2024). Additional evaluation is needed to more accurately assess factors affecting student performance and teachers' interest in using the VR program beyond an informal learning tool. How teachers present this experience could have implications for other virtual experiences. Some of the performances could be attributed to students not taking the VR experience seriously, which was observed by Pulley et al., (2024). While students completed the program differently, they completed it as intended. These findings have important implications for the broader domain of agricultural education. As different components of education move to a virtual format, it will be important to address how these students perform and what factors are affecting their performance.

Currently, VR-integrated welding training has shown promise in creating a positive knowledge transfer from the training to real-life activities (Stone et al., 2013). Wells and Miller (2020) found that of 101 university agricultural sciences students, the ones who participated in 100% VR welding training held the highest mean score among the welding training groups. In other areas of education, McGovern et al. (2020) found that 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 than 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 improved laboratory safety and confidence.

Additional studies document user performance is needed before comparisons can be made between the tractor simulator user experience and other VR-simulated environments. Getting a better score is not necessarily the goal of all students; it is possible that other factors, including personal goals, cognitive styles, and computer attitudes, may affect performance instead (Lee et al., 2010; McGill & Klobas, 2009).

Summary

The results highlight usefulness of the VR tractor experience and its potential integration with other trainings. It is also recommended that more training be done with students' teachers so they may become more familiar with VR technology. This additional training will aid both groups as VR becomes more commonplace in the educational setting. The researchers acknowledge that this new VR experience was not designed to replace the in-person driving component. It was developed to complement the in-person or remote learning format. As the novelty of VR training programs becomes more commonplace in the agricultural education classroom, there is potential for new vocational tools to enhance student performance. This study will begin to bridge the gap in the literature for VR integration for agricultural applications.

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