Research Article

ISSN 2770-2928

International Journal of Agriculture and Technology

Reducing Beginning Welders' Anxiety by Integrating Virtual Reality Simulations

Byrd Preston[1*], Stone Richard T[2] and Anderson Ryan[3]

[1]*Assistant Professor, Department of Agricultural Education and Communications, Abraham Baldwin Agricultural College, Tifton, Georgia.*

[2]*Associate Professor, Industrial & Manufacturing Systems Engineering, Iowa State University, Ames, Iowa, USA.*

[3]*Associate Professor, Agricultural and Mechanics Education, Texas State University, San Marcos, Texas, USA.*

[*]Correspondence:
Preston Byrd, Department of Agricultural Education & Communication, 2802 Moore Hwy 134A Environmental Horticulture Building, Tifton, Georgia, Tel: 229-391-5256.

Received: 30 Dec 2024; **Accepted:** 22 Jan 2025; **Published:** 31 Jan 2025

Citation: Byrd Preston, Stone Richard T, and Anderson Ryan. Reducing Beginning Welders' Anxiety by Integrating Virtual Reality Simulations. Int J Agriculture Technology. 2025; 5(1): 1-8.

ABSTRACT

This study examined the use of virtual reality to reduce the anxiety of beginning welders. With the multiple safety concerns related to the welding profession, numerous triggers of anxiety were present. This study utilized VRTEX® virtual reality welding simulators to examine if virtual reality could reduce anxiety in welders. Researchers recorded anxiety related measures by utilizing a BioHarness® data logger and telemetry physiology monitoring system. The collected measures included heart rate, respiration rate, body temperature, and pulse. Participants were recorded during the completion of test welds to help identify triggers of anxiety during the welding process. It was concluded that all participants experienced anxiety during the completion of test welds which affected the ability to produce a passing weldment. This implies that if industry can reduce the anxiety trainees would experience during the training program and testing process, it may lead to a higher percentage of individuals obtaining welding certifications. With the release of an augmented reality training system which provides feedback for beginning welders during the actual welding process in real-life, future research needs to be conducted to see the effect it has on a beginning welder's anxiety level.

Keywords
Anxiety, Beginning welders, Virtual reality, BioHarness.

Introduction

Agricultural mechanics courses have been a popular course in secondary education for many years and continue to be [1-3]. Hubert and Leising reported over 60% of school-based agricultural education teachers across the U.S. teach agricultural mechanics [4]. One of the reasons that agricultural mechanics draws so much interest is the substantive amount of time spent in an agricultural mechanics laboratory learning hands-on skills [5]. The incorporation of laboratory-based experiences allows opportunities for students to engage in scientific inquiry and STEM based projects [6,7]. Incorporating laboratory-based experiences for students requires teachers to become more attentive to student safety concerns. Agricultural mechanics laboratories are an inherently dangerous learning laboratory because of the age and experience level of the learners being introduced to the operation of power mechanics machinery [8,9]. Since students tend to live in a risk-taking world with a disregard to rules, they are more apt not to know and understand the consequences of unsafe behaviors and are susceptible to injuries in an agricultural mechanics laboratory [5].

The safety of the students is the most important of all the jobs that a laboratory teacher performs and this responsibility to ensure a safe learning environment within agricultural mechanics laboratories is given to the career and technical education teachers [8,10,11]. Talbert et al., posited that laboratory management and student safety is a larger concern for career and technical education teachers than academic teachers [12]. With ill-prepared teachers, anxiety in teaching proper laboratory safety concepts may arise. This in turn could negatively affect students' safety behaviors through transference of anxious behavior of their teacher because the safety attitudes learned by students are related to the safety attitudes of their instructor [8,13,14].

There are numerous places throughout an agricultural mechanics laboratory that one could get injured because of learned anxious behaviors from their teacher. One such place that learned anxious behaviors could lead to injury is in a welding booth. When learning to weld there are several safety concerns to consider to stay safe. Some of the safety related issues include potential exposure to electrical shock, compressed gases, air contamination, fire, explosion, and arc radiation [15,16]. With the different types of safety issues related to welding those individuals who are beginning welders may exhibit more anxiety related symptoms.

In trying to reduce anxiety in beginning welders, it is necessary to understand, "what is anxiety?" describes anxiety as a tense and unsettling anticipation of a threatening event, which has a negative effect on a person [17]. Within the welding booth there is always the possibility of getting injured if safety precautions are not followed. This puts an individual in a state of heightened vigilance which causes an uneasy tension where the cause is not readily identifiable [17].

One suggested method that may lead to reduced anxiety in beginning welders is the integration of virtual reality simulations [18]. Virtual reality environments can be used to train workers to acquire the basic skills necessary to perform the tasks required for a job in a technical field [19]. The utilization of virtual reality simulations allows trainees to learn basic skills within a safe environment [20-23]. Multiple studies have found that full and partial virtual reality integration into a welding training program were appropriate, depending on the level of task difficulty [24-26]. Heibel at al., identified three benefits to virtual reality welding including a safe environment, personalized feedback and costs savings, but did not identify participant anxiety [27]. Would the introduction of virtual reality into a welding training program lead to the reduction of anxiety exhibited by inexperienced individuals?

Conceptual Framework

The conceptual framework that drove this study was the test anxiety model by Lowe et al. [28]. This model was originally used to examine test anxiety in secondary students, however this study sought to examine the anxiety of performing a weld test at the end of a training program which is a very similar context. The test anxiety model begins with the social environment that the individual is in which would include influences from society, community, family, and school [28]. Followed by the variables that occur within an individual such as intelligence, trait anxiety, social-emotional functioning, study skills, academic ability, and academic self-efficacy [28]. Previous research has shown that each of these areas affect an individual's ability in taking tests [29-34]. The level of anxiety experienced is often due to the perceived level of negative outcomes by the individual [28,35]. During a test, there are several areas of distraction that can occur within an individual that affect behavior, cognition, and physiology [28]. Behaviorally, the individual has to determine to focus on task relevant and irrelevant behaviors to do well on a test. Cognitively, the amount of worry that is dealt with can be detrimental, such as fear of failure. Physiologically, changes in heart rate, breathing rate, and sweaty palms can occur in an individual. After the test, test anxiety can further affect the individual by receiving an immediate appraisal of test performance and the final grade [28,36]. In this study, participants are attempting to pass an American Welding Society welding examination to receive a welding certification.

Purpose and Objectives

The purpose of this study was to examine the effect of virtual reality on anxiety in beginning welders in a welding training program. The insight gained relating to how anxiety affects beginning welders can benefit welding training programs as well as any educational setting that teaches welding-based skills such as career and technical education programs. This research aligns with the National Career and Technical Education research agenda objective 3.2.1 Innovative Instructional Technologies by providing technology to assess and possibly reduce anxiety levels in the participants [37]. This study also aligns with research objective 4.1.5 Technical Skill Assessment because the study examined whether participants could produce a passing test weldment [37]. This study aligns to the National Research Agenda Priority Area Two: New technologies, practices, and products adoption decisions [38]. Specifically relating to improving safety in the workplace by the adoption of an innovation. This study aligns with the American Association for Agricultural Education's National Research Value: Increasing Prosperity through innovation in Agricultural, Food, and Natural Resource Systems by connecting STEM content aligned to agricultural mechanics curriculum [39]. The following objectives were identified to address the purposes of this study.

1. Describe the average welding program trainees' level of anxiety in terms of anxiety index scores.
2. Examine the pass/fail rating of visual inspection of test welds performed by participants.
3. Determine if a relationship exists between participants' level of anxiety and the visual inspection pass/fail rating.
4. Examine the number of instances participants exhibited anxiety in terms of ECG heart rate spikes.
5. Determine if a relationship exists between participant's anxiety and the visual inspection pass/fail rating.
6. Identify the triggers of anxiety experienced by participants during the completion of test welds.

Methodology

This study is a small portion of a larger study that utilized a virtual reality integrated welding school and real-world welding school. The welding schools were hosted at the agricultural mechanics laboratory located on the [UNIVERSITY] Farm. The real-world welding school was overseen by a certified welding instructor (CWI) during this study. The virtual reality school was overseen by the researchers. The materials stocked for the real-world welding school included welding jackets, gloves, slag hammers, wire brushes, auto-darkening welding helmets, Miniflex® Portable weld fume control units, and Power Wave® C300 multi-purpose welders. The consumable material used included 3/8-inch-thick by eight-inch-long coupons (groove weldments), 1/2-inch-thick by eight-inch-long coupons (Tee weldments), and Excalibur® 7018 electrodes conditioned in an electrode oven.

The virtual reality welding school was supervised by the researchers who were extensively trained to use the VRTEX® Virtual Reality Arc Welding Trainers. The virtual reality welding school was equipped with five VRTEX® Virtual Reality Arc Welding Trainers with shielded metal arc welding (SMAW) stingers, helmet, and plastic coupons. This trainer was chosen because it was the highest fidelity virtual reality simulator currently available [40]. his virtual reality simulator allows users to be fully immersed in a 3D virtual reality welding environment. For the virtual training, users wore a welding helmet with integrated stereoscopic virtual reality screens and used dynamic visual feedback, in the form of visual overlays, for known welding variables such as travel speed, position, travel angle, work angle, and arc length. The beginning welders also wore welding gloves and jackets to help further simulate the real world feel of welding.

Participants

Before any training took place, participants were given an informed consent form. Based on the recommendations of Moore, et al., we selected 20 male participants and three female participants to be randomly assigned to either the integrated training (15 participants) or the Virtual Reality (VR) training (eight participants) [41]. The number of participants were initially limited to having a student to CWI ratio that was representative to a real-world welding training program, which generally do not exceed 12 students at a time. The amount of experience of the participants was not known until after participants were grouped to create true random samples. After they were grouped their level of welding experience was identified. Participants fell into two groups based on experience. The first group (n =20, 87%) had little to no practical experience in SMAW prior to the beginning of the study. This would be similar to someone that had tried welding in the past or a hobby welder that might use a welder once or twice a year. The second group (n = 3, 13%) had practical experience in SMAW. Participants with practical experience either teach welding or weld on a regular basis, but do not hold any welding certifications.

Participants chose to complete either a one- or two-week welding training program. In the one-week training program, participants were taught how to SMAW the 2F (horizontal fillet weld) and 1G (flat groove weld) welds. The two-week training program additionally taught the 3F (vertical fillet weld) and 3G (vertical groove weld) welds. All participants completed the one-week training (n = 23) and 15 individuals completed the two-week training.

The three groups that participants were randomly assigned into multiple training programs including: 100% virtual reality training; 75% virtual reality and 25% real-world training; and 50% virtual reality and 50% real-world training. The 75% virtual reality and 25% real-world training group only had a one-week training program. This group was added at the behest of the industry sponsor to compare data to previously completed research. The participants received safety training before entering the welding environment. Within the VR training room, participants received instruction from the researchers on how to use the VRTEX® Virtual Reality Arc Welding Trainers. Participants worked in groups of three or four per VRTEX® Virtual Reality Arc Welding Trainer. In the real-world training, participants had individual welding booths but were allowed to work together if they desired. Prior to using the actual welders, the participants received instruction from the CWI on how to use the Power Wave® C300 multi-purpose welders and were provided feedback during the training program.

The schedule for the weld training program were as follows: Monday through Thursday was practice time and Friday was testing day. The only exception to this schedule was the 100% virtual reality group. The 100% virtual reality group received real-world training on Thursday afternoon to acclimate to real-world welding so that participants could perform the test welds on Friday. All test welds were visually inspected by the CWI following American Welding Society (AWS) D1.1 code. To assess anxiety levels, participants filled out the Zung self-rated anxiety scale (SAS) and electrocardiogram (EKG or ECG) readings were recorded [42]. The Zung SAS was used to measure the participants' level of anxiety [42]. This instrument was administered the first day before the weld training began. The Zung SAS is a survey instrument that utilized 20 statements that addressed how an individual might feel when anxious [42]. The participants rated each statement on a four-point summated rated scale consisting of none or a little of the time, some of the time, good part of the time, or most of the time [42]. The responses given were then converted into a point system between one through four. The points were then added together giving an overall raw score. The raw score was then converted into an anxiety index. The anxiety index ranges from 25 to 100. Zung recommended the following clinical interpretation for the anxiety index: 25 - 45 = normal range; 45 – 59 = minimal to moderate anxiety; 60 – 74 = marked to severe anxiety; and 75 - 100 = extreme anxiety [42]. This interpretation was used to describe participants' level of anxiety. The established Cronbach's alpha for self-rated anxiety scale (SAS) is $\alpha = 0.85$ [43].

The ECG measurements collected included blood pressure, respiration rate, temperature, and pulse rate. Heart rate was utilized due to prior research that linked heart rate to anxiety [44]. To obtain these data points or variables, participants used a BioHarness® system. The BioHarness® is a chest strap that has two sensors and a removable transmitter/logger-built in. Data was streamed live to a laptop computer and logged on the transmitter/logger. To accurately identify periods of anxiety, a basal reading was taken for all participants while standing at rest. The basal reading was taken in a standing position because the real-world welding stations required participants to stand while welding. The basal reading was compared to the ECG measurements recorded during the participants test welds to identify moments of anxiety, specifically utilizing an individual's heart rate. The participants were also video recorded as they welded their certification test plates via a closed-circuit camera system. The recordings of the participants' test welds were utilized to help identify the cause(s) of anxiety when present. Researchers utilized the ECG readings to identify the time of anxiety and then viewed the recorded footage of the welding process to identify the trigger of the anxiety. The data was analyzed using Microsoft Excel 2010 and Predictive Analytics SoftWare (PASW) Statistics 18 software package. Descriptive statistics were calculated to identify frequencies for pass/fail rates and dexterity percentile rankings. A bivariate correlation was calculated to examine the relationship between participants' level of anxiety and visual pass/fail rates. With a numerical variable and a dichotomous variable utilizing the bivariate correlation calculation is needed to evaluate the relationship between the variables [45]. Researchers utilized the r squared (r^2) statistic to examine the effect size of the bivariate correlation. To evaluate the effect size of a bivariate correlation Gravetter and Wallnau indicated that r^2 should be used [45].

Results

This study sought to describe the effect of virtual reality on anxiety of individuals participating in the different welding training treatment groups. The intent of objective one was to describe the participants' level of anxiety as measured with the Zung SAS instrument [42]. The results are shown in Table 1. Out of the 23 participants in the study, only two participants exhibited a level of anxiety in the range of minimal to moderate. The other 21 participants fell into the normal range of anxiety susceptibility. The two participants that had the higher level of anxiety were in the 75 percent virtual reality to 25 percent traditional and 100 percent virtual reality treatment groups.

Table 1: Anxiety Level of Participants by Welding Training Program.

Program Type	*n*	%
Overall		
Normal	21	91.3
Minimal - Moderate	2	8.7
50/50 VR/Trad.[a]		
Normal	4	100.0
Minimal - Moderate	0	0.0
100 VR[a]		
Normal	4	100.0
Minimal - Moderate	0	0.0
50/50 VR/Trad.[b]		
Normal	6	100.0
Minimal - Moderate	0	0.0
75/25 VR/Trad.[b]		
Normal	4	80.0
Minimal - Moderate	1	20.0
100 VR[b]		
Normal	3	75.0
Minimal - Moderate	1	25.0

Note: VR = virtual reality, Trad. = Traditional

[a]One week training program; [b]Two week training program.

Objective two sought to describe participants' visual inspection pass/fail rate of completed test welds. The visual inspection pass/fail results are shown in Table 2. The participants in this study had an even pass/fail rate (n = 38, 50.0%) of the 76 test welds completed. Only two welding training programs visually failed a majority of the test welds. The two training programs were the one-week 50 percent virtual reality to 50 percent traditional and two-week 50 percent virtual reality to 50 percent traditional treatment groups. The program that exhibited the highest percentage of test welds that failed inspection (n = 7, 87.5%) was the one-week 50 percent virtual reality to 50 percent traditional training treatment group. When examining the pass/fail rates by weld type, the participants visually passed more of the simple welds (2F and 1G, 56.5%) than the complex welds (3F and 3G, 43.5%).

Table 2: Visual Inspection Pass/Fail Rates of Participants' Test Welds by Program Type.

Program Type	*n*	Pass *f* (%)	Fail *f* (%)
Overall	76	38 (50.0)	38 (50.0)
50/50 VR/Trad.[a]	8	1 (12.5)	7 (87.5)
100 VR[a]	8	6 (75.0)	2 (25.0)
50/50 VR/Trad.[b]	24	10 (41.7)	14 (58.33)
75/25 VR/Trad.[b]	20	11 (55.0)	9 (45.0)
100 VR[b]	16	10 (62.5)	6 (37.5)

Note: VR = virtual reality, Trad. = traditional

[a]One week training program; [b]Two week training program.

The relationship between the visual pass/fail rate and participants' level of anxiety was examined for objective three. To determine if any relationship existed between the two variables a bivariate correlation was calculated. The results of the bivariate correlation can be seen in Table 3. The results showed no statistical significance between the average participant susceptibility of anxiety and visual inspection pass/fail rate for any test weld type.

Table 3: Bivariate Correlation of Average Participants' Susceptibility of Anxiety and Visual Inspection Pass/Fail Rates by Weld Type.

SMAW Weld Type	*n*	*r*	*p*
2F	23	-0.271	0.212
1G	23	-0.131	0.551
3F	15	0.207	0.459
3G	15	-0.026	0.926

Researchers sought to examine the number of times participants exhibited anxiety during the completion of test welds for objective four. To determine the number of instances that participants exhibited anxiety researchers utilized the ECG readings and counted the number of spikes in heart rate above the initial basal readings for participants. When examining the one-week training session, the 100 percent VR group on average experienced anxiety more than the 50 percent virtual reality to 50 percent traditional treatment group. The same trend was seen within the two-week training program. Also in the two-week training programs, the average number of times anxiety that was experienced decreased between the welding positions. This trend was seen in all three variations of training programs in varying degrees. Table 4 displays the average number of instances anxiety occurred by training group and by welding position.

Table 4: Average number of instances Anxiety Occurred by Training Group and Welding Position.

Training Program	Flat Position n(M)	Vertical Position n(M)	Overall n(M)
50/50 VR/Trad.[a]	34 (8.5)	-	34 (8.5)
100 VR[a]	33 (11)	-	33 (11)
50/50 VR/Trad.[b]	39 (6.5)	32 (6.4)	71 (11.8)
75/25 VR/Trad.[b]	39 (7.8)	28 (5.6)	67 (13.4)
100 VR[b]	33 (8.25)	26 (6.5)	59 (14.75)

Note: VR = virtual reality, Trad. = traditional

[a]One week training program; [b]Two week training program.

In objective five, the researchers analyzed data to determine if a relationship existed between participant anxiety, in terms of heart rate and breathing rate, to the visual inspection pass/fail rate. A bivariate correlation was calculated to determine if any relationships exist. The significant results are showed in Table 5. Not all the weld types showed a statistically significant relationship with the overall anxiety measures of heart rate and breathing rate. The 3F – SMAW weld type indicated statistical significance with the minimum heart rate ($r = .736$, $p < .01$) and average heart rate ($r = .750$, $p < .01$) on test day of week 1. Also, the 3F – SMAW weld shown a significant relationship with the maximum heart rate ($r = .770$, $p < .01$) during test day during week two. The other welds that the bivariate correlation indicated a statistical relationship with heart rate or breathing rate included the 2F and 3G in SMAW and 1G, 3F, and 3G in GMAW. When examining the magnitude of the relationships indicated between participant anxiety measures and weld types, Gravetter and Wallnau indicated that r^2 should be used. The results of the r^2 calculations can be seen in Table 6 [45]. Gravetter and Wallnau suggested the following scale when interpreting the r^2 statistic: 0.01 = small effect; 0.09 = medium effect; 0.25 = large effect [45]. The 2F – SMAW weld type and the maximum breathing rate on test day of week one was the only relationship to display a medium effect size. The other significant relationships display a large to very large effect size.

Table 5: Bivariate Correlation (r) and Effect Size (r^2) of relationships between Participant Anxiety Measures and Visual Inspection Pass/Fail Rates.

Weld Type/ Anxiety measure	2F-SMAW $r(r^2)$	3F-SMAW $r(r^2)$	3G-SMAW $r(r^2)$
Week 1			
HR – Min	-.129 (0.016)	.736** (0.541)	.137 (0.018)
HR – Max	-.497* (0.247)	.160 (0.025)	-.245 (0.060)
HR – Avg	-.023 (0.000)	.750** (0.562)	.510 (0.260)
BR – Min	.261 (0.068)	.477 (0.227)	.511 (0.261)
BR – Max	-.446* (.198)	.-.355 (0.126)	-.442 (0.195)
Week 2			
HR – Max	.198 (0.039)	.770** (0.592)	.555 (0.308)
BR – Min	.496 (0.246)	.164 (0.026)	-.253 (0.064)
BR – Max	-.562* (.315)	-.264 (0.069)	-.626* (.391)

Note: $r(r^2)$, **$p < .01$, *$p < .05$. HR = Heart rate, BR = Breathing rate.

To examine if the training program type had an effect on the relationship between anxiety measures and the visual inspection pass/fail rates, the data was separated by training program types. The 3F – SMAW weld type had statistical relationships with five anxiety related measures. When examining the weld types, the four complex welds all had statistically significant relationships with anxiety related measures. The two-week 50 percent virtual reality to 50 percent traditional treatment group revealed the largest number of statistically significant relationships. Whereas the one-week 100 percent virtual reality treatment group shown no statistically significant relationships. Following the suggestions by Gravetter and Wallnau (2009) all the relationships found had a large effect size. To further examine the relationship between participant anxiety and the visual inspection pass/fail rate, a bivariate correlation was calculated between the average number of instances participants experienced anxiety and the visual inspection pass/fail rate. Only two instances of statistical significance were found. The two weld types that showed statistical significance were the 2F ($r = .448$, $p = .036$) and 3F ($r = .530$, $p = .042$). When examining the magnitude of the relationships, anxiety exhibited a medium effect on the 2F ($r^2 = 0.20$) and a large effect on the 3F ($r^2 = 0.28$) weld types.

Objective six sought to identify triggers of anxiety during the completion of test welds. Moments of anxiety were identified by using an individual's basal ECG reading and comparing that to the ECG readings during the individuals test weld. Time stamps were used to pinpoint the moment during the participant's test weld video recordings to identify what may have caused an individual's anxiety.

The following results were present during all the training program variations within this study. In the flat position test welds, moments of anxiety were present at various times during the welding process such as before starting the weld, starting the weld, during the weld, completing the weld, and after the weld has been completed. Several participants revealed anxiety while setting up their weldments in preparation of beginning the welding process. This was identified by participants practicing the psychomotor skills needed prior to striking an arc and shuffling the weldment around trying to get in a better position to perform the weld. Multiple participants revealed anxiety at the start of the weld. Identified anxiety triggers at the beginning of a weld included the electrode sticking while trying to establish an arc or an arc not being established while striking the electrode.

Several participants experienced anxiety during the welding process. The anxiety triggers that were identified included moments when the participants realized they were either at the wrong travel/work angles or out of position with the bead. These indicators were identifiable by the participants shifting their hands and body position to correct themselves. Another anxiety trigger identified occurred when stopping a weld and trying to start it back. Finishing out a weld properly was another instance when participants exhibited anxiety. Several participants' anxiety was triggered once they realized they did not completely finish out a weld or realized the quality of the weld was unacceptable. Failure to properly finish out a weld refers to participants running out of an electrode prior to reaching the end of a weldment. The most common time that participants' anxiety was triggered was after a weld was completed. After completing a weld, all participants had to chip away the slag covering left by the flux and clean the weld with a wire brush. Anxiety was identified in most participants during the chipping and cleaning phase after a weld. The identification of triggers in several cases were impossible to identify due to the participants blocking the view of the camera.

Conclusions and Discussion

Several conclusions can be drawn from the results of this study. First, participants' susceptibility to anxiety is normal, but everyone experienced anxiety during the completion of test welds. Pflanz and Heidel postulated that anxiety could have a negative effect on job performance [46]. The pass/fail rate of the test welds reinforced the notion of Pflanz and Heidel. It can also be concluded that participants' level of anxiety did not affect the chances of passing or failing a test weld. Although participants experienced anxiety during the completion of the weld tests this did not relate to participants being susceptible to anxiety. This conclusion leads to the question, is the Zung SAS appropriate to access anxiety susceptibility for a welding training program [42]?

Another conclusion that can be drawn is that participants' heart rate during the completion of test welds did affect the ability to produce a passing weldment. An increase in heart rate could be an indication from the participants that the triggers of anxiety could be harmful. According to Lowe et al., a high heart rate or physiological change in an individual would lead to test anxiety [28]. The presence of a high heart rate shows that participants may have been experiencing test anxiety. The participants in the present study all reacted to the anxiety triggers in the same manner, by learning how to cope with the anxiety in order to complete the test welds. When participants became aware of a mistake their heart rate spiked, indicating anxiety; however, instead of quitting participants fixed the mistake (i.e. fixing weld angles, speed, placement), and completed the test weld. Furthermore, the number of instances of anxiety was experienced also shown an effect on an individual's ability to complete test welds. This aligns with the test anxiety model with immediate appraisal of test performance, where the student has identified a mistake which may have triggered test anxiety. With more instances like this, an individual's level of anxiety could rise each time. One trend identified was as the percentage of virtual reality training increased so did the number of instances anxiety was experienced. Although there was an increase in anxiety, the passing rate increased as well. This could be attributed to the effect of increased feedback within the virtual reality training simulations. With increased feedback, the beginning welders could be better able to see mistakes when they happen and fix them immediately, which may have led to a higher passing rate. In addition, the number of instances of anxiety decreased from the flat to the vertical position. This could be because the participants completed the flat welds in a week prior to transitioning to the vertical welds becoming more familiar with the welding environment and familiar to the social environment [28]. This shift in familiarity of the social environment, the welding booth and real-life welding, could have had a positive effect on a participant's ability to pass the test weld. Finally, test anxiety could have also been triggered after the completion of a test weld by their own immediate appraisal of their weldment and subsequently by the final grade from the CWI of visually passing or failing. According to Lowe et al., this could increase or decrease test anxiety on subsequent test welds they would have completed [28].

Recommendations

Conclusions from this study lead to several recommendations. First, it is recommended that welding programs prepare trainees for the anxiety triggers, highlighted in this study, to reduce the effect experienced during the completion of the certification tests. With the high need of welders, it is imperative to create an environment that is conducive to learning and not to trigger anxiety in trainees. Due to the beginning welders working individually during training, could creating team-based learning groups to decrease the amount of anxiety experienced during the welding process?

It is recommended that training programs utilize teaching methods and strategies that are helpful at reducing anxiety in both formal and informal instructional settings. Whether that be evaluating various transitioning schedules from virtual reality to a real welding booth. This might include having students that exhibit a level of anxiety to observe a certified welder to help acclimate to a live welding environment. The ability to acclimate an individual to a situation by placing them into it, allowing them to observe completion of a weld may lead to a reduced level of anxiety when the individual tries to complete the same task. Within the typical agricultural education pre-service teacher training program, welding skills are typically taught in an agricultural mechanics course [1]. It is recommended that agricultural mechanics instructors utilize virtual reality simulators, if available, to incorporate more practice and increased amount of feedback to teach students to weld properly. Instructors also need to inform the students of possible triggers of anxiety to relieve some anxiety before it happens. If instructors create well informed students before entering a welding booth the students may be more able to process and overcome any anxiety that they might encounter.

Future studies are recommended to further assess the ability of an individual's level of level of anxiety to predict future performance by purposively selecting participants who exhibit anxiety. Researchers also recommend utilizing various instruments that assess level of anxiety to determine if there is an instrument better suited for a welding training program. Purposively selecting participants will allow for a higher ratio of individuals susceptible to anxiety than the present study to help increase validity and reliability. Future research is needed to examine if team-based learning groups are effective at reducing anxiety in a welding training program. Also, with the release of an augmented reality training system which provides feedback for beginning welders during the actual welding process in real-life, future research needs to be conducted to see the effect it has on a beginning welder's anxiety level. As well as if there needs to be a transition between virtual reality and augmented reality then to the actual welding booth.

References

1. Burris S, Robinson JS, Terry R. Preparation of pre-service teachers in agricultural mechanics. Journal of Agricultural Education. 2005; 46: 23-34.
2. Granberry T, Blackburn JJ, Roberts R. The state of agricultural mechanics in the preparation of school-based agricultural education teachers. Journal of Agricultural Education. 2023; 64: 144-158.
3. Trickett L, Byrd AP, Anderson RG. Preparing pre-service agricultural education teachers to teach agricultural mechanics: Are we doing enough? Journal of Agricultural Education. 2023; 64: 261-273.
4. Hubert D J, Leising J. An assessment of agricultural mechanics course requirements in agriculture teacher education programs in the United States. Journal of Southern Agricultural Education Research. 2000; 50: 24-31.
5. Hubert D, Ullrich D, Lindner J. An examination of Texas agriculture teacher safety attitudes based on a personal belief scale from common safety and health practices. Journal of Agricultural Systems, Technology and Management. 2003; 17: 1-13.
6. McKim BR, Saucier PR. A 20-year comparison of teachers' agricultural mechanics laboratory management competency. Journal of Agricultural Education. 2013; 54; 153-166.
7. Haynes JC, Anderson R, Byrd P. Determining the Teaching Resources Needed for an Ideal Post-Secondary Applied STEM (Agricultural Mechanics) Learning Laboratory: A Delphi Approach. The CTE Journal. 2024; 12: 18-37.
8. Dyer JE, Andreasen R J. Safety Issues in Agricultural Education Laboratories: A Synthesis of Research. Journal of Agricultural Education. 1999; 40: 46-54.
9. Shultz M J, Anderson RG, Shultz AM, Importance and capability of teaching agricultural mechanics as perceived by secondary agricultural educators. Journal of Agricultural Education. 2014; 55: 48-65.
10. Rudolphi J, Retallick MS. Agricultural safety and health education: Practices, attitudes, and needs of Iowa agricultural educators. NACTA Journal. 2015; 59: 174-179.
11. Anderson R, Velez J, Anderson S. Using the Health Belief Model to Comparatively Examine the Welding Safety Beliefs of Postsecondary Agricultural Education Students and their Non-agricultural Education Peers. Career and Technical Education Research Journal. 2014; 39; 9-22.
12. Talbert BA, Camp WG, Heath-Camp B. A year in the lives of three beginning agriculture teachers. Journal of Agricultural Education.1994; 35; 31-36.
13. Hard DL. Correlates of accidents in Ohio vocational agriculture laboratories [Unpublished doctoral dissertation]. The Ohio State University. 1990.
14. Harper JG. Analysis of selected variables influencing safety attitudes of agricultural mechanics students. Paper presented at the Central Region Research Conference in Agricultural Education, Chicago. 1984.
15. Cary H, Helzer S. Modern Welding Technology (6th ed.). Upper Saddle River, NJ: Pearson Education, Inc. 2005.
16. Jeffus L. Welding and Metal Fabrication. Clifton Park, NY: Delmar. 2012.
17. Rachman S. Anxiety (2nd ed.). New York, NY: Taylor and Francis, Inc.2004.
18. Byrd A, Anderson R. Integrating virtual reality to reduce anxiety in beginning welders. Poster presented at the North Central Region – American Association for Agricultural Education Research Conference, Champaign, IL. 2012.
19. Manca D, Brambilla S, Colombo S. Bridging between virtual reality and accident simulation for training of process-industry operators. Advances in Engineering Software. 2013; 55: 1-9.
20. Kunkler K. The role of medical simulation: an overview. Int J Med Robot. 2006; 2: 203-210.
21. Lucas J, Thabet W, Worlikar P. Using virtual reality (VR) to improve conveyor belt safety in surface mining. 24th W78 Conference Maribor 2007 & 5th ITCEDU Workshop & 14th EG-ICE Workshop: Bringing ITC knowledge to work. Maribor, Slovenia. 2007: 431-438.
22. Whitney S, Stephens A. Use of simulation to improve the effectiveness of army welding training. Defence Science and Technology Organisation. 2014.
23. Heibel B, Anderson R, Drewery M. Virtual reality in welding training and education: A literature review. Journal of Agricultural Education. 2023: 64.
24. Stone RT, McLaurin E, Zhong P. Full virtual reality vs. integrated virtual reality training in welding. Welding Journal. 2013; 92; 167-174.
25. Wells T, Miller G. The effect of virtual reality technology on welding skill performance. Journal of Agricultural Education. 2020; 61: 152-171.
26. Heibel B, Anderson R, Swafford M. Integrating Virtual Reality Technology into Beginning Welder Training Sequences. Journal of Agricultural Education. 2024; 65: 210-225.
27. Heibel B, Anderson R, Borges B. Assessing the Effects of Virtual Cue Implementation in Virtual Reality Welding Training. Journal of Agricultural Education. 2024; 65: 413-428.
28. Lowe PA, Lee SW, Witteborg, et al. The test anxiety inventory for children and adolescents (TIACA): Examination of the psychometric properties of a new multidimensional measure of test anxiety among elementary and secondary school students. Journal of Psychoeduational Assessment. 2008; 26: 215-230.
29. Beidel DC, Turner SM. Comorbidity of test anxiety and other anxiety disorders in children. J Abnorm Child Psychol. 1988; 16: 275-287.

30. Cassady JC. The influence of cognitive test anxiety across the learning-testing cycle. Learning and Instruction. 2004; 14: 569-592.
31. Hembree R. Correlates, causes, effects, and treatment of test anxiety. Review of Educational Research.1988; 58: 47-77.
32. Mc Donald AS. The prevalence and effects of test anxiety in school children. Educational Psychology. 2001; 21: 89-101.
33. McIlroy D, Bunting B, Adamson G. An evaluation of the factor structure and predictive utility of a test anxiety scale with reference to students' past performance and personality indices. Br J Educ Psychol. 2000; 70: 17-32.
34. Sub A, Prabha C. Academic performance in relation to perfectionism, test procrastination and test anxiety of high school children. Psychological Studies. 2003; 48: 7-81.
35. Hancock D R. Effects of test anxiety and evaluative threat on students' achievement and motivation. Journal of Educational Research. 2001; 94: 284-290.
36. Berger VF, Munz DC, Smouse AD, et al. The effects of item difficulty sequencing and anxiety reaction type on aptitude test performance. Journal of Psychology: Interdisciplinary and Applied. 1969; 71: 253-258.
37. Lambeth JM, Elliot J, Joerger R. Research report: The national career and technical education research agenda. Techniques. 2008: 52-55.
38. Roberts TG, Harder A, Brashears MT. American Association for Agricultural Education national research agenda: 2016-2020: Gainesville, FL: Department of Agricultural Education and Communication. 2016.
39. American Association for Agricultural Education (AAAE). AAAE research values. 2023.
40. Lincoln Electric. VRTEX® 360® single user virtual reality welding training simulator on pallet. 2021. Retrieved from https://www.lincolnelectric.com/en/products/K4601-1?product=K4601-1.
41. Moore CG, Carter RE, Nietert PJ, et al. Recommendations for planning pilot studies in clinical and translational research. Clinical and translational science. 2011; 4: 332-337.
42. Zung WK. A rating instrument for anxiety disorders: Psychosomatics. 1971; 12: 371-379.
43. Mc Dowell I. Measuring health: A guide to rating scales and questionnaires (3rd ed.). New York, NY: Oxford University Press. 2006.
44. Shinba T, Kariya N, Matsui Y, et al. Decrease in heart rate variability response to task is related to anxiety and depressiveness in normal subjects. Psychiatry Clin Neurosci. 2008; 62: 603-609.
45. Gravetter F, Wallnau L. Statistics for the Behavioral Sciences. Belmont, California: Wadsworth. 2009.
46. In J Kahn, A Langlieb. Mental health and productivity in the workplace: a handbook for organizations and clinicians. Jossey-Bass. 2003: 276-296.