Developing Welding Safety Concepts and Behaviors through the Use of Accident Prediction and Prevention Activities

By

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Abstract

This study took place in a rural high school Introduction to Agricultural Mechanics class. The class consisted of 1 female and 19 male students from a variety of backgrounds and experience. The intervention took place over a period of 2 weeks, and observational data was collected for 2 additional weeks. The purpose of this intervention was to explore whether accident prediction and prevention activities would make welding safety education meaningful to students in a way that affected their behavior. After taking a pre-intervention welding safety test and completing the survey, students divided themselves into groups to research possible accidents and preventions related to arc and gas welding units. Groups presented their results to the class. During presentations, students generated their own set of safety guidelines, which were then used in class discussion to develop a class set of welding safety guidelines. Following discussion, the class took the welding safety test and completed the attitude survey again. Observational data was collected during the intervention to measure student on-task level, and after the intervention to measure the effect on student behavior while working in the shop. The study concluded that replacing teacher-led safety instruction with accident prediction and prevention activities may be an effective way to engage students in actively learning about welding safety. The study also suggests that motivation for safe shop behavior depends on more than safety knowledge.

Table of Contents

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Many students are entering the workplace without the knowledge and experience to recognize and address workplace hazards and risks. One theory that may explain this is the idea that when teaching safety, emphasis is placed on knowledge and skill acquisition without developing skills in communication, listening and observation (Okojie, 2003). In my agriculture mechanics class in the early fall, the first unit we covered was general shop safety. The safety unit is important because many students have little or no shop experience before taking the class. In order to conduct the class safely, each student must demonstrate that they understand safe shop procedures for each piece of equipment they will be using by passing a series of safety tests. Many students quickly lost their focus during this initial safety unit. Based on what I saw during our general shop safety unit, I sense that students see safety as a chore, something they have to endure so they can work in the shop. My concern is that safety lessons are teaching students the correct answers to written questions but not affecting their behavior. I propose that learning activities which ask students to predict and prevent accidents may bring about a greater change in student behavior because students may relate better to their peers than to the teacher.

Okojie and Olinzock (2003) found that safety is commonly viewed in the workplace as something that is only applied on the job. Knowledge and skill acquisition is often the focus of education, but in order to create a safe work environment, employees must learn safe work habits. It is important for employees to develop a "pre-set mental alertness and conscious awareness of a work site's dangers and health risks" (Okojie & Olinzock, 2003, p. 25). It takes time to develop safe work habits, and Okojie and Olinzock point out that "incorporating safety instruction in the school curriculum gives students time to develop safety consciousness before entering the workforce" (Okojie & Olinzock, 2003, p. 25). Howell (2003) concedes that students in most industrial technology classes learn safety at the beginning and rarely revisit it once they begin working in the shop. He then offers several questions that have helped to develop this project. "How do we make safety a full-time part of our program? How do we get students to take responsibility for their own safety and the safety of others in the class?" (Howell, 2003, p. 30). These last two questions posed by Howell are at the heart of my intervention. In his work, Howell used a series of student-based learning exercises where students were directly involved in assessing situations and developing their own safety rules. I believe teaching safety in a meaningful, interesting way is the biggest challenge in teaching shop safety. In my study, groups of high school students were asked to identify shop accident scenarios, identify the behaviors that cause such accidents, evaluate the consequences and identify preventative behaviors.

Past and current efforts to promote shop safety have focused on the areas of controlling student performance, avoiding faculty and institutional negligence, and minimizing hazardous conditions. These efforts have largely been reactive in response to unsafe situations. In discussing safety education in today's shop classrooms and learning labs, Yeager (1997) describes time, effort and perceived authoritative control as being some of the reasons that students compromise shop safety. Lundberg (2003) used activities to engage students in collaborative learning with their peers. The study showed that student learning increased greatly when activities were structured around peer collaboration. Lundberg's research was based on college students who had limited amounts of time to study. These results may also apply to high school students who spend little time studying outside the classroom. Through peer collaboration, high school students will spend more time studying shop safety in ways that are meaningful to them. When safety is meaningful, students will not compromise it for these other reasons.

Discussion of meaningful safety instruction has led to the following research question: *What are the advantages and disadvantages of replacing teacher-led safety instruction with accident prediction and prevention activities?* Early in the school year, I led my agricultural mechanics students through the general shop safety unit before moving into the shop. My lessons consisted of three parts: lectures, worksheets and safety tests. Regrettably, students often complained about how bored they were with this format for teaching safety. Many tried to sleep through class. It was common to hear students say that they couldn't wait to finish safety so they could actually get into the shop. The attitudes displayed by these students indicated to me that they had little regard for shop safety. To them it seemed simply a hoop to jump through so they could work in the shop. While pondering this, I became concerned that the safety unit was not affecting student behavior. Instead, it was simply a way for the school to avoid liability in the case of an accident. I determined to take a fresh approach to my next safety unit: welding safety.

As I began the welding safety unit, I planned to use an intervention which would allow students to explore the consequences of unsafe shop behavior and share their findings with each other. Welding safety is a rich domain for student research in that there are a great many hazards, such as working with compressed gasses, electricity, heat, fire, chemicals and metals. For their own safety and the safety of others, novice students must be adequately prepared to work in a safe manner before they enter the shop to begin working. Data collected during this intervention was designed to answer several sub-questions.

Can groups of 10th, 11th and 12th grade agriculture students generate accurate safety guidelines by identifying possible accidents with a piece of welding equipment and reflecting on equipment operating procedures that would lead to or avoid accidents? There are experts who believe that many accidents are caused by the inability of people "to foresee, to judge appropriately, or perceive and interpret a sequence of events that may lead to an accident" (Okojie & Olinzock, 2003, p. 25). This intervention explores whether a group of high school students with limited shop experience can generate a complete and accurate list of safety guidelines that will help them to pass a safety test and develop safe work habits. As students research the behaviors surrounding welding accidents, they begin to develop the ability to foresee, perceive and interpret events in a sequence. Students who enlarge their thinking with this type of thought process are more likely to develop safe work habits. Through this intervention, students learned that "they can prevent accidents and injuries through planned, conscious effort" (Okojie & Olinzock).

What are the effects on students' engagement in the classroom when learning from student-developed safety scenarios and presentations? The expectation of this intervention was that it would engage most of the students. Today's youth are accustomed to being entertained. It is increasingly difficult for teachers to impress students with technology, and this leads to challenges in keeping students focused on learning. It was expected that the subject of welding accidents and hazards would appeal to students who come from a society inundated with graphic entertainment. The nature of this project allowed students to be entertained while gathering information. The researcher expected that students would further perceive this intervention as enjoyable when they presented their findings to the class through their chosen method. While students were putting on a gory show for one another, focusing on the results of accidents, they were exposed to real-life situations in which unsafe behavior led to accidents. The expectation was that this type of intervention would lead students to become more safety-minded without hearing lecture from an instructor.

It was also a possibility that some students would become less engaged and less motivated to learn when participating in this type of intervention. Students who are comfortable receiving a set of parameters from an instructor and going to work within those parameters may not have been satisfied with this welding safety project. The expectation for these students was that they would do a minimum amount of work because they were required to but would have preferred to simply receive a list of rules, pass a test and go to the shop. They already trusted the instructor and knew that safety was important in their work.

Another possible student response to this intervention was non-participation. There were some students in the class who, because of laziness or defiance, had not actively participated earlier in the year. It was possible that they would continue with their non-participation even though the potentially graphic nature of the project would seem to lend itself to their senses. The expectation of the intervention in this case was that it would have little effect on their safety attitude and shop behavior.

What are the effects on students' beliefs and attitudes about safety and shop behavior after having participated in small groups that analyze the causes of accidents? Many students may have already heard so much about safety that they developed an "It won't happen to me" attitude (Howell, 2003). The expectation of the researcher was that students who discover safety through their own work would develop a more personal attitude of safety. Howell (2003) used an activity where students developed their own safety rules and discussed the importance of their rules as a class. He asserts that the effectiveness of the activity is due to the idea that students are teaching themselves. Whereas Howell used a safety rule assignment, the intervention for this research involved the additional steps of having students explore welding accidents and present findings to each other regarding the causes, consequences and preventions of their explored accidents. As students in this group taught themselves about welding safety, it was expected that they would develop a more positive attitude toward learning shop safety.

The goal of this inquiry was to explore a meaningful way in which to teach welding safety. It was expected that if the intervention proved to be effective in influencing student behavior in the shop, it could be utilized in other areas of professional technical education to improve lab safety, decrease the frequency of accidents, and better prepare students to safely work in industry.

Method

Participants

This research focuses on an Introduction to Agricultural Mechanics class of twenty students at Martindale[1] High School. The school is on a block schedule with periods one through four on "A" days and periods five through eight on "B" days. Class periods are 90 minutes long. The focus class for this study meets during sixth period. The ethnicity of the entire class is Caucasian. There are 19 boys and 1 girl in the class. Sixteen students are in 10th grade, two are in 11th grade, and two are in 12th grade. Eleven students are 15 years old, six are 16, one is 17, one is 18 and one is 20. Three of the 20 students are developmentally challenged, and two of these students require an aide to attend class with them.

Martindale High School is in what used to be a rural Idaho town but is now a suburban bedroom community for a nearby city. Founded in 1904, the community grew to a population of 5,000 in its first 90 years and has reached 15,000 in the last decade. The economy in this community has largely been agriculturally based, but the farm ground is rapidly being converted into residential neighborhoods. The area south of the community is mostly high plains desert managed by the Bureau of Land Management. Several other communities lie to the North, East and West, with diminishing agricultural land in between.

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[1] All names are pseudonyms

Academically, Martindale High School compares favorably to the state. In Idaho Standards Achievement Test (ISAT) results, the high school is well above the state proficiency average in the reading and language use areas. Math proficiency is slightly below the state average. The high school's graduation rate is 81%, while the state is 84%. The proficiency goals for the Adequate Yearly Progress (AYP) score are 72% proficiency in reading and 60% proficiency in math. The high school reading score is 81% proficiency, well above the goal but still below the state average of 84%. Math proficiency is 63%, slightly above the goal, but well below the state average of 83%. The average American College Test (ACT) score for high school students is 20.5, slightly below the state average of 21.3. The national average falls between these two scores. Economically disadvantaged students make up 19% of high school enrollment, 26% of district enrollment, and 38% of state enrollment. English Learners are 1.9% of the student population in the school district, while the state has 8.7%.

School district demographics break down in several ways. Of all the students in the district, 26% are considered economically disadvantaged, 1.9% are English Learners, and 9.3% have disabilities. Table 1 shows the ethnic, economically disadvantaged, and gender populations for Martindale High School, the school district, and the state.

Table 1

School, District & State Enrollment Information

Enrollment	School	District	State
Enrollment of Racial/Ethic Groups			
White (%)	94.4	93.7	84
Black (%)	0.5	0.8	0.9
Hispanic (%)	4	4.6	12.1
Asian/Pacific Islander (%)	0.7	0.8	1.5
American Indian/Alaska Native (%)	0.3	0.3	1.6
Enrollment of Students with Special Needs			
Economically Disadvantaged (%)	19.2	26	38.1
Enrollment Distribution by Gender			
Female (%)	46.2	48.8	48.4
Male (%)	53.8	51.2	51.6

http://www.schoolmatters.com/app/data/q/stid=13/llid=118/stllid=371/locid=1026510/catid=812/secid=3130/compid=771/site=pes

The median household income in this community is $43,450, which is higher than the $39,730 state average. The median home value of $107,600 is also above the state average of $104,471. Only 7% of students in the district come from single parent homes, and there are strong religious ties in the area. These factors indicate that students in this area have a high level of social capital, or the support from home and community that can help them to be successful.

Intervention

In this intervention, students were divided into groups of two or three. Each group was assigned either gas or electric welding units by drawing their assignment out of a hat. The groups were given two class periods to develop an accident analysis for their assigned equipment and give a presentation to the class based on these guidelines (see Appendix A for assignment handout):

- *Identify at least five different types of accidents associated with your assigned equipment.*
- *Explain the behavior that could lead to each accident.*
- *Explain the consequences of this behavior.*
- *Explain what behavior could prevent the accident.*
- *Using a role play or visual aid, present to the class the causes, consequences and preventions of each type of accident you researched.*

While watching group presentations, each student was asked to make a list of 10 safety guidelines for welding. These safety guidelines supported class discussion after the group presentations were completed.

Observational data was gathered during the group research and presentation portion of the intervention to determine student on-task level. Observations were made at 10-minute intervals. During group research, the instructor began with the same group each time and observed groups in the same order. While the class was presenting their projects, the instructor stood in the back of the room and observed which students were attentive and which were not. Students who were on task received a “T” on the observation sheet (Appendix B) and students who were not on task received an “O”.

Class discussion was led by the teacher, who asked students to list the safety guidelines they had written. Each guideline was written on the board. The teacher asked the class why each guideline was important, and the class talked about what could happen if guidelines weren't followed. When a student listed a guideline that was unsafe, the guideline was still written on the board, but the teacher followed up with questions and hypothetical situations that helped students to realize that the guideline was not safe. It was then removed from the list. The purpose of such discussion was to help the class make connections between the accidents/behaviors presented and the safety guidelines developed by the students. The instructor hoped that through this dialogue, students would gain an understanding of the importance of creating a safe work environment through appropriate behavior. The intent of the intervention was to help students begin to develop the pre-set mental alertness and conscious awareness of dangers and health risks that will lead to safe work habits (Okojie & Olinzock, 2003, p. 25).

The intervention took approximately two weeks to complete, and was followed later by additional observation in the shop. Groups developed their safety projects during the first week of the intervention. Presentations and class discussion took place during the second week. Following presentations and class discussion, the class took the post-intervention safety survey and the post-intervention test, which they were required to pass to qualify for working in the shop.

After completing this safety unit, students were required to complete a unit on the principles of welding, which was not associated with the intervention, so they could begin working in the shop. Additional observational data was collected when students began welding in the shop. The instructor used a set of prompts to question students about their behavior.

Data Collection Procedures

To document the inquiry and to provide insight into the research questions, three types of data were collected: student work and achievement data, observational data, and attitude data.

Student work and achievement data was determined based on a welding safety test given before and after the intervention (see Appendix C). The 32-question test was developed from the Arc Welding and Oxy-acetylene Welding safety tests currently used by the Martindale High School agriculture department. It is a practical test that provides scenarios, and students determine if each scenario is safe or unsafe. *Figure 1* shows an example of questions from the welding safety test. For the purpose of this research, I added two open-ended questions. The first asks students to list five types of accidents that can occur while arc welding, and the second asks students to list five types of accidents that can occur while welding with oxy-acetylene. These additional questions may be an additional indicator of what students learn from the intervention because open-ended questions require a different type of thought than scenario questions. Student achievement level was based on student improvement from the first test to the second.

Write the word "safe" or "unsafe" in the space provided to describe the practices related to the safe operation of the arc welder. (1 point each)

______ 1. To weld without a helmet.

______ 2. To weld while standing on wet ground or in water.

______ 3. To weld without safety glasses when wearing a helmet.

______ 4. To weld with gloves.

______ 5. To start welding without warning others nearby.

______ 6. To use a number 10 lens in your helmet.

Figure 1. Sample of questions from the welding safety test.

Each group was asked to produce a written accident analysis based on accidents they researched as related to their assigned piece of welding equipment. Students were to identify at least five types of accidents, behaviors that led to the accidents, consequences of the accidents, and behaviors that could have prevented the accidents (Appendix A). This work was evaluated based on a rubric (Appendix D), which was given to the students with the assignment sheet at the beginning of the intervention.

The project rubric was developed to quantify the work presented by each group. In order to maintain content validity (Woolfolk, 2004), the rubric was designed to assign a score to each of the project requirements. Points were awarded to each student for the accidents, the behaviors that caused the accidents, the consequences of the behaviors, the preventative behaviors, and the presentation of these findings. Points were also given for listing sources of information and generating a list of at least 10 safety guidelines. Because it is the nature of some students to let others do the work when working in collaboration, students had the opportunity to rate the participation of their group members during the inquiry. Students rated their partners on a scale of one being the lowest and five being the highest. If a group had two people, the partner's rating was added to the student's grade. If a group had three people, the participation score was determined by taking the average of the two partners' ratings and adding them to the third student's grade.

Observational data was collected while the groups were developing and presenting their projects. The instructor collected on-task data based on classroom observation at 10-minute intervals. Every 10 minutes, the teacher began with the same group and observed the class groups in the same order. If students were discussing or actively working on their safety project, they were give a "T" in their blank on the observation sheet. Students who were not in some way working on developing their safety project received an "O" to indicate they were off task. The instructor observed each group in the same order each time, moving from group to group. If a group completed the project early, they were considered on task as long they were not keeping other groups from working. These observations were designed to provide data to answer sub-question two: *What are the effects on students' engagement in the classroom when learning from student-developed safety scenarios and presentations?* This observational data indicates the level of student engagement on the project by observing time on task by each student.

Following the presentations, the class discussed and developed a class list of safety procedures. As the leader of the discussion, the teacher wrote student suggestions on the board. Once the list was written, the teacher went back through the list asking the class to talk about possible scenarios, behaviors and consequences related to the safety guidelines given. The teacher led the class through hypothetical situations to illustrate situations involving each listed safety procedure and then asked the class if they thought the guideline was safe or unsafe. This list helps to support sub-question one: *Can groups of 10th, 11th and 12th grade agriculture students generate accurate welding safety guidelines by identifying possible accidents with a piece of equipment and reflecting on equipment operating procedures that would lead to or avoid accidents?* If students listed guidelines that were unsafe, the teacher had the opportunity to help the class re-think through the situation and understand why the guideline was not safe. When the class list had been generated, students voted to accept the guidelines as listed. If there had been objections to the list, discussion would have continued. This part of the intervention was completed when the class unanimously voted to accept the guidelines as listed.

Following the intervention, the welding safety test was again administered to the class in order to assess student achievement. This test was the same as the pretest given at the beginning of the intervention. Achievement data from the test will support the main research question: *What are the advantages and disadvantages of replacing teacher-led safety instruction with accident prediction and prevention activities?*

The groups were dissolved at this point, and observational data was gathered to assess student attitude and the level at which the intervention experience affects shop behavior. Three data sources were used to help answer the question: *What are the effects on students' beliefs and attitudes about safety and shop behavior after having participated in small groups that analyze the causes of accidents?* An attitude survey was given before and after the intervention to assess student attitude toward safety. The instructor used a list of questions about behavior to pose to students working in the shop. A list of safety guidelines was used to observe student adherence to principles they discussed in the classroom.

Attitude data was collected before and after the intervention using a survey (see Appendix E). The survey was a five point Likert scale which explored students' backgrounds, attitudes about welding safety, and attitudes about working in the shop. Many of the questions were developed from the safety test in order to explore student attitudes about acceptable shop behavior. Some of the questions were given to identify what Howell describes as the "It won't happen to me" syndrome, when students believe that accidents happen to others but not to them (Howell, 2003). Several survey questions ascertained the welding experience level of the students. Some of the questions provided a general idea about how students view the class. *Figure 2* shows a sample of questions from the welding safety survey. Giving the survey before and after the intervention showed changes of student attitude toward welding safety.

1 2 3 4 5	24. Loose or torn clothing as well as hair can cause serious accidents.
1 2 3 4 5	25. Horseplay, such as throwing objects at another student, is okay sometimes.
1 2 3 4 5	26. I can be trusted to work safely in the shop.
1 2 3 4 5	27. It is the job of the teacher, not the students, to ensure shop safety.
1 2 3 4 5	28. Learning about welding safety is a waste of time because I already know how to work safely.
1 2 3 4 5	29. I know how to work safely, but I choose not to because working safely is boring.
1 2 3 4 5	30. Welding safety is the responsibility of everyone working in the shop.

Figure 2. Sample questions from Welding Safety Survey.

The list of behavioral questions was designed to ascertain how the students' experience with the intervention impacted their shop behavior. The instructor questioned students about their shop behavior using the following prompts: (a) Why did/didn't you ____________________? (b) Do you consider this behavior safe or unsafe? (c) How did the things you learned in the classroom affect your behavior in this situation? These questions are designed as metacognitive prompts to get students to think about why they exhibited a certain behavior. Students who learn to self-evaluate will develop the pre-set mental alertness and conscious awareness described by Okojie and Olinzock as being necessary for safe work habits (2003, p. 25). This observational data serves as an indicator of the effect of the intervention on student shop behavior.

The safety guideline list compiled by the class was used by the instructor to observe the effect of the safety unit on student behavior. During two class periods, the instructor marked on the list the number of times a member of the class was observed not following one of the safety guidelines. Observing whether or not the class follows its own safety guidelines is an indicator of the effect of the intervention on shop behavior.

Results

In order to explore whether groups of 10th, 11th and 12th grade agriculture students can generate accurate welding safety guidelines by identifying possible accidents with a piece of welding equipment and reflecting on equipment operating procedures that would lead to or avoid accidents, the instructor asked each student to generate their own list of 10 welding safety guidelines during the presentation phase of the intervention (Appendix F). Students referred to these lists during class discussion, and the class developed and voted to accept a list of guidelines they agreed to follow when working in the shop. *Figure 3* shows the welding safety guidelines developed and accepted by the class.

STUDENT WELDING SAFETY GUIDELINES

1. Tie back long hair.
2. Wear safety equipment (glasses, gloves, coveralls, leather shoes/boots, helmet).
3. Be sure equipment is in good condition.
4. Be familiar with equipment before using.
5. Keep shop clean.
6. Use the proper lens shade.
7. Know your surroundings.
8. Close tank valves when not welding.
9. Know the location of emergency equipment.
10. No horseplay in the shop.

Figure 3. List of welding safety guidelines developed by the class.

This welding safety guideline list developed by the class is evidence supporting the idea that 10th, 11th and 12th grade agriculture students can generate accurate welding safety guidelines by identifying possible accidents with a piece of welding equipment and reflecting on equipment operating procedures that would lead to or avoid accidents. When compared with a safety guideline list from The James F. Lincoln Arc Welding Foundation (Kennedy/Lee, Inc., 1988) shown in *Figure 4*, the class list directly addresses 7 out of 10 principles taught in the professional guidelines. The three professional guidelines not spelled out in the student list were: don't weld in wet areas, don't weld on or near flammable materials, and be aware of what is going on around you. Although these principles of welding safety were not specifically mentioned on the student list, each of them was discussed by the class while developing welding safety guidelines. These three professional guidelines were considered by students to have been implied in other guidelines.

PROFESSIONAL WELDING SAFETY GUIDELINES

1. Make sure you have a safe working environment.
2. Know the location of safety equipment.
3. Wear eye protection.
4. Wear welding helmet/face shield with proper lens shade.
5. Wear safety clothing (gloves, long sleeves, pants, leather shoes).
6. Know your equipment.
7. Be sure equipment is in good condition.
8. Don't weld in wet areas.
9. Don't weld on or near flammable materials.
10. Be aware of what is going on around you.

Figure 4. List of professional welding safety guidelines.

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*From "*Welding Safely – The Way the Pros Do It*"

Throughout the intervention, the researcher collected on-task data to determine the effect of the intervention on student engagement when learning from student-developed safety scenarios and presentations. On-task data was collected during group work time, group presentations, class discussion, post-test, and post-survey.

The first set of on-task data was collected while student groups were developing their safety projects during the first two days of the intervention. When observed, students were considered on task if they appeared to be working on the project or if their project was complete. The data shows that on the first day of the intervention, 90% of the class was engaged on the project. After 30 minutes, student engagement began to decrease, reaching a low of 60% before the end of the class period. On the second day of the intervention, student engagement began at 60%. Engagement rose slightly as students went to work finishing their projects. Again, after about 20 to 30 minutes of work time, student engagement decreased. This seems to support the idea of an engagement cycle. If students remain on the same task for a period of time longer than 20 to 30 minutes, they tend to lose their focus and disengage from their work (*Figure 5*). Data from the rest of the second day may be somewhat misleading. As groups finished their projects, the students were considered to be on-task. In some cases, an off-task group member was suddenly considered on-task because his group was finished. This may explain the 75% level of engagement during the last 30 minutes of class.

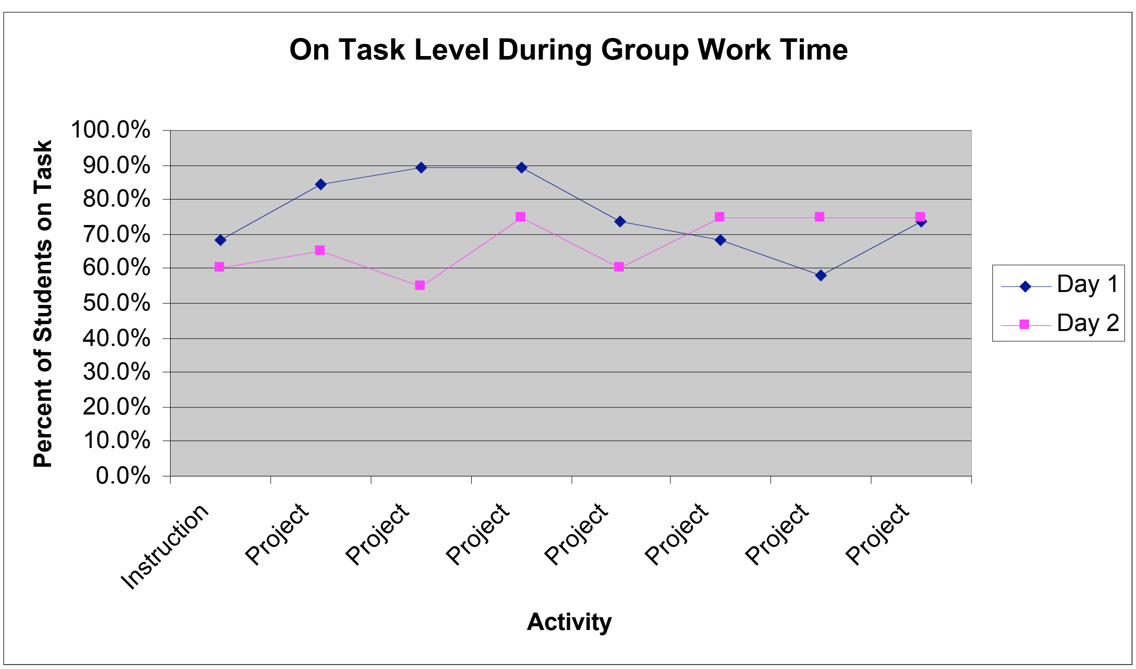

Figure 5. Student engagement during the group work portion of the intervention.

This quantitative data is important, but perhaps even more important is the qualitative data observed by the researcher during the group research portion of the intervention. The average engagement level for the class during the two day research period was 72%. It was evident to the researcher that within this 72% of engaged students, there were different levels of engagement. The researcher estimates that 55% to 60% of the class was actively engaged in their work throughout this portion of the intervention. Roughly 20% were somewhat engaged, meaning that these students had to be periodically redirected to work. The remaining 20% were students who did not engage in the assignment at all. Two of these four students, Trevor and Joe, refused to do the assignment. Cade began working but disengaged after about 40 minutes and did not re-engage in spite of constant redirection from the instructor. The fourth, Jeremy, seemed unable to focus when working in a group situation. He had to be constantly redirected to work and never seemed to engage in the activity. When questioned about this, Jeremy explained that his Attention Deficit Hyperactive Disorder (ADHD) was the reason for his inattentiveness and that he was not taking his medication.

The second set of on-task data was collected during group presentations on the third and fourth days of the intervention. Student engagement was determined by instructor observation of the class while students were presenting. Data was recorded in the same manner as before, placing a "T" next to names of on-task students and an "O" by the names of off-task students. Each group took 10-15 minutes to present their welding safety research. Student engagement for the class remained at 100% for the first 20 minutes. At 30 minutes, engagement fell to 94% indicating that one student was off task. Only 70% of students were on-task at the 40 minute mark, and engagement returned to 100% just 10 minutes later. Student engagement remained at 82% for the remainder of the presentations on day three. The loss of student focus after 20 minutes of presentations is further evidence supporting the idea of an engagement cycle. At 50 minutes into class on the third day, there was a dramatic increase back to 100% engagement that can be attributed to a particularly good group presentation that recaptured the focus of the class. This particular presentation was Corey's group, which included the two short animations.

The last remaining presentations were given on day four and took only 30 minutes to complete. Engagement during these presentations was 89%-94%, indicating that only one or two students were off task.

An encouraging part of the intervention results was the unexpected level of engagement and performance of certain students in the class. Corey took the assignment seriously enough to give up an entire Saturday to develop two animations for his group's presentation. Using the program Microsoft ® Paint, he created two short animations depicting possible consequences of two welding scenarios (Appendix G). The first was a depiction of the dangers of welding on a closed container with faulty equipment, and the second illustrated the hazards of working in a cluttered workspace. For their presentations, this group met the expectations of the instructor by giving causes, consequences and preventions for five different types of welding accidents related to oxy-acetylene welding. Corey exceeded the instructor's expectations with his animated visual aids.

The two-person group of Kyle and Tyler showed an unexpectedly high level of engagement and focus during the intervention. Both students had previously struggled with classroom work, displaying their social nature and being easily distracted. For the instructor, it was an unexpected result when these students were 100% engaged for the duration of the intervention. They chose a work area that was isolated from the rest of the class and worked intently to develop a presentation that met the expectations of the instructor and received a perfect score. Their presentation visual aid slideshow is shown in Appendix H.

Another group that showed a 100% level of engagement was the group of Sam, Mitch and Justin. Their enthusiasm for the project showed at the end of the first day when Justin exclaimed, "This is the fastest class has ever gone by!" These students have historically been hard working students, and for them the intervention was no exception. They remained on task and did excellent work throughout the project, exceeding the expectations of the instructor. The key motivational element for this group seemed to be the idea of finding the goriest pictures of accidents on the internet and somehow associating those pictures with welding in order to impress or disgust their classmates. This type of learning activity seemed to appeal to the senses of these students, who come from a generation that is growing up in a world of graphic entertainment such as video games and movies. Appendix I is the slideshow used as a visual aid during the presentation. Their work was thorough, and even though some of the pictures were probably not from a welding accident, the presentation captured the attention of the class and taught safe welding principles.

PowerPoint presentations were the most popular choice of groups for this assignment. Five groups chose this method for presenting the results of their welding safety research. One group used animations created with Microsoft ® Paint to illustrate their points, and one group used a role play to present their findings. The eighth group failed to complete the project.

During the class safety discussion following the presentations, student engagement was at 100%. Each student participated in the discussion as the class developed their safety guideline list. At one point during the safety list discussion one student deviated from the dialogue, but the instructor quickly helped this student to re-focus and stay on-task.

After the class voted to accept its list of safety guidelines, students were given the safety test and attitude survey. The 100% level of student engagement while taking the test indicates that students understood what behavior was expected of them when taking a test. Even after they finished, students remained quiet and respectful of their peers who were still working.

These results show that when learning from student-developed safety scenarios and presentations, students will engage in learning activities. The data also supports the idea of an engagement cycle, meaning that when students remain on the same task for a period longer than 30 minutes, they can lose their focus.

The researcher collected three different data sets for the purpose of assessing student attitude. The welding safety survey assessed student attitude about learning and working safely. A list of behavioral questions was used to investigate how the intervention impacted student shop behavior, and the list of safety guidelines developed by the class was used in observing whether or not students adhered to their own ideas.

The welding safety survey was given to 20 students before and after the intervention to measure changes in student attitude toward safety (Appendix F). This survey was designed to determine the attitude of students with regard to learning in the classroom, behavior in the shop, and prior experience. Students were asked to respond to a series of statements according to their level of agreement using a five-point Likert scale (*Figure 6*). Scale data from each student was calculated and pre- and post-intervention averages were determined for the class. Given a protection level of $\alpha = .05$ and a set of 30 items, between one and two items would be expected to show a significant difference between the pre- and post-survey results simply by chance; however six items were found in which the post-survey response differed significantly from the pre-survey response.

Use the following ranking system to evaluate the statements regarding the class:

1 Strongly Disagree
2 Disagree
3 Neutral
4 Agree
5 Strongly Agree

Figure 6. Survey key – the Likert scale used by students to rate their level of agreement with statements given on the welding safety survey.

Table 2 compares the pre- and post-intervention class averages and the change in scores for survey questions regarding student attitude toward learning safety. Each item is listed according to the change in score from the pre- to the post-intervention survey.

In this data set, five of the first six items showed a significant change in score. The two most significant changes occurred for the statements: "I do my best work for this class," and "I play an active part in the learning process in this class." Significant increases in the responses to these two statements imply that after the intervention, students may have placed more value on their classroom work than they did before. Students had a more positive perception of their role in the learning process for this class.

Two statements, "I learn from the safety assignments and activities in this class," and "the time I spend learning about safety in class is used productively," showed a significant increase in the value students placed on classroom learning activities. This suggests that the intervention had a positive effect on student attitude toward classroom safety lessons. The intervention may have given students a more meaningful, real-life connection with welding safety principles.

The fifth statement in this data set that showed a significant increase in student agreement was "I wish this class would push me more." While it seems that the intervention helped students to have a more positive attitude toward welding safety, it may also have awakened within the students a desire to learn more. This would explain such a result.

Table 2

Student Attitude with Regard to Learning Safety

Item (1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly Agree)	Pre-Intervention Average	Post-Intervention Average	Change in Scores	P-value
I do my best work for this class.	3.55	4.47	+.92	0.004
I wish the class would push me more.	2.50	3.24	+.74	0.02
I play an active part in the learning process in this class.	3.30	4.00	+.70	0.007
This class pushes me to work harder.	3.25	3.82	+.57	0.289
I learn from the safety assignments and activities in this class.	3.60	4.13	+.53	0.015
The time I spend learning about safety in class is used productively.	3.95	4.41	+.46	0.015
I feel challenged in this class.	3.20	3.47	+.27	0.088
It is important to review safety before working in the shop.	4.15	4.31	+.16	0.333
I enjoy learning in this class.	3.70	3.82	+.12	0.668
It is the job of the teacher, not the students, to ensure shop safety.	2.35	2.41	+.06	0.484
Learning about safety is boring.	3.85	3.76	-.09	0.848
The level of difficulty is appropriate for this class.	4.15	4.06	-.09	0.718
It is impossible to make safety interesting.	3.45	3.29	-.16	0.718

Statements like “Learning about safety is boring,” and “It is impossible to make safety interesting,” showed very little change in student agreement. Even though student perception of their own work quality level was higher, these results indicate that after the intervention, students still viewed safety lessons as boring.

The second type of question on the attitude survey focused on student attitude toward shop behavior (*Table 3*). Most statements showed very little change from pre- to post-intervention. None of the results in this data set showed a significant change. Students agreed that safety is the responsibility of everyone in the shop. Students agreed that they should not interfere with others who are working. The class also showed agreement that the things they learn in the classroom affect their shop behavior, giving this statement a pre-intervention rank of 4.20 and a post-intervention rank of 4.00. They agree that even if the instructor does not see, horseplay in the shop is not acceptable.

One change of note in this section was the decrease in agreement with the statement, “Others may need to worry about shop safety, but I don’t. I won’t get hurt.” The class average for this statement was 2.5 before the intervention and 2.06 after. Although this average was not statistically significant, three students showed a dramatic change in their agreement with this statement. James and Carter originally agreed with this statement, rating it a four on the scale and indicating that they believed they would not get hurt while working in the shop. After the intervention, their agreement fell to a scale rating of two. Sam originally disagreed with the statement, giving it a rating of two. Following the intervention, Sam agreed with the statement, changing the rating to a four. It appears that he may have had a less personal connection with shop safety after the intervention, exhibiting the “It won’t happen to me” attitude (Howell, 2003. p. 30). This is an indication that the intervention may have affected individual students differently. It may also have been an anomaly.

Table 3

Student Attitude with Regard to Shop Behavior

Item (1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly Agree)	Pre-Intervention Average	Post-Intervention Average	Change in Scores	P-value
Students working unsafely should be required to take more safety instruction.	4.00	4.24	+.24	0.422
It is the responsibility of every student to work in a safe manner.	4.75	4.88	+.13	0.579
Not interfering with others is a good safety rule.	4.45	4.53	+.08	1
I should not talk to another person when they are operating machinery.	4.35	4.41	+.06	1
I can be trusted to work safely in the shop.	4.75	4.71	-.04	0.332
Welding safety is the responsibility of everyone in the shop.	4.75	4.71	-.04	1
When I work in the shop, I forget the safety lessons we talked about in the classroom.	1.95	1.88	-.07	0.627
The student must pay strict attention to their work to insure their safety.	4.20	4.12	-.08	0.773
Horseplay is okay if the instructor doesn't see.	1.90	1.71	-.19	0.632
The safety principles I learn in the classroom affect my behavior in the shop.	4.20	4.00	-.20	0.27
Loose or torn clothing as well as hair can cause serious accidents.	4.50	4.29	-.21	0.543
Others may need to worry about welding safety, but I don't. I won't get hurt.	2.50	2.06	-.44	0.683
Horseplay, such as throwing objects at another student, is okay sometimes.	2.50	1.76	-.74	0.854

The data presented in *Table 4* shows student perceptions of their own prior welding experience. The unexpected result in this section of the survey was with the statement "I had welding experience before I took this class." With a p-value of .021, the change for this statement is well within the protection level of $\alpha = .05$ and is therefore a significant result. Brad, Sam, Jeff and Jeremy initially expressed that they had a low level of prior experience. After the intervention, these students expressed that their level of previous welding experience was much higher, even though their prior experience did not change during the intervention.

An explanation for this result is that the intervention affected a change in these students' perceptions of their prior experience. This intervention may have changed student understanding of the meaning of prior experience. What might have initially seemed insignificant to these students became applicable when considering previous experience.

Students may have felt like they gained experience during the intervention. It is possible that the class felt that researching welding accidents and safety precautions gave them experience. This could explain why students' perceived prior experience level increased so much on the post-survey.

The intervention may have brought to remembrance previously unaccounted-for experiences. While researching welding safety, students in the class may have remembered past personal experiences that led to a greater sense of prior experience which was indicated on the post-intervention survey.

Table 4

Student Prior Experience

Item (1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly Agree)	Pre-Intervention Average	Post-Intervention Average	Change in Scores	P-value
I had welding experience before I took this class.	2.25	3.12	+.87	0.021
Learning about welding safety is a waste of time because I already know how to work safely.	2.25	2.59	+.34	0.369
I know how to work safely, but I choose not to because working safely is boring.	1.85	1.94	+.09	0.547
I already know welding safety and don't need to spend class time on it.	2.58	2.41	-.17	0.806

When considering survey data, it should be noted that the surveys from Trevor and Joe were determined to be outliers and were excluded from the class averages in order to avoid skewing the results. Both students selected a rating of one for every question on the survey. At the bottom of the page, they wrote comments like “Fight the man!” and “Stick it to the man!” Instead of writing their names on their surveys, they wrote “Billy-Bob Thornton” and “John Jacob Jingle-heimer-Schmidt.” These same students refused to participate in the group projects and are responsible for much of the off-task behavior observed during the intervention. However, their surveys may be accurate indicators of their attitudes toward welding safety.

After the intervention, both of these students chose to leave the class. Joe, who was struggling in the traditional high school environment, has completely left Martindale High School and is attending an alternative technical preparation school in a neighboring town. Trevor is still attending Martindale High. When given the choice to remain in the welding class, he explained, “I don’t think I can trust myself to work safely in the shop.” His confession shows that even though the intervention may not have affected a change in his shop behavior, it influenced a change in his attitude. He came to understand the importance of welding safety for each individual in the class and responsibly made the decision to remove himself from a potentially dangerous situation.

The second set of attitude data was collected through in-shop observation using a set of prompts to question students about their shop behavior. Students were asked three questions: (1) Why did/didn’t you _________________? (2) Was this behavior safe? (3) How did the safety unit in the classroom affect your behavior in this situation? The following are several examples of student responses to questions regarding their shop behavior.

Jeremy was observed working in the shop without safety glasses. When asked why he wasn’t wearing safety glasses, he replied, “I can’t. They’re fogging up.” He then explained that this behavior was safe because he couldn’t see through foggy glasses and his eyes were still protected by his welding helmet. When asked how this behavior was affected by the safety unit, he replied, “It wasn’t. We learned that we are supposed to wear [safety glasses].” At this point, the teacher reminded the student that the welding helmet only protects the eyes while welding and that safety glasses must be worn at all times in the shop. The student continued his attempt at re-negotiating the rule until given the choice of either wearing safety glasses or leaving the shop. He chose to wear his safety glasses.

This student clearly understood what was expected with regard to eye protection, but his attitude clearly placed personal comfort above safety. This was evident when he had to be told two more times during the same class period to put his glasses back on. The safety intervention had little effect on this student's attitude regarding eye protection.

When asked why he wasn't wearing a face shield while gas welding, Corey said he was simply being lazy and didn't think about it. He admitted the behavior was unsafe and said he knew from the safety unit that he needed to wear a face shield with the proper shade of lens. He just didn't think about it.

This same student was later observed bending over to pick a rod up off of the floor. As he did so, he held his lit torch up with his other hand and the flame inadvertently pointed at the torch hoses. The instructor quickly got the student's attention in order to avoid an accident. When questioned about the reason for his behavior, Corey responded that he dropped the rod and thought he could quickly pick it up without taking time to turn the torch off. He explained that the behavior was unsafe because the flame could have damaged the hoses causing leaks and fires. Corey was puzzled by the question about how his behavior was affected by the safety unit because the unit did not directly address such behavior. He may not have connected safety presentations or guidelines to this particular behavior or perceive that it was taught. When asked what he should have done, Corey reasoned that he should have turned the torch off before bending over to pick up the rod. The irony of the situation is that Corey was the student who created the animation depicting the dangers of using a torch with a leaking or damaged hose.

In these situations, Corey demonstrated that he understood appropriate and safe shop behavior, but he did not have an attitude that put safety first. Instead he chose convenience or simply did not think about his actions. The intervention gave Corey knowledge, but it did not affect an adequate change in his behavior. He failed to think before acting.

Before beginning to weld, Aaron was observed yelling "cover!" When questioned, he explained that this was a warning for others to shield their eyes or look away because he was about to strike an arc. He explained that this was a safe behavior that he learned in the classroom from the welding safety unit. In this instance it is clear that the safety unit affected this student's shop behavior. He is aware of others working around him, and he takes responsibility for their safety as well as his own.

At the beginning of the class period, Sam was observed tying his hair back. When asked why, he explained that he did not want it to catch on fire. He said that he learned from the welding safety unit that this was safe behavior for working in the shop. Later in the class period, Sam was observed cleaning part of the shop even though it was not the designated shop clean-up time. When the instructor questioned him about this, he replied that there were some pieces of metal lying on the floor and he wanted to keep the shop safe, so he cleaned them up. He said he learned during the safety unit that this is safe shop behavior.

Sam's behavior is evidence that students in the class learned from other students. Though Sam said he gained this knowledge during the safety unit, his group did not present any material about maintaining a clean shop. Therefore, Sam acquired this knowledge indirectly from the presentation of another group.

Results in this data set show that the intervention affected individuals differently. Some internalized safety and made it a part of their behavior. Other students who seemed to have a less personal connection with welding safety placed personal comfort and convenience above their own well-being. Most of these students said they gained knowledge of safe behavior from the intervention, but those who behaved in an unsafe manner said they did so because of thoughtlessness, personal comfort or convenience.

The researcher collected the third attitude data set by observing for two class periods (180 minutes) how closely the class followed their own safety guidelines. This data was recorded by placing a tally mark next to each guideline whenever someone was observed not following it. *Table 5* shows the class list of safety guidelines and the number of violations observed by the researcher.

Table 5

Student Adherence to Safety Guidelines

Safety Guideline	Number of Observed Violations
Tie back long hair.	0
Wear safety equipment (glasses, gloves, coveralls, leather shoes/boots, helmet).	4
Be sure equipment is in good condition.	0
Be familiar with equipment before using.	0
Keep shop clean.	5
Use the proper lens shade.	2
Know your surroundings.	4
Close tank valves when not welding.	0
Know the location of emergency equipment.	4
No horseplay in the shop.	0
Total Violations	**19**

Throughout the 180 minute observation period, students were observed failing to comply with their own welding safety guidelines 19 times. Of these 19 instances, 15 were situations where students either didn't think about what they were doing or did not want to take the extra time and effort to comply with accepted safe behavior. The other four were the students who could not locate all of the safety equipment.

Over the two observation class periods, the researcher observed four instances when students failed to wear their safety equipment. In one instance, a student did not wear a glove while quenching hot metal. This student received a minor steam burn on his hand and first-hand lesson about wearing protective equipment whenever handling hot metal. The other three incidents involved eye protection. One student complained that his glasses were fogging up and attempted to justify not wearing them. He was observed without his eye protection four times during the 180 minute observation period. Because these observations involved the same student with the same guideline violation, this student was only counted once on Table 5 in the “wear safety equipment” category. The remaining three instances when students failed to wear safety glasses involved students who simply said, “I forgot,” and immediately put their glasses back on their face.

The researcher observed three instances of students leaving practice metal on the floor where someone might step on it. Ten students were observed dropping their welding rod tips on the floor, but only two of those students failed to clean their area without being asked when it was time to clean up. These two students reluctantly cleaned up their mess, but it was clear that they were not self-motivated to keep the shop clean. This guideline seems to be a matter of convenience.

Two students did not initially follow the sixth guideline which says to wear the proper lens shade for welding. The first student was observed gas welding without a face shield and lens. He explained that this behavior was due to laziness and inconvenience. The second student was going to arc weld with a gas welding helmet when the instructor saw him and corrected the behavior.

Guideline seven written by the class said “Know your surroundings.” The researcher observed four examples of students failing to follow the guideline “Know your surroundings.” Three of these were arc welding students who did not completely close the curtains of their booths before welding. The response in each case was that they just didn’t think about it. The fourth example was a student who reached over another working student to get a tool. Although he knew the behavior was unsafe, he explained that the reason he reached over was to save time and effort.

“Know the location of safety equipment” was the ninth guideline on the class list. Out of 20 students, 16 were able to locate the fire extinguisher, first aid kit, fire alarm and safety shower. The other four students could locate some of the safety equipment but had to be reminded of the location of the rest. This result suggests a need for subsequent reinforcement of safety guidelines following the safety unit, which supports the idea of teaching safety every day (Howell, 2003, p. 30).

Some of the safety guideline observations were positive. One student who was preparing to arc weld found that his welder had a defective power switch. He immediately notified the instructor who removed the welder from the shop until it could be repaired. The student knew that it was dangerous to work with faulty equipment. Two students, who missed some of the equipment instruction, asked the instructor for help before attempting to use an unfamiliar machine. These students clearly understood that they needed to be familiar with equipment before working.

Results of this observation period indicate that students generally understand safe behavior. When they act in an unsafe manner, it is not usually because of ignorance. The reason for unsafe behavior seems to be that students sometimes give their own personal comfort or convenience a higher value than safety.

Achievement data was used to address the main research question: "*What are the advantages and disadvantages of replacing teacher-led safety instruction with accident prediction and prevention activities?*" The Welding Safety Exam served as an achievement data source in this study (Appendix C). Tests were scored and the results for each student's answer to each question were calculated. The class average on the test is shown in *Table 6*.

Table 6

Pre- and Post-intervention Achievement Test Scores

	Pretest	Posttest	Difference	*p*- value
Class Test Average	86.8%	93.6%	6.8%	0.003

As a whole, the class showed a 6.8% increase on their test scores. A reason for such little test improvement was the ceiling effect. A ceiling effect occurs when "performance is nearly as good as possible in both treatment and control conditions," (Cohen, 1995). In other words, class pre-test results were so high they left little room for improvement. This indicates an insufficient level of test difficulty. When developing the test, the researcher was limited to existing welding safety tests required by the agriculture department for student shop qualification. These parent tests are practical in nature, and their purpose is to ascertain whether students can identify unsafe behavior. Some might consider this type of test to be "common sense" which is most likely why the class did well initially.

Although the class test average did not show a large change, overall class improvement was significant, with a *p*-value of .003 (*Table 6*). Only results from two specific test questions showed statistically significant class improvement (*Table 7*). This is expected with a protection level of $\alpha = .05$ and a set of 32 items. The class showed a 50% improvement on question three recognizing that safety glasses are necessary even when wearing a welding helmet. Initially, only 10 out of 20 students answered the question correctly, indicating that it is not necessary to wear safety glasses if using a welding helmet. On the post-intervention test, all 20 students answered question three correctly, identifying that it is unsafe to weld without safety glasses even when one is wearing a welding helmet.

On question 32 on the pre-intervention test, 11 students were able to list five types of accidents that can occur when welding with oxy-acetylene. Only one student failed to complete this list on the posttest. It is appears from this result that following the intervention, students were more aware of hazards associated with oxy-acetylene welding.

Table 7

Significant Achievement Test Results

Test Question	Pre-test # of students correct	Post-test # of students correct	P-Value
To weld without safety glasses when wearing a helmet.	10	20	0.0003
List 5 types of accidents that can occur when welding with oxy-acetylene.	11	19	0.0054

The most commonly missed questions on the pre- and post-intervention tests were those dealing with safe operation of gas equipment used in oxy-acetylene welding. Students in this class had little previous experience with gas welding. They were unfamiliar with the equipment, and because the intervention focused on safety and not operation, it did not provide students with the knowledge necessary to correctly answer these questions. A disadvantage of this intervention is that it only addressed welding safety. When it was over, welding theory and technique still had to be taught.

Another disadvantage arose in the on-task data. It is clear from classroom observation during this intervention that student engagement decreases if students remain on the same task for a long period of time. In this case, students lost their focus when tasks lasted longer than 30 minutes.

However, student engagement can be an advantage of replacing teacher-led safety instruction with accident prediction and prevention activities. Each time the instructor redirected the class activity, student engagement returned to near 100%. The students in this class showed they would engage in the intervention activities.

Effect on student attitude could be considered an advantage and a disadvantage of this intervention. Student attitude is a difficult thing to measure. Results of this intervention show that some students did not exhibit an attitude of safety after the intervention. The survey results showed that one student seemed to develop an "it won't happen to me" attitude after the intervention. Observational data showed students who overlooked safety guidelines for convenience or personal comfort. In a 180 minute period, there were 19 instances where students failed to follow their own safety guidelines. In some students the intervention did not instill an attitude of safety.

Effect on student attitude could also be considered an advantage of this intervention. The same data that showed an unsafe attitude for some students showed a safe attitude for others. Based on survey data, two students grew past their "it won't happen to me" attitude and were more concerned about safety after the intervention. Observational data showed that even though some students exhibited unsafe behavior, they understand what behavior would have been more appropriate. In a class of 20 students over a 180 minute period, there could have been many more than 19 unsafe behaviors observed. The advantage here appears to be that the intervention instilled in students an awareness of safety which can be built upon using teachable moments to help students develop safe work habits.

Another advantage of this intervention is the ability it gave 10^{th}, 11^{th} and 12^{th} grade agriculture students to generate accurate welding safety guidelines by identifying possible accidents with a piece of welding equipment and reflecting on equipment operating procedures that would lead to or avoid accidents. Every student was able to make at least a short list of safety guidelines. When they came together as a class, students were able to generate a final, more complete list.

Discussion

Based on the results of this intervention, it appears that student safety projects can be an effective and engaging way to teach welding safety. The advantages of replacing teacher-led safety instruction with accident prediction and prevention activities were giving students the ability to generate accurate welding safety guidelines, affecting student safety attitudes and engaging students in an activity about welding safety.

The researcher observed three disadvantages of this intervention. The first was the extra time required for such an intervention. Students in this subject group were eager to begin working in the shop. When the safety unit ended, students were disappointed to find out that they still had to complete a unit on welding theory and methods before they could begin welding.

The second observed disadvantage was the amount of tests and surveys the students took. Because there was no control group available for this research, it was necessary to use pre- and post-intervention tests and surveys to measure achievement and changes in attitudes. The subject group expressed dislike at the idea of completing one test and survey. Students were extremely dissatisfied to have to complete them a second time and still be required to pass further tests on welding theory and method.

The third major disadvantage observed by the researcher was that student engagement was low when the class remained on the same task for a period longer than 30 minutes. This cycle of engagement might be avoided in the future by focusing on specific tasks for periods less than 30 minutes. This may increase the amount of class periods necessary to complete projects such as the one used in this intervention; however, combining units like welding safety and welding theory may make more effective use of this time.

These advantages and disadvantages have strong implications for teaching welding safety. The presence of the engagement cycle during the intervention suggests that accident prediction and prevention activities may be more effective when paired with other learning activities that allow a more frequent change of focus. While this intervention focused on teaching welding safety guidelines, it was necessary to follow the safety unit with a welding methods and theory unit not included in this research. In theory, it might be more effective to teach these units concurrently. Teaching welding theory at the beginning of the class period and then working on accident prediction and prevention projects could avoid the disengaging effects of the engagement cycle seen during this intervention. Teaching welding theory and method during the first half of class, followed by student work time for the welding safety project could address the disadvantages of the intervention by shortening the overall length of time students spend in the classroom, refocusing student attention to avoid the engagement cycle, and combining the tests into one. It might also provide deeper meaning for student safety projects by giving greater context to safety practices.

An implication of the intervention is that students develop safe welding behavior differently. While students may have a similar knowledge of safe welding behavior, they have different levels of motivation for practicing safe behavior. Shop observations found examples of levels of behavior motivation in three students: *the Negotiator, the Absent Minded Gas Welder and the Spontaneous Cleaner.*

After the intervention, Jeremy, the Negotiator, only chose to wear his eye protection because failure to do so would have resulted in a loss of shop privileges. When his safety glasses became fogged, Jeremy felt justified in removing them. He explained to the instructor that he felt it unsafe to wear foggy glasses. He reasoned that his welding helmet would protect his eyes from danger and the glasses were not necessary. Placing personal comfort over safety and defying an accepted guideline demonstrates that he had not yet developed a habit of safety. Jeremy had to be extrinsically motivated to practice safe behavior because he perceived himself as the exception to the rule.

Corey, the Absent Minded Gas Welder, failed to think about the possible consequences of his actions. When he bent over to pick something up while holding a lit torch with his other hand, he inadvertently pointed the flame dangerously at the gas hoses. Ironically, Corey is the same student who developed the animation depicting an explosion resulting from a damaged hose. He had knowledge of safety but had not integrated it into his behavior. Corey had not yet developed a habit of safety, but he was willing to change his behavior when it was brought to his attention that his actions were unsafe.

Sam, the spontaneous cleaner, was observed cleaning the shop of his own volition. He recognized a situation that was potentially dangerous to students and took it upon himself to clean up the work area to avoid accidents. Cleaning the shop to maintain a level of safety demonstrated that Sam is intrinsically motivated to behave in a safe manner. For Sam, safety is becoming a habit.

Jeremy, Corey and Sam had the same amount of safety training in the classroom, but they each developed safe behavior at different rates. This research suggests that an engaging activity such as the one used in this intervention can help students think about safety, but until safety becomes personal to them in some way, they may not develop habits of safety.

The observational data collected during this research suggests that there is a hierarchy of safety behavior (*Table 8*). The students described above are examples of behaviors observed throughout the class. As students began working in the welding shop, their safe behavior seemed to occur at different levels. The lowest level in this hierarchy is "the exception to the rule". People like Jeremy, who operate on this level of behavior, may have a knowledge of safety but exhibit the "it won't happen to me" attitude as described by Howell (2003, p. 30). They look for ways to excuse themselves from following accepted guidelines. These people place a higher value on their own comfort and convenience than on safety. They rationalize their unsafe behavior and seek justification by attempting to negotiate compromises.

Table 8

Hierarchy of Safety Behavior

Level 1:	The exception to the rule.
Level 2:	The apathetic worker.
Level 3:	The compliant worker.
Level 4:	The safety steward.

The second level on the safety behavior hierarchy is “the apathetic worker”. The apathetic worker has knowledge of safety but doesn’t seem to apply that knowledge. Corey showed apathy in his situation when he inadvertently pointed the torch at his gas hoses. His explanation that he knew what he should have done but just didn’t think about it shows that he was apathetic toward welding safety. The knowledge was there, but Corey had not yet incorporated it into his behavior.

“The compliant worker” is the third level on the safety behavior hierarchy observed in this research. A compliant worker is someone who has acquired knowledge of safety and successfully incorporated that knowledge into their behavior. These people recognize unsafe situations and take necessary measures to correct them. Sam gave us an example of this behavior when he was observed cleaning the work area on his own outside of the designated clean-up time. Sam recognized a potentially hazardous situation and took action to prevent accidents. He is compliant with accepted safety guidelines and takes responsibility for his own safety and the safety of others.

When analyzing the observational data, it became apparent to the researcher that there is a fourth level on the safety behavior hierarchy which could be called “the safety steward”. The safety steward is someone who actively seeks unsafe situations in order to prevent accidents before they occur. In many welding classes, this role is most likely filled by the instructor, who is the steward of the shop.

During shop observations, the instructor estimated that 15% of students in the focus group were at level one on the behavior hierarchy, considering themselves to be an exception to the rule. It appeared to the researcher that 60% of the focus group fell into the apathetic worker category or level two. The remaining 25% of the group showed that they were compliant students who could recognize and correct unsafe situations. No students exhibited behavior during observation that would place them at level four, the safety steward.

Perhaps the greatest advantage of this intervention is the unconventional, bottom-up approach to teaching welding safety that allows students to learn from each other with very little instruction from the teacher. In this research, student safety presentations and subsequent class discussion led to the development of a common culture of shared norms around welding safety within the class. This class culture has its own language stemming from the experiences shared by students during the project. Welding students learned basic safety guidelines without sitting through a lecture that they may have considered to be boring. They developed their own accurate class set of safety guidelines.

Traditionally, the approach to teaching shop safety has been a top-down, from-on-high approach that asks students to adopt someone else’s safety guidelines. While the traditional method may be effective at preparing students for the safety test in order to avoid litigation, the bottom-up approach may have a greater effect on student behavior because it allows students to "own" their safety guidelines.

A teaching model for helping students develop habits of welding safety based on the results of this research would begin with teaching welding theory and methods while implementing an activity that allows students to explore for themselves the consequences of unsafe shop behavior. This welding unit would be followed by consistent behavior reinforcement in the shop, making students aware of both their safe and unsafe behaviors in an attempt to raise their behaviors to the upper levels of the safety behavior hierarchy.

Because helping students commit to abiding by safe shop practices on a daily basis will take more than one safety lesson at the beginning of the semester, safety should be revisited often (Howell, 2003, p. 31). Students can begin to develop safe work habits when they understand which behaviors are safe. The next step is to get students to apply their safety knowledge in the shop.

Traditionally, the purpose of welding safety has been to avoid litigation. While a traditional welding safety education method may prove effective in helping students answer written safety questions, it may not be the most effective way to affect their behavior. Student accident prediction and prevention assignments can be a powerful method for teach welding safety in a way that engages students and influences their behavior. Findings of this research have led to the need for further study. This project covered the safety unit alone, and the welding theory unit had to be covered separately. What effect does welding theory instruction have on accident prediction/prevention activities when taught concurrently with welding safety? Howell (2003) talked about revisiting safety often. How often should safety be revisited in a welding class? How can welding safety be frequently and effectively revisited? Another implication of this research was that students seem to behave in levels of safety which can be described by the hierarchy of safety behavior. Future research could focus on the length of time it takes for students to move from one level of the hierarchy to another. After the safety unit, how long does it take students to exhibit safe behaviors on their own? While there are many questions yet to be answered, this research has one definite implication: welding safety doesn't have to be a chore.

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Appendix A

Welding Safety Project Assignment Sheet

WELDING SAFETY PROJECT

Turn in a written report that includes the following information:

- Identify at least 5 different types of accidents associated with your assigned welding system (gas or electric).
- Explain the behavior that led to each accident.
- Explain the consequences of this behavior.
- Explain how the accident could have been prevented.
- Include a list of your information sources for each accident.
- Using role plays or visual aids, present the causes, consequences and preventions of each type of accident to the class.

During the other presentations, develop your own list of at least 10 welding safety guidelines. This list will be turned in at the end of the project.

Participation – At the end of your safety guideline list, write the names of your group members (including yourself). Using a scale of 1-5 (1=lowest, 5=highest), rate each group member according to their participation in the group work.

Appendix B

On-Task Data Collection Sheet

INTERVENTION ON-TASK DATA

group #	Student # / Task	10	20	30	40	50	60	70	80	
1	7									
1	2									
1	8									
2	9									
2	1									
2	15									
3	10									
3	14									
3	16									
4	11									
4	19									
4	20									
5	6									
5	18									
6	12									
6	5									
7	3									
7	13									
7	4									
8	17									
	Total Off Task									
	Total On Task									

T = on task
O = off task
A = absent

Appendix C

Welding Safety Test

NAME ______________________________ DATE ________________

ARC WELDER
SAFETY EXAM

Write the word "safe" or "unsafe" in the space provided to describe the practices related to the safe operation of the arc welder. (1 point each)

______ 1. To weld without a helmet.

______ 2. To weld while standing on wet ground or in water.

______ 3. To weld without safety glasses when wearing a helmet.

______ 4. To weld with gloves.

______ 5. To start welding without warning others nearby.

______ 6. To use a number 10 lens in your helmet.

______ 7. To weld in a t-shirt.

______ 8. To weld in dirty or greasy clothes.

______ 9. To chip slag without safety glasses.

______ 10. To weld closed containers without first making them safe.

______ 11. To weld with a cigarette lighter in your pocket.

______ 12. To use a welder that is not grounded.

______ 13. To weld while the floor around you is covered with scraps.

______ 14. To weld indoors when the ventilation fan is not running.

______ 15. To leave hot metal lying where someone may come in contact with it.

16. List 5 types of accidents that can occur when arc welding. (5 points)

OXY-ACETYLENE WELDER
SAFETY EXAM

Write the word "safe" or "unsafe" in the space provided to describe the practices related to the safe operation of the oxy-acetylene welder. (1 point each)

______ 17. To light the torch with a match or another torch.

______ 18. To drop gas cylinders off a truck.

______ 19. To repair hoses with tape.

______ 20. To blow dust off your clothing with oxygen.

______ 21. To weld or cut with oil-soaked clothing.

______ 22. To raise the acetylene hose pressure above 15 psi.

______ 23. To wear a shaded face shield while cutting with the oxy-acetylene welder.

______ 24. To wear leather gloves while cutting.

______ 25. To let out adjusting screws before opening tank valves.

______ 26. To blow out cylinder valves before attaching regulators.

______ 27. To use soap and water to find leaks.

______ 28. To keep the protector caps on cylinders not in use.

______ 29. To cut galvanized metal indoors.

______ 30. To cut or weld on a container before it has been made safe.

______ 31. To work with oxy-acetylene equipment when you think it may be defective.

32. List 5 types of accidents that can occur when welding with oxy-acetylene. (5 points)

I have taken the above exam and have correctly answered the questions. I have successfully demonstrated the safe operation of the arc welder and the oxy-acetylene welder with my instructor's supervision. I promise to conduct myself in a fashion that will not create hazards that may cause injury to others or myself while working in the laboratory.

Signed: ______________________________ ______________________________
Student Instructor

Date: ______________________________

Appendix D

Welding Safety Project Rubric

Teacher Name: **Mr. Edwards**

Student Name: ______________________

CATEGORY	5	4	3	2	1
Accidents	Project includes at least 5 different types of accidents related to assigned topic.	Project includes 4 different types of accidents related to assigned topic.	Project includes 3 different types of accidents related to assigned topic.	Project includes 2 different types of accidents related to assigned topic.	Project includes 1 type of accident related to assigned topic.
Causes	Project includes causes for all 5 accidents.	Project includes causes for 4 accidents.	Project includes causes for 3 accidents.	Project includes causes for 2 accidents.	Project includes causes for 1 accident.
Consequences	Project includes consequences for all 5 accidents.	Project includes consequences for 4 accidents.	Project includes consequences for 3 accidents.	Project includes consequences for 2 accidents.	Project includes consequences for 1 accident.
Preventions	Project includes preventions for all 5 accidents.	Project includes preventions for 4 accidents.	Project includes preventions for 3 accidents.	Project includes preventions for 2 accidents.	Project includes preventions for 1 accident.
Information Sources	Project includes a list of information sources for all 5 accidents.	Project includes a list of information sources for 4 accidents.	Project includes a list of information sources for 3 accidents.	Project includes a list of information sources for 2 accidents.	Project includes a list of information sources for 1 accident.
Oral Presentation	Oral presentation included causes, consequences, preventions and visual aids for all 5 accidents.	Oral presentation included causes, consequences, preventions and visual aids for 4 accidents.	Oral presentation included causes, consequences, preventions and visual aids for 3 accidents.	Oral presentation included causes, consequences, preventions and visual aids for 2 accidents.	Oral presentation included causes, consequences, preventions and visual aids for 1 accident.
Safety Guideline List	Student has developed and turned in their own list of 10 safety guidelines based on presentations.	Student has developed and turned in their own list of 7-9 safety guidelines based on presentations.	Student has developed and turned in their own list of 4-6 safety guidelines based on presentations.	Student has developed and turned in their own list of 2-3 safety guidelines based on presentations.	Student has developed and turned in their own list of 1 safety guideline based on presentations.
Group Participation	Student participated equally with the rest of the group.		Student participated half as much as the rest of the group.		Student did not participate with the group.

Appendix E

Welding Safety Survey

NAME ______________________________ DATE ______________

WELDING SAFETY SURVEY

Use the following ranking system to evaluate the statements regarding the class:

1 Strongly Disagree
2 Disagree
3 Neutral
4 Agree
5 Strongly Agree

1 2 3 4 5	1. It is the responsibility of every student to work in a safe manner.
1 2 3 4 5	2. The time I spend learning about safety in class is used productively.
1 2 3 4 5	3. I feel challenged in this class.
1 2 3 4 5	4. I learn from the safety assignments and activities in this class.
1 2 3 4 5	5. This class pushes me to work harder.
1 2 3 4 5	6. I play an active part in the learning process in this class.
1 2 3 4 5	7. I do my best work for this class.
1 2 3 4 5	8. The level of difficulty is appropriate for this class.
1 2 3 4 5	9. When I work in the shop, I forget the safety lessons we talked about in the classroom.
1 2 3 4 5	10. I enjoy learning in this class.
1 2 3 4 5	11. I had welding experience before taking this class.
1 2 3 4 5	12. It is important to review safety before working in the shop.
1 2 3 4 5	13. I already know welding safety and don't need to spend class time on it.
1 2 3 4 5	14. Others may need to worry about welding safety, but I don't. I won't get hurt.
1 2 3 4 5	15. Learning about safety is boring.
1 2 3 4 5	16. It is impossible to make safety interesting. It is better to just push through it so we can go to work.
1 2 3 4 5	17. The safety principles I learn in the classroom affect my behavior in the shop.
1 2 3 4 5	18. I wish the class would push me more.
1 2 3 4 5	19. The student must pay strict attention to their work to insure their safety.
1 2 3 4 5	20. Not interfering with others is a good safety rule.

1 2 3 4 5	21. Horseplay is okay if the instructor doesn't see.
1 2 3 4 5	22. Students working unsafely should be required to take more safety instruction.
1 2 3 4 5	23. I should not talk to another person when they are operating a machine.
1 2 3 4 5	24. Loose or torn clothing as well as hair can cause serious accidents.
1 2 3 4 5	25. Horseplay, such as throwing objects at another student, is okay sometimes.
1 2 3 4 5	26. I can be trusted to work safely in the shop.
1 2 3 4 5	27. It is the job of the teacher, not the students, to ensure shop safety.
1 2 3 4 5	28. Learning about welding safety is a waste of time because I already know how to work safely.
1 2 3 4 5	29. I know how to work safely, but I choose not to because working safely is boring.
1 2 3 4 5	30. Welding safety is the responsibility of everyone working in the shop.

31. In your opinion, what is your role as a student in this class?

32. In your opinion, what is the teacher's role in this class?

33. Is it important to learn about safety before working in the shop? Why or why not?

34. Please write any additional comments/feedback you would like to share with regards to this class.

Appendix F

Student work samples: safety guideline lists

STUDENT 1

Long hair must be tied up

weld on only safe workspace

wear eye protection

make sure you have the proper shade of welding helmet

Close tanks when done

Clean shop

proper footwear

update equipment

make sure ventilation works

STUDENT 13

Safety guidelines

1) cap on tank
2) keep hair tied back
3) Shoes
4) gloves
5) sheild & glasses, Dark lenses
6) proper clothing
7) clean work area
8) follow rules
9) warn before welding
10) Equipment, know how to use
11) tie hair back
12) electricity
13) clean area
14) turn off tanks
15) keep safety equipment available, know how to use the equipment.

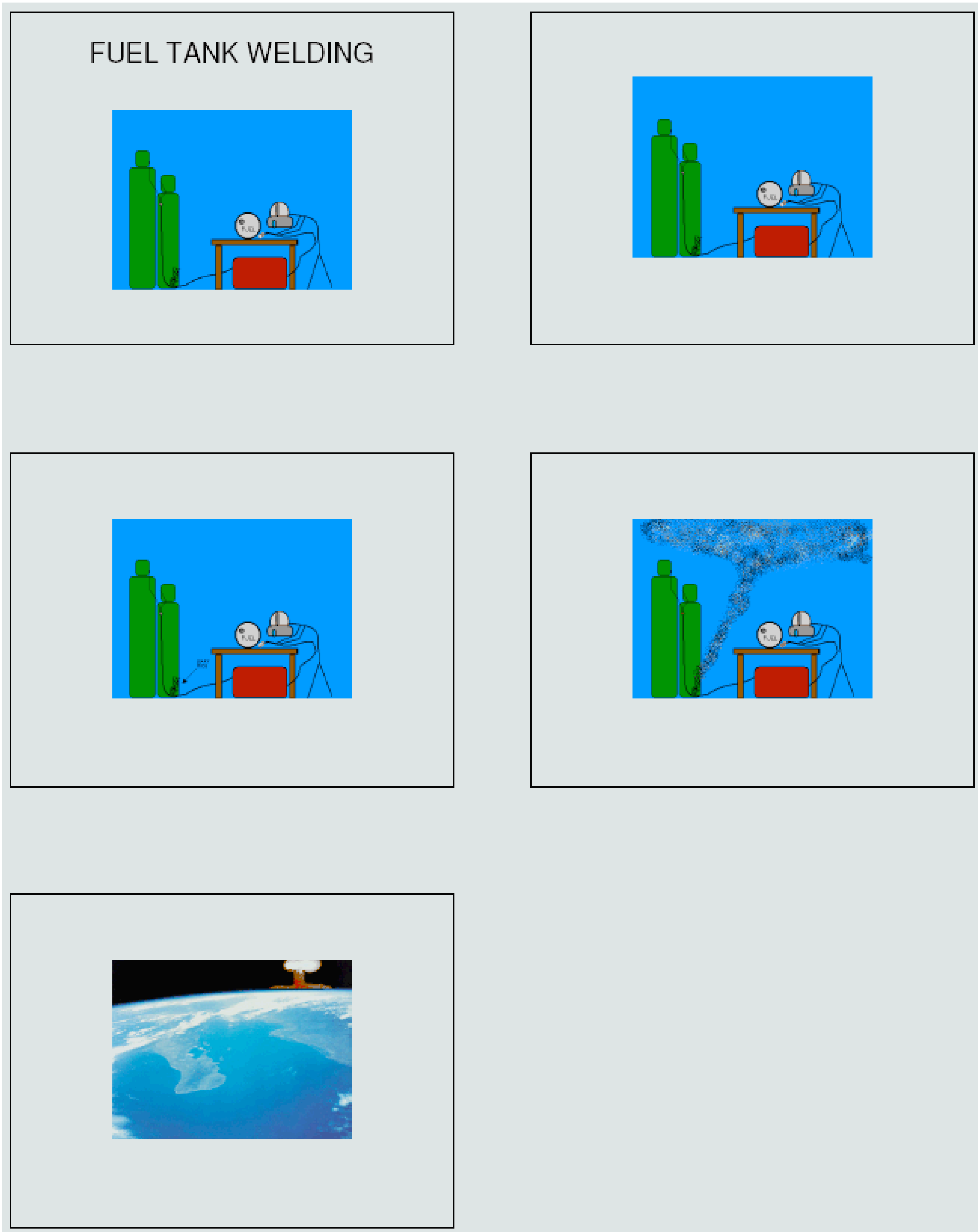
STUDENT 15

welding guidlines

1 long hair must be tied up
2 welding on a barrel of gas unsafe
3 wear welding gloves
4 wear face sheild
5 not closing tanks when done unsafe
6 wear proper footwear
7 clean shop
8 make sure equipment isnt defective
9 make sure work area is properly ventilated
10 don't light the torch with a match

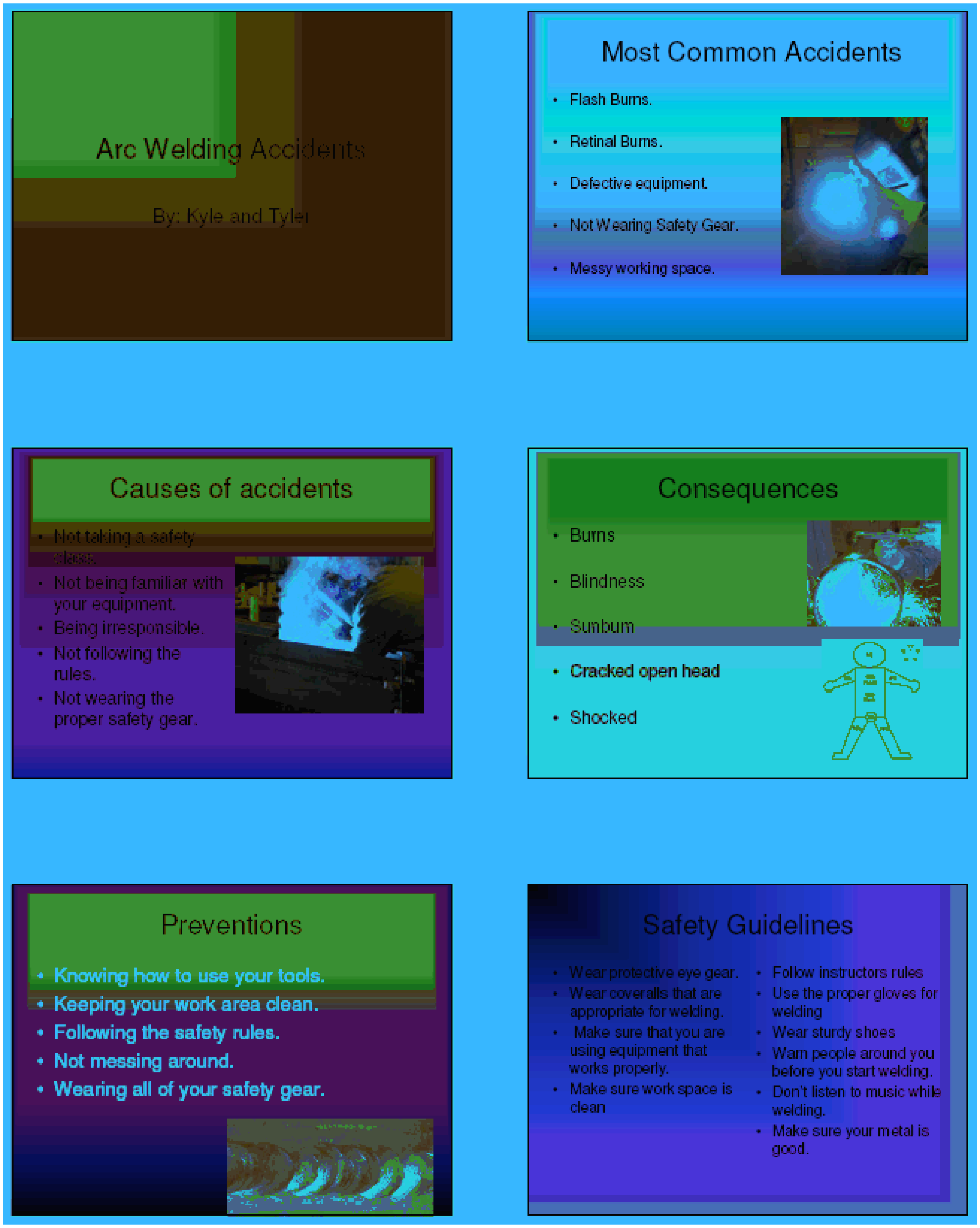
Appendix G

Safety Animation Slides



Appendix H

Visual Aid Example from Group Safety Presentation



Appendix I

Visual Aid Example from Group Safety Presentation