UNIVERSITY OF ARIZONA AGTM GREEN WELDING: ENVIRONMENTALLY-FRIENDLY WELDING SKILL DEVELOPMENT

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University of Arizona AGTM Green Welding: Environmentally-Friendly Welding Skill Development Project

Project Abstract

Funding will be used to acquire the new VRTEX® virtual reality arc welding training system from Lincoln-Electric for the Agricultural Technology Management Education program at the UA Agricultural Technology Education Center. The system makes it possible to teach students to learn to weld in an eco-friendly manner. Educational programs using the virtual reality training system minimize material waste and environmental footprint. The system helps the instructor to teach welding skills without the use of shielding gas, welding electrodes, or weld coupons. Additionally, welding fume removal is reduced. Welding programs reduce the disposal of waste as a result of training such as base material (mild steel), electrode stubs, welding slag, consuming Carbon Dioxide gas, and welding machine consumable parts. The VRTEX® system allows students to be taught with a reduction in overall energy consumption by requiring less energy than a traditional welding machine, wire feeder and weld fume control system. Utilization and implementation of the system can greatly reduce: facility electrical consumption, welding material usage such as mild steel coupons, metal scrap and waste, welding consumable usage, and costs associated with capturing and filtering welding fumes and gases.

Tangible benefits include: Economic impact for the Department: (1) decreased spending on purchase of mild steel flat stock used for practice welding coupons; (2) decreased spending on supplies used to cut and shear metal for welding coupons; (3) decreased funds spent on student worker labor to handle, cut, and inventory practice welding material prior to and during the academic semester; (4) Reduced time spent in laboratory clean up and disposing of waste materials at the conclusion of laboratory welding skills practice. Environmental impact: (1) Reduced waste from electrode welding stubs, metal slag, used welding coupons; (2) Reduced amount of welding fumes extracted from laboratory; (3) Reduced amount of water used for cooling hot metal. Instructional impact: (1) Reducing student apprehension of going into the welding booth for the first time and engaging in hands-on skill exposing the student to heat, electrical current, and welding fumes; (2) Introducing state-of-the-art technology into the UA course curriculum.
Project Personnel and Involved Units

Project Director
Edward A. Franklin, Associate Professor
Department of Agricultural Education
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Role: Project management, secure project funding and external funding and in-kind matching. Order equipment; attend and participate in training in use of equipment; communicate with project member, implement welding simulator into AGTM 100 and AED 460/560 courses; provide training for high school agriculture science and welding instructors.

Project Co-Director
Charles Defer, Machinist
Agricultural & Biosystems Engineering Department
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Role: Assist with agricultural education and agricultural & bio systems engineering student training; provide training to UA Campus Agricultural Center farm maintenance staff.

Business Manager
Ms. Michelle Hintz
Department of Agricultural Education
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Role: Business manager, track and handle account payables and provide statements.

Project Description

This project will enable the Department of Agricultural Education to add state-of-the-art virtual reality training to our welding instruction unit of our Agricultural Technology Management (AGTM) curriculum to enhance the quality of our training, increase the number of agricultural education teachers and agricultural technology management students with welding skills we can train, and attract computer-savvy young people to well-paying careers in welding. Demand for skilled welders is growing as one generation of workers retires and fewer young people seek industrial careers. Through Virtual Reality Arc Welding (VRAW™) we can provide a safe introduction to the field to future teachers who may become high school instructors of welding and then provide the highest quality training for them.

The arc welding trainer allows students to learn and practice welding in a safe, simulated environment. It consists of a computer contained in the realistic body of an arc welding machine, advanced virtual reality software, an electrode holder for the virtual electrode, a virtual stinger for shielded metal arc welding (SMAW), a virtual gas metal arc torch for gas metal arc welding (GMAW) and flux-cored welding (FCAW), a stand that holds welding coupons, and a helmet that immerses the student in the sight, sound, and touch of actual welding. Students can practice welding
“virtually” before they enter the welding lab. Through the high-tech face mounted display imbedded in the helmet, students are able to watch and listen as they strike an arc, guide the electrode, and create a “puddle” of molten metal. The device scores each weld and gives immediate feedback to the student welder. Other students can watch simulated welds projected on a screen while the instructor teaches welding technique and theory.

Welding is the most common way of permanently joining metal components. In this process, heat is applied to metal pieces, melting and fusing them to form a permanent bond. Because of its strength, welding is used in military, shipbuilding, automobile manufacturing and repair, aerospace applications, and thousands other manufacturing activities. Welding also is used to join beams in the construction of buildings, bridges, and other structures and to join pipes in pipelines, power plants and refineries.

The U.S. Department of Labor’s Bureau of Labor Statistics (BLS) projected openings for 617,900 workers in jobs that require welding to replace retirees and others leaving the occupations between 2008 and 2018. According to BLS, job placement prospects are good for welders trained in the latest technologies. The BLS says welding schools report that graduates have little difficulty finding work, and many welding employers report difficulty finding properly skilled workers.

Industry confirms the needs for welders. The American Welding Society (AWS) declared, “The United States in the midst of a welder shortage that is expected to intensify as booby boomers age and the need for skilled labor grows.” The same AWS report said more than half of all welders are nearing retirement age and adds:

> Compounding the problems is the fact that high schools, universities, and vocational institutions across the country are struggling to recruit younger talent to meet the burgeoning demand for welders. Additionally, stereotypes have stigmatized the welding industry, invoking the image of a “dark” and “dirty” job with little prospect for advancement and salary growth. The fact is welding is one of the oldest and thriving fields that plays a key role in the vast manufacturing sector. A career in welding can be extremely lucrative and exciting, and can lead to a high-level employment in various industries. In fact, for those who are involved in the welding industry, there is a strong conviction that large part of the U.S. economy is dependent on welding, and that continued advances in the field are necessary to increase productivity and strengthen the nation’s financial stability.

Historically, students entering the agricultural education teacher training program possessed farm or ranch backgrounds, were mostly male, and were engaged in vocational agriculture programs in high school where welding skills were taught, or they completed welding courses at a community college program before coming to the U of A. Today’s agricultural education and agricultural technology management student is “different”. Our research of students entering our AGTM 100 course reveals an equal number of female and male students enroll in the program, come from urban and suburban communities, and have experience with computers and virtual software programs. However, the majority has not completed career and technical education (CTE) coursework in high school, nor do they possess previous welding experience. This trend suggests students needing additional instruction to become familiar with process of operating a welder and
additional laboratory time to develop the skills to become comfortable in the laboratory welding booth.

Twenty-four agricultural education (AED) and agricultural technology management (AGTM) students will complete the welding training in the AGTM 100 course during the period of the grant in the fall 2013 semester. Students will complete a pre-instruction assessment to measure their previous welding experience, perceived ability and levels of confidence with welding, and use of virtual instruction in preparation for hands-on training. Each student will be introduced to and have the ability to practice virtual welding of shielded metal arc welding (SMAW), gas metal arc welding (GMAW), and flux-core arc welding (FCAW) before moving to live welding skill practice in the AGTM lab. Following the completion of laboratory welding skills and project construction, students will be administered a post-welding instruction and experience assessment to determine measurable changes in knowledge, attitude, or perceived ability and levels of confidence to perform assigned welding skills. This pilot survey data along with student responses will be used to develop and test instructional strategies for future AGTM 100 offerings to best take advantage of implementing virtual welding instruction into our teacher preparation program.

Currently, our AGTM 100 Principles and Practices in Agriculture Mechanics course covers topics as laboratory safety tool and equipment identification and use, woodworking, shielded metal arc welding, gas metal arc welding, flux core arc welding, oxy-fuel welding and cutting, manual and automated plasma arc cutting, cold metal work, and powder coating applications. Students complete multiple skill activities during six hours of weekly laboratory instruction which culminates with the construction of four projects: sawhorse (wood working), battery cable puller (cold metal), Wilbur cutout (plasma cutting & powder coating), and a pipe hand truck (welding and cutting). Students enrolled in the AGTM 100 course pay a laboratory fee (currently $50.00, based on FY 2007 material costs) which is used to help the Department defray the cost of operating equipment and tools used to gain hands-on skills, and materials for constructing projects which students take home at the end of the course. A portion of the fee goes to the purchase of shielded metal arc welding electrode, mild steel flat stock, multiple cylinders of carbon dioxide gas, gas metal arc welding contact tips, flux core arc welding contact tips, spools of gas metal arc welding electrode wire, and spools of flux core arc welding electrode wire.

The program is under the leadership of an experienced instructor with 13 years of high school welding instruction experience, and 12 years as a university teacher-educator. Twenty-four students may go on to become secondary or community college agricultural educators, or obtain positions in agriculture technology management-related industries following graduation. In addition, we will use the system during annual open-houses and field days for high school agriculture science students and FFA members so they can experience welding in a realistic and safe environment, and for professional development workshops for both high school agriculture science, and welding instructors.

The specific objectives of this project are to:
1. **Expose UA students to virtual welding training technology.** Develop, test, and modify a pre and post-instruction instrument to measure undergraduate student knowledge of welding skill instruction.

2. **Begin reducing energy consumption used by traditional shielded metal arc welding machines.** By introducing students to virtual welding instruction, we will be taking steps to reduce the time students are in the welding booth using actual machines to develop the hands-on psychomotor skills.

3. **Begin reducing the production of welding fumes from burning electrodes.** By introducing students to virtual welding instruction, we will be taking steps to reduce the production of welding fumes, a byproduct of the arc welding process which occurs from the burning of steel electrodes.

4. **Begin reducing the amount of material used for welding practice.** Our goal is to scale back on the amount of mild steel we purchase annually that is cut up and used for “practice coupons”. Thus saving our laboratory equipment (i.e., horizontal band saws and metal chop saws) used to cut steel into coupons.

5. **Begin reducing the amount of water used to cool hot metal from welding practice.** By reducing the amount of time and material used in the welding booths, we can begin conserving water used to cool hot metal and later dumped in the landscape.

6. **Evaluate** the use of the instructional materials and teaching module to effectively teach undergraduate AED, AGTM in small-scale off-grid systems.

The major expected outcome of this project is reduction in use of electrical energy, reduction in use of welding materials such as welding electrodes, carbon dioxide shielding gas, mild steel for welding coupons, reduce wear on equipment used to cut and shear steel for welding skill activities, labor used to cut material, and reduction in production of welding fumes.

The scope of this project is to evaluate the effectiveness of incorporating virtual welding training technology into a principles and practices course designed for preparing industry managers and classroom instructors, and our instructional methods course as tool to provide exposure to the use of a state-of-the-art virtual technology hands-on trainer to effectively change knowledge and attitudes of undergraduates about technology instruction.

Additionally, we will target other populations including secondary agriscience instructors, and welding instructors.
Benefits to UA Students

The perceived benefits to UA students enrolled in the AGTM 100, AED 460/560, or AED 597g is the opportunity to gain hands-on experience with the simulated welding system. In AGTM 100, the target audience is undergraduate students developing laboratory welding experience. In AED 460/560, the target audience is both undergraduate senior and graduate pre-service agricultural education student teachers studying instructional strategies and preparing for their 13-week student teaching internship experience. Graduate students in AED 597g are completing course work developed to meet their individualized needs to complete their graduate program in agricultural education. For all audiences, the opportunity to use a virtual welding simulator.
Student enrollment in our AED and AGTM courses using the laboratory teaching facility is limited to due to the size of the facility. In the fall semester, enrollment in AGTM 100 is limited to 24 students. AED 460/560 enrollment is dependent upon the number of student applicants admitted to the agricultural education student teacher preparation program. AED 597g may convene with AGTM 100 depending on space. The size of the course will vary with each class to a maximum of 24 students.

With the acquisition of this welding system, there is an opportunity to create a modified version of the AGTM 100 course and offer it during both the spring semester and summer session with a focus on welding technology.

Benefits to Non-UA Students

We hope the addition of this technology will entice non-UA students, such as the population of high school agricultural education teachers (N = 80), high school welding technology instructors (N=40) to come to the UA Campus Agricultural Center to participate in specialized welding technology workshops during the summer months to gain professional development experience for graduate credit.

The Association for Career and Technical Education of Arizona (ACTEAZ) (http://www.acteaz.org/events/summer-conference/2013_sc_general_info/) conducts the association’s annual conference in Tucson during the month of July. For the past two summers, our Department has played host to the ACTEAZ welding instructor’s professional development workshops providing the association with access to our AGTM classroom and laboratory. This workshop has been limited to 40 instructors. Here is an opportunity to showcase the welding instructional system for the state’s high school welding instructors. We can take advantage of their presence here in Tucson and present opportunities for this group to possibly make use of the technology at our facility. Should the ACTEAZ conference organizers desire to have conference attendees participate in a virtual welding system workshop, a special workshop may be developed by the Department.

Another target audience is high school agricultural education students who come to the UA Campus Agricultural Center annually to compete in the State Agricultural Mechanics Career Development Event (CDE) conducted during the Spring FFA Field Day, hosted by the College of Agriculture & Life Sciences. Each year the state’s top 25 high school agricultural mechanics CDE four-person teams compete in a hands-on competition to determine the top school and state champion team to represent Arizona in the National FFA Agriculture Technology & Mechanical Systems CDE in Louisville, KY. This is an opportunity to showcase state-of-art welding technology and attract potential undergraduate students.

Project Timeline

If our proposal is selected, we would use the time between the award announcement (March, 2013) and the funding date (July 2013), to coordinate a welding simulator training session for Dr. Franklin to attend and participate with Lincoln-Electric. An order for system delivery after July 1 would be arranged. This will provide the Department of Agricultural Education time to make the necessary arrangements to the
teaching facility prepare for the welding simulator and plan its actual integration into the fall AGTM 100 course curriculum.

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<th>MONTHS</th>
<th>TASK/ACTIVITY</th>
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| Jul – Aug | • Set up Green Fund account.  
• Set up account with Lincoln-Electric to acquire VRTX™ 360 System.  
• Acquire system.  
• Schedule for instructor training. | • Prepare a pre-instruction assessment of student welding knowledge, attitude, and perceived ability. |
| Sep | • Introduce VRTX™ 360 into the AGTM 100 course curriculum by rotating three groups of eight students.  
• Introduce VRTX™ 360 to pre-service student teachers during the regular AED 460/560 Friday course. | • Pilot-test pre-instruction assessment with both AGTM 100 and AED 460/560 classes.  
• Begin with SMAW and continue with GMAW simulated welding instruction for AGTM 100 students.  
• Collect comments from pre-service student teachers about use of the system as an instructional method to introduce welding technology to students and provide simulated welding instruction to students. |
| Oct – Nov – Dec | • Continue with simulated welding instruction to AGTM 100 students using the SMAW, GMAW, and FCAW simulator programs. | • Continue exposing AGTM 100 students to the VRTX™ 360 until all enrolled students have gained time under the hood and experienced the virtual welding system prior to moving to the laboratory for hands-on instruction in the welding booth.  
• Administer post-instruction assessment.  
• Analyze results of pre and post assessment instruments.  
• Prepare and submit progress report to Green Fund Committee. |
| Jan – May | • Conduct AGTM 100 spring course with special emphasis on detailed welding instruction using VRTX™ system to introduce each section of SMAW, GMAW, and FCAW welding prior to laboratory welding. | • Monitor use of virtual system.  
• Chart AGTM student use and performance on the system.  
• Develop and test hands-on welding skill activities utilizing virtual system as the foundation. |
| June – July | • Prepare for summer ACTEAZ conference and presenting VRTX™ to agricultural education teachers and welding instructors. | • Analyze feedback from instructors on the value of the virtual system as a classroom instructional tool and pre-laboratory training tool.  
• Share results with Arizona Agriculture Teachers Association leadership, and ACTEAZ leadership. |
Metrics

Through UA Green Fund support of this project we envision the following impacts:

- Introducing virtual welding technology instruction to **24 undergraduate AGTM 100** and estimated **12-15 AED 460/560 pre-service student teachers** during the fall 2013 semester.

- Develop and pilot-test a spring version of AGTM 100 with a focus on welding technology targeting developing extended student time with VRTEX™ 360 training system.

- Decreasing the amount of laboratory welding machine use dedicated to start up welding instruction.

- Decreasing the amount of mild steel, stick welding electrodes, GMAW welding machine consumables, and carbon dioxide gas used for practice skill development.

- Decreasing the amount of welding fumes produced from the burning of stick welding electrodes as a result of practice skill development.

**HOW TO MEASURE AND REPORT IMPACTS** – Use of pre and post instruction assessment on student knowledge and attitude about welding experience and the use of the virtual welding system as tool to introduce welding instruction. This information will reveal impact of the virtual welding instructional method to overall change in student knowledge and attitude about welding instruction.

**Supporting Project in the Long Term**

We feel the technology is so important that we will be able to create professional development opportunities for students outside of the university and through the development of workshop presentations and short-course classes, be able to generate funding from workshop fees to continue the update of software for the virtual welding system.
