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Teaching and Learning Agricultural Mechanics in the 21st Century

Adjusting to Teach Agricultural Mechanics at a Distance

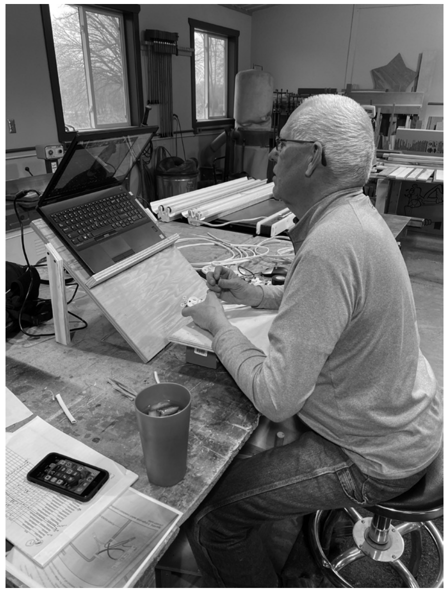
by Gaea Hock

As I write the editor comments for this issue we are living through the COVID-19 pandemic. It is a surreal time for everyone, but especially for educators who were tasked with converting their classes to an online environment.

Commodity groups, agricultural organizations, textbook companies, and private industry are providing curriculum and virtual experiences for the students. Teachers are helping each other find and utilize the best resources possible. With all of the material being shared with teachers, I wondered how students could learn and practice agricultural mechanics competencies via distance. What can teachers do to help students when there is a need to practice the skills with equipment in a lab setting?

Brandie Disberger, the instructor for the emerging technologies class at K-State, scrambled to find electricity kits to teach the unit on electronics and sensors in agriculture technology and mailed them to the students.

The KSU agricultural structures class is taught by a former agriculture teacher at an area high school. The move to a virtual environment forced him to consider how he could teach the concepts via distance. Wiring components and diagrams were shipped to each student to complete the unit. He then rigged up his laptop and hosted a live Zoom session to walk the students through the process of electrical wiring.



Mr. Kurt Dillon, Kansas Ag Ed Program Consultant and Instructor for Agricultural Structures, teaches electrical wiring to shelter-at-home students via Zoom.

High schools across the nation also had to find a way to teach their students via distance technologies. Each school district is handling the situation in their own way. Jim Weller, agricultural mechanics teacher at Chapman High School, shared with me how he adjusted his classes for distance delivery. He had his students complete a Google Form to indicate what tools and equipment they had access to at home. He then created a choice board using that information and expanded the choices to include other skills (i.e. checking fluids in a vehicle, servicing a lawnmower for the spring). Each week he has them fill out a Google Slide with a short description and at least one photo of the skill. He does not want them to stress about the tasks, but rather recognize and document skills they are already doing or should learn to do. This is just one example of how teachers are adjusting to help guarantee their students are still learning.

The articles included in this issue were written prior to the challenges currently facing agricultural educators. There are concepts included in the articles that closely connect to what teachers are teaching now that they do not have students in a traditional lab setting. I wonder what changes will occur in our agricultural education classrooms when we are able to return to a "new normal." What concepts should we be teaching in our agricultural mechanics courses? Which concepts could be taught in a different manner? What materials should be ordered to be prepare for distance learning situations? We do not know what the future holds, but we can use this time to evaluate our current programs and plan for what we can adjust when we are able to return to our classrooms. I believe we will return with an improved appreciation for the innovativeness of our education system, our resources, and our students.

Dr. Gaea Hock is an Associate Professor of Agricultural Education at Kansas State University and Editor of ***The Agricultural Education Magazine.***

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Considering the Possibilities: Agricultural Mechanics in the 21st Century

by Trent Wells

When I ask pre-service agricultural education teachers what the term "agricultural mechanics" means to then, I get a wide range of answers. Many responses are traditional in scope and include topics such as welding, small gas engines, and tractor operation. I then ask them where their definitions of agricultural mechanics came from. These responses are typically narrower in range and include, "It's what I learned in high school," or "We do repairs on the farm, so it's what I believe to be important for kids to learn about." I ask why agricultural mechanics is important, why we should teach it, and how it should be taught. The discussion is rich and overflowing with ideas about teaching and learning agricultural mechanics. Much opining about how agricultural mechanics reaches students who may have no other positive outlet at their school or how agricultural mechanics should be very hands-on in nature occurs. This conversation occurs at the beginning and the end of the semester. It is refreshing to hear their perspectives and passion each time. I question their ideas and they question mine. We challenge each other to consider the possibilities.

I talk with many in-service agricultural education teachers during student teacher visits and elsewhere. I enjoy conversing with them about their entire program and the community. My attention is frequently drawn, however, to agricultural mechanics laboratories and coursework. The discussion with student teachers and their cooperating teachers usually turns toward the projects students are working on this year. I often hear about projects of varying complexity, including bird houses, picnic tables, barbecue pits, trailers, and ornamental yard signs. Some projects are being used as fundraisers for the program while other projects are serving as students' SAEs. I have even seen a few Agriscience Fair projects that addressed an agricultural mechanics-related topic.

As I observe the projects, tools, and equipment available within programs, teachers inevitably discuss what the program looked like when they arrived there and how it has changed over the years. Many teachers talk about how kids have changed and how it is harder to get them engaged now versus 20 years ago. Many teachers also talk about the resources now available that were not present even 10 years ago. A veteran teacher once told me about how he has used grant funds to purchase his program's computer numerical control (CNC) plasma cutting system. When asked about what motivated him to pursue this equipment for his program, he said he wanted to better train students in his metal fabrication course. He knew a local manufacturing company employed some of his program's recent graduates and the company wanted students to have some idea of how to operate CNC systems. Articulating his grant application to focus on science, technology, engineering, and mathematics (STEM) principles, he acquired the funds to add this new teaching tool to his arsenal. He said he "never imagined that he would have something so high-tech in an agricultural mechanics laboratory." He considered the possibilities.

These instances are intended to communicate the need to reflect on and challenge pre-conceived notions as well as be open to new ways of doing things. Considering recent global events, thinking about new ways of looking at traditional components of our work is vital. This issue contains topics ranging from the value of agricultural mechanics instruction in rural, geographically isolated programs to teaching alternative energy sources through agricultural education programs to using smartphone applications to facilitate agricultural mechanics instruction. These authors share their insight into how they have considered the possibilities. I hope that you find their ideas meaningful to your own practice.

Trent Wells is an assistant professor of agricultural education at Southern Arkansas University.

The Value of Teaching Agricultural Mechanics in the Modern Era

by Brad Cox

I am the first to admit that teaching agricultural mechanics is at the core of our program. We are located in a small, geographically-isolated community in northwest Alabama. The local population is less than 5,000 people. Our program predominantly consists of rural students, many of whom have some sort of a background in agricultural mechanics-related activities. I have the privilege of instructing many students who work on row crop, poultry, and livestock operations. The employment opportunities in my local area are made up of primarily agricultural, forestry, and mining jobs. As such, the expectations of our stakeholders are that students receive training in these specific areas. As with any area of instruction, our program strives to maintain its relevance by focusing on the needs and wants of our local and regional stakeholders.

This approach has proven to be successful for us in many respects, including funding the educational endeavors of our program. We have received various grants, in-kind donations, and other revenue sources due to our program being focused on the agricultural mechanics-related needs of our community. I cannot stress enough the importance of these revenue sources in making our program one of the highest-performing in our part of the state. I hope that I can share a few items with you that have allowed our program to grow and remain relevant. I also want to share with you some of my experiences on practices that I have found to be useful in making agricultural mechanics content enjoyable and interesting for you and your students while addressing the concept of relevance in the 21st century.

The first item I want to address in depth is program funding. I have had the opportunity to tour and visit various agricultural education programs all throughout the Southeast and the United States more broadly. One of the primary concerns that I have heard from teachers is that their programs lack the funding to purchase modern equipment, curriculum, and other necessities. I agree that this is a major issue, especially considering that we get a very limited number of dollars from our respective boards of education. You may be in a better situation than most, but at best you may only receive a few thousand dollars annually to fund your program's activities. Fundraising is essential to the operations of any program, but this is never enough. So the question is, "What do I do to purchase the resources that I need?" One thing that has proven to be successful for our program is getting your local agricultural organizations on board with your vision for the program. Our local Farm Bureau office, Cattlemen's Association, and area businesses have been instrumental in funding our program. Identifying these revenue sources and supporters of your program is essential if you want to be the premiere career and technical education program within your school. Not only have they provided financial assistance, but their in-kind contributions of metals, lumber, portable and stationary power equipment, hand tools, feed, seed, and other items have saved our program thousands of dollars. Having adequate funding is a key first step in keeping your program relevant.

Secondly, I would recommend that you continuously and effectively promote your program. If you do not sell your program nobody else will! Keeping your program relevant means that you must keep local leaders, legislators, parents, and school administrators abreast of what you are doing. If your school administrators and other local stakeholders see you are teaching real-world, hands-on concepts they will support your program. Continue to think outside the box of traditional brochures, newspaper articles, and posters. These sorts of advertisements are not geared toward the modern audience. Instead, consider using large-scale mass communications that are cost-effective. We have seen a tremendous amount of responses from our social media accounts on Facebook and Instagram. We post photos

of Career Development Events (CDEs), agricultural mechanics projects, meetings, our school farm, and any other activities that we are involved with. In the modern era in which we live, constant, effective communication is fundamental to keeping your program relevant. When you can sell the message that you are training and instructing the next generation of agricultural leaders, they will be inclined to invest in the program like you have never seen before!

Each year, I am tasked with giving my principal a list of the courses that I want to teach for the forthcoming academic year. I have my "bread and butter" courses, such as Animal Science and Agriscience, but I try to keep my options fresh and new each year. I tailor the courses to the industry needs of my area. For instance, I am teaching a construction class this year due to the input of local businesses and my school administration. I am also teaching a landscape management course due to the high demand for trained landscape technicians in the surrounding larger cities. If you can offer an industry-based, knowledge and skill-focused credential that accompanies your course, I strongly suggest seeking out such alignment. When you are able to provide students with a useful credential, they can leave high school ready to enter the workforce or to pursue their post-secondary education. Beginning this upcoming academic year, we will offer the OSHA 10-Hour Safety course which is recognized nationally and by many local employers, which puts our students at a competitive advantage. We offer two credentials annually and this has proven to be a game changer for our program. When employers see that students are leaving your program ready to work, I believe that it pushes your program to a level of relevance that is often unparalleled.

I am asked, "What are we doing in the shop?" at least ten times during the course of a regular school day. Many students have enrolled in your course to get a hands-on education, whether it takes place in the agricultural mechanics laboratory, the animal science laboratory, the greenhouse, or the school garden. For the most part, many of your students are pretty eager to do hands-on activities. I spend the vast majority of my time in either our animal science or agricultural mechanics laboratories because students are engaged and it creates an atmosphere where learning is fun and new. While I cater my instruction to address the needs and wants of the local area, we also spend time engaging in a wide range of content areas, including welding, wood structure framing, electrical wiring, land preparation, finishing construction, and plumbing. Preparing students with relevant agricultural mechanics skills sets them up for success in a variety of different arenas as they depart from your program and school. Keeping the instruction and work fun is paramount. I have found that using games, contests, and prizes for students who have the highest-quality projects has been an effective motivator. To further engage students, considering entering their projects into agricultural mechanics project shows and allow them to compete in CDEs that showcase their unique skill sets. When it comes to making your program relevant, the students' needs must be addressed. When students are engaged in the learning process, they will buy into your program. There is no better testament to the worth and relevance of your program than that of a student who has been able to become successful as a result of your dedication to high-quality instruction.

One of the greatest challenges is convincing stakeholders and administrators that your program is relevant and helps address the needs of your community. We have had success with the items mentioned earlier in this article, but this list is certainly not inclusive. Each agricultural education program is unique and has its own set of challenges and obstacles to overcome. I am sure that I speak for most of us as agricultural teachers when I say that maintaining, growing, and expanding our programs is at the forefront of our minds. To remain relevant, we must embrace technology, partner with our stakeholders, invest in teaching relevant content, and offer industry-recognized credentials. If we can implement these items, I believe that we can and will see our programs become catalysts for cultivating the next generation of agricultural leaders in our communities.

Brad Cox is an agricultural edcuation teacher at Fayette County High School in Fayette, Alabama.

Using Team-Based Learning (TBL) in an Agricultural Mechanics Laboratory: Examining its Use in Secondary and Post-Secondary Education

by Whitney Figland

Background

As a first-year agricultural education teacher, finding new and innovative ways to reach diverse students' needs has been somewhat of a challenge. However, this seems to be a common trend among teachers, as we try to find new ways to engage all types of learners and meet the challenges of the 21st century (Allen, Donham, & Bernhardt, 2011; Hanson, 2006). As an educator, I am always challenging myself to find new and innovative ways to teach content that will build students' critical thinking and problem-solving skills, which have been identified as crucial components of today's workplace (Ulmer & Torres, 2007). While searching for new teaching methods, I came across an instructional strategy called team-based learning (TBL). This strategy allows students to take control of their own learning by having them develop their conceptual knowledge outside of class time and dedicating more in-class time for hands-on learning (Michaelsen & Sweet, 2012). Due to the hands-on nature of an agricultural mechanics course, I felt that this instructional strategy would allow my students to gain important hands-on skills in the laboratory and still learn the foundational, requisite knowledge.

Utilizing TBL in Secondary and Post-secondary Education

While studying at Louisiana State University (LSU), I had the opportunity to implement TBL into an Introduction to Agricultural Mechanics course. In order to align with the fundamentals of TBL, the course was redesigned to focus on: (a) safety, (b) agricultural structures, (c) residential electricity, and (d) small gas engines. The course was also designed to be 75% in the laboratory learning hands-on skills and 25% in the classroom learning conceptual knowledge. During class time, students would participate in an Individual Readiness Assurance Test (IRAT) and a Team Readiness Assurance Test (TRAT). These tests address the materials students read or viewed outside of class time. The IRAT allows the students to gauge their own level of knowledge on the material, while the TRAT allows them to collaborate with their team members on material they struggled with (Sibley & Ostafichuk, 2015). This course structure is designed to allow students to really take control of their own learning by learning the conceptual knowledge outside of class time and having more in class time for hands-on learning.

Throughout the semester, students engaged in many hand-on applications designed to build their conceptual knowledge and procedural knowledge. An important component of TBL is collaborating and working within your team on application exercises. These application exercises are specifically designed to target a real-world problem in a given domain. For example, in this course, students learned about small gas engines. The students learned about the major systems and how to disassemble / reassemble an engine. During a lesson on using measuring tools, the students had an application exercise that allowed them to use specific measuring tools (ex. Vernier calipers, dial calipers, etc.) to measure parts of their engine to ensure compliance with manufacturer standards. They were asked to use the correct tool to measure the part and make sure the engine component met specifications. In this exercise, the students used their conceptual knowledge of measuring tools to solve a real-world problem.

Being the instructor allowed me to notice that the hands-on portions of this course always seemed to intrigue and engage students in the learning experience. I can recall students saying that the TBL instructional strategy allowed them to understand complex topics by collaborating with

their team members and having the ability to engage in real-life experiences. At the end of the semester, many students also stated that the course really helped them build their problem-solving skills and allowed them to be open to new ideas from other people. Also, I can recall many female students stating that they felt more comfortable working with agricultural mechanics-related topics and skills.

Since transitioning from my role as a graduate teaching assistant to a high school agricultural education teacher, I have continued to use TBL in my outdoor power equipment class. This class is devoted to learning about small gas engines including single-cylinder two-stroke and four-stroke engines as well as multiple-cylinder engines. I designed this course much like the one taught at LSU except with a few modifications. I have learned that expecting high school student to read outside of class time and be prepared to come to class to take a test is a little bit of a stretch. However, I have modified the TBL strategy to better suit my students. My students still have materials they go over before class time starts, but much of it is done by watching videos or reading short excerpts and following a note guide. When they come to class, they turn in their note guides for a grade and take their test. This way allows me to give them a grade for learning the material outside of class and holding them more accountable. My students still participate in application exercises and spend the majority of their time in the small engine laboratory gaining hands-on experiences.

During the short time I have been teaching at the high school level, my students have seemed to really enjoy having the ability to learn hands-on and see what they are learning from reference materials in real life. Many of them have stated that it has helped them to understand the material more concretely and has helped them to fix some of their own equipment at home. I do believe that using TBL in a high school setting is more challenging due to the nature of the students, but with modifications this strategy can be quite successful in transitioning the classroom away from teacher-centered instruction.

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CASE: Agricultural Engineering in the Classroom

by Carl Aakre

Over ten years ago, the National Council for Agricultural Education started the CASE (Curriculum for Agricultural Science Education) initiative. The goal of the initiative is to have a nationally-based agricultural curriculum with a focus on science, technology, engineering, and math applications to increase the academic rigor of agricultural courses and prepare students for future careers in the agricultural workforce. An initial plan was made to develop courses in four major pathways; animal production, plant production, natural resources, and agricultural mechanics. The first courses written were animal and plant science. A challenge faced when writing these courses was how to develop a "nationally" -based curriculum when plant and animal production across the nation varies immensely from hogs to rabbits and corn to lawns. Even though an agricultural education teacher's local economy and workforce demand has a significant impact on content, the writers realized while developing the courses that the type of plants or animals used for teaching the sciences in the course did not matter. The foundational scientific principles that define all plants and animals are very similar and applied to a farmer raising hogs to a pet owner caring for a rabbit, or producer growing corn to landscaper caring for a lawn.

The history is essential when understanding the development of the CASE courses in the Agricultural Engineering, formerly agricultural mechanics, pathway. The animal and plant science courses had to address the broad needs of students understanding animal and plant production across the country. The same issue is faced when addressing agricultural mechanics. With agricultural mechanics being so comprehensive with the most diverse number of careers available, how do we prepare students to enter that career field? Agricultural mechanics is defined very differently in each individualized program. Welding, small engines, electrical wiring, plumbing, power equipment, construction, concrete, and the list goes on. The question then is, if we are developing a nationally-based curriculum for agricultural mechanics, which topics should the courses include?

During the development of the CASE agricultural mechanics courses, a consensus among all developers was that the courses needed to prepare students to be mechanical problem solvers. They should be able to identify a problem, analyze it, determine a solution, construct the solution, and solve it. Most importantly, students should be able to do this safely. Problem-solving goes beyond teaching a specific technical skill. Technical skills are absolutely needed, but how can we teach students to apply those technical skills as problem solvers and not just as manufacturers on an assembly line. We need to prepare students with the skills to operate, maintain, and troubleshoot the machines replacing those workers. With mechanical problem solving as the primary focus, course development began. The result was an Agricultural Engineering pathway with two courses, *Agricultural Power and Technology (APT)* and *Mechanical Systems in Agriculture (MSA)*. The pathway title, Agricultural Engineering, addresses the larger scope of those working in agricultural mechanics. Agricultural engineering careers go beyond the typical engineer. Engineering requires a team of individuals, including engineers, technicians, and tradespersons, each with unique skill sets required in agricultural mechanics.

Both courses in the Agricultural Engineering pathway have common themes, including safety, the engineering method, and troubleshooting, that spiral and scaffold throughout the courses. The foundational course, *APT*, introduces students to the core physical sciences and fabrication processes while applying them in an agricultural context. *MSA* goes more in-depth into complex systems found in agriculture and the new technologies used. Course writers identified these thematic areas as essential for students to be successful in new and innovative careers found in agricultural mechanics. The scope of these courses can enhance what teachers are already doing and possibly be an entirely new program of study in their local agricultural education program.

Engineering Method

Many agricultural education teachers work with students to develop their agriscience projects using the scientific method. I have seen this incorporated in many animal, plant, and natural resources classes. It is not typically used as often in an agricultural mechanics class. One reason is the scientific method for researching and answering a question does not always fit as seamlessly into an agricultural mechanics curriculum in comparison to other areas of agricultural education. However, the engineering method, or the engineering design process, does fit quite comfortably.

The engineering method is a systematic process for finding a solution to a problem. Although similar to the scientific method, there are some distinct differences. Instead of a question, an engineer writes a problem statement. The problem statement outlines the problem without limiting the design. The statement should explain who the problem affects, what the problem is, when and where the problem occurs, and why the problem should be solved. Once an engineer writes a problem statement, he or she identifies criteria and constraints. Criteria are guidelines explaining what the engineer wants the design to do and how the design should work. Constraints are limitations to the design or challenges to overcome. Common constraints include resources such as time, materials, space, and environmental conditions. After an engineer knows the limitations for his or her design, he or she can brainstorm practical solutions. After constructing the solution, it is tested to determine if the design meets all the criteria. If the solution does not meet the criteria, the design process begins again.

Agricultural education teachers have long been introducing students to the engineering method throughout agricultural mechanics courses, but may not be using the terminology or the entire process. An example of a problem would be a welding table a student is constructing in class. The table solves the problem of needing a place to weld. Criteria should include dimensions for the table and material that can withstand high heat. Limitations include the cost and time for construction. After construction is complete, students assess the project using the set criteria; dimensions, correct material, level table-top, etc. If the project does not meet the set criteria, engineers make modifications. Many students may be doing this in the agricultural mechanics laboratory, but are they recognizing the entire process and analyzing each component along the way? If students become familiar with the engineering method early on, they can use this strategy to design and solve larger and more complex problems including electrical wiring, building construction, and power mechanics.

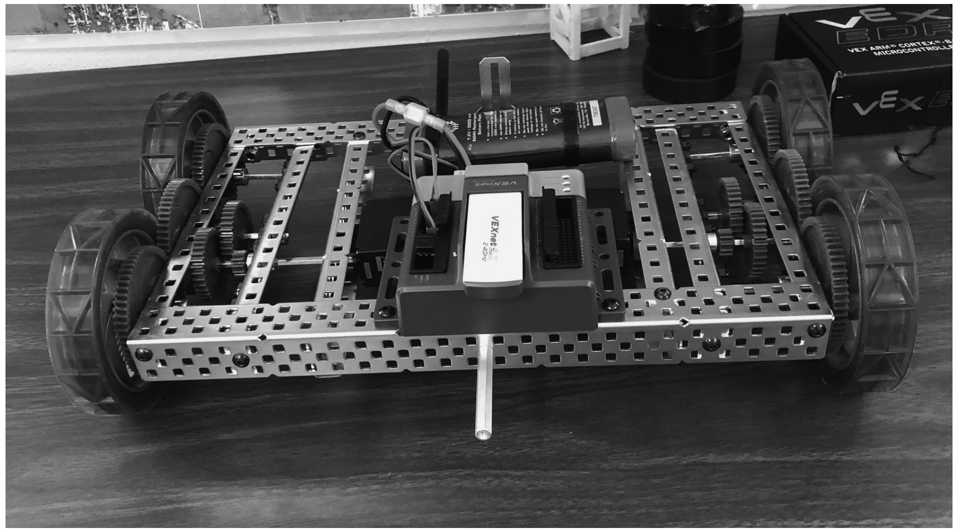
Safety

When you discuss agricultural mechanics classes with a fellow teacher, one of the first topics addressed is safety. From safety for students, safety for yourself, OSHA rules and regulations, to local district rules and regulations, safety can become its own agricultural mechanics course. As a nationally-based curriculum, CASE needed to develop a foundational process for teaching safety that can be built upon in the classroom to meet district, local, and state requirements. Three core areas of safety were identified to include in the courses; facility safety requirements, procedural safety, and personal responsibility in the workplace.

The type of tools students will be exposed to vary. Preparing students for using all of these tools safely is a teaching challenge in itself. CASE uses a consistent method of introducing students to tool safety. Students are taught to view all machines the same way, with the same basic components. All tools, no matter how simple or complex, have a power source, power transmission, operating controls, and a point of operation. By identifying these components on any tool, a student can analyze and inquire about the safety concerns with each component. This does not mean that inquiry will allow a student to identify all safety issues, but it does make a good starting point for the student to start the discussion and be an active learner. With a consistent method for analyzing a tool for safety hazards, students will have a better understanding of identifying safety concerns and operation methods with tools they will eventually use outside of the school setting.

CASE also addresses the importance of reporting safety hazards and near misses at the workplace. Employers want to reduce the potential for accidents. Potential for accidents include near-misses. Most of us have been in situations where we could have been injured but were "lucky" enough not to get hurt. These incidents, called near-misses, often occur in industry and manufacturing. If employers and teachers do not address the incidents, next time the incident may become a severe accident.

Upon completion of the CASE Agricultural Engineering pathway, students can identify safety hazards in a shop environment, know how to address the root causes of accidents, and prevent near misses. Understanding the root cause of accidents reduces their occurrence. For example, the root cause of an accident may not be an unsafe machine, but an



untrained person using improper procedures. If workers identify the root causes of accidents, they can prevent a majority of injuries at the workplace. All near-misses have a root cause, as well. Identifying the root cause of a near-miss can prevent an accident from happening in the future. An example near-miss would be a coworker operating a power drill without personal protective equipment (PPE). Avoiding injury does not mean it is acceptable not to wear PPE. The risk of an eye injury is much higher when not wearing eye protection. An immediate root cause may be the PPE was not available. Underlying root causes could be improper training or the coworker rushing to complete a job. Near-misses such as this need to be addressed to prevent accidents in school and work settings.

Chemical and Physical Science

APT focuses on the physical and chemical principles of mechanical machines and structures in agriculture, just as the animal and plant science courses focus on biological principles. In animal science classes, students learn cells are the building blocks of an organism. In agricultural mechanics, the building blocks are the materials used to construct the machines and structures. By identifying the materials used and the properties of those materials, a student will have a core foundation they need for designing and constructing solutions in an agricultural mechanics laboratory. Today, manufacturers use many types of metals and plastics to fabricate equipment. Fabricators choose the types of metal and plastics used based upon their specific properties. What happens when metals become exposed to moisture in the environment? Does corrosion look the same on steel as it does on aluminum? The science of chemical reactions and properties of metals and plastics can help a student understand why certain materials are selected, how they react in an environment, and if a new type of material must be created.

Machines, structures, and equipment transfer energy to do work. The *APT* course introduces students to the principles of electrical, thermal, and mechanical energy transfer. Students learn how electrical power is generated chemically, such as a battery, and mechanically with an electrical generator. Once students generate electrical power, they learn how to direct and control the energy in circuits to power electrical structures and machines. A model windmill used throughout the course is a core teaching tool addressing the concept of energy transfer. Students start by addressing the design of blades to harness fluid (air) energy. Then they generate electrical power by designing a geared powertrain. Gear systems introduce mathematical and scientific principles of speed and torque. By finding a balance between speed and torque of the windmill, students can generate enough electrical energy to operate a water pump. By the end of the course, students apply their knowledge of materials, energy transfer, gear ratios, and calibration to develop a working model of an irrigation system powered by wind. The final project is a result of spiraling and scaffolding of concepts, which shows students the interrelationships and applications of what they are learning throughout the course.

Systems Thinking

Once students have a strong understanding of the materials, fabrication, and energy taught in the *APT* course, they are challenged to think more analytically at entire systems found in agricultural mechanics. The *MSA* course introduces three systems found in agriculture, structures, machines, and engines. Systems thinking requires students to evaluate the components of the system, how the system functions, and how the system relates to multiple systems working seamlessly together. A great example of applying systems thinking in agricultural mechanics is a small engine. Addressing small engines using a systems approach requires in-depth thinking and analysis of all engine components and an understanding of how parts are interrelated and dependent upon each other. A meaningful connection between all the systems in an engine is the flow of energy. By understanding the interrelationship of systems, students can practice a systematic process for troubleshooting and failure analysis.

CAD and 3D Printing Technologies

With innovative technologies being introduced every day and requiring new skills and knowledge, it is difficult for a teacher to decide what to include in an agricultural mechanics course. With a limited amount of time and an unlimited amount of information, how can we address the needs of the agricultural industry and use new technologies to teach core concepts in the classroom?

Core components of all design solutions include technical drawings, schematics, and prints. Computer-aided design (CAD) is a standard tool used for product development and prototyping for new machines and structures. All projects students design today should include a technical drawing or schematic to go along with the final product. Industry-based software is available free online for teachers to use in the classroom. Onshape (www.onshape.com) is one option for students to use. Students can use Onshape on multiple platforms from a laptop to an app on a tablet for CAD. With new computer technologies, students can view a three-dimensional design, calculate material mass, and determine assembly procedures before making the actual product. In addition, a prototype can be printed using a 3D printer.

Three-dimensional printing technologies allow students to get their hands on and test the products they design. As the cost of 3D printing has gone down, the accessibility to 3D printers has gone up in secondary schools. Agricultural education teachers can take advantage of this by having students print intricate designs. Three-dimensional printing is an alternative for students who

may not have access to a mill or lathe, or the skills to use them to make complex prototypes.

The *MSA* course incorporates CAD and 3D printing into the engine systems unit. The first application is designing a measurement tool to determine the reject size of a crankshaft. Students use CAD to design their tools and take it a step further by printing and using them in the laboratory. In another activity, students create a prototype replacement component for a small engine. Most teachers have heard a student say, "I would not design it that way!" With CAD and 3D printing, we can challenge the student to come up with a new design to see if they can make it better.

Robotics and Automation

Many students today who do not come from an agricultural background or farm are not as interested in, and often do not understand, the technology found in today's agricultural equipment. However, many do gravitate towards robotics and automation technologies, which are used in the agricultural industry but not always seen by students. Robotic systems contain the same types of electrical, powertrain, and fluid power systems as agricultural equipment. The *MSA* course uses robotics to introduce students to mechanized equipment found in agriculture.

Instead of researching or simply observing a geared powertrain on a tractor, students construct a three-speed powertrain and measure the effect that gear reductions have on torque, speed, and energy usage. They apply what they learned about gear ratios to construct a robotic "model tractor" that must pull a set amount of weight. Constructing the model tractor introduces students to hitching, stability, weight distribution, and efficiencies such as tire friction and energy usage. Model tractor design using robotics may not get students' hands as dirty as the traditional way we view an agricultural power class, but it does allow all students to engage in a project requiring critical thinking and problem-solving skills needed when working with systems found in agricultural equipment.

Next, students learn how today's equipment uses sensors, electrical controls, and programming. Automation in agriculture is quickly becoming a reality and agricultural education teachers need to prepare our students for that future. Microsoft has already invested in the development of a fully automated farm to be in operation by the year 2025 as a model for technologies to come. Even if a fully automated farm is not in the near future, electrical sensors, controls, and computer programming of equipment are already here. *MSA* introduces students to program equipment that reacts to its environment using sensors. The same types of technologies found in global positioning systems on equipment. Automation in agriculture goes beyond what we see in the field. Equipment manufacturers and agricultural processors use the same technologies in mechatronic systems found in factories supporting the agricultural industry. To emphasize mechatronic applications, students apply all they have learned in the *MSA* course to design a manufacturing line that includes powertrains, pneumatic cylinders, and programmable controls in a single mechatronic system.

As previously discussed, courses in the Agricultural Engineering pathway start with the basics of materials and energy and lead to systems thinking using new technologies with agricultural applications. Whether you are interested in completely revamping your agricultural mechanics program or just looking for something new to enhance your curriculum, I encourage you to contact CASE by visiting their website at www.case4learning.org. During the summer months, CASE will be offering professional development to prepare teachers to use the *APT* and *MSA* curriculum. Professional development scholarships are available for those who want to attend the *APT* and *MSA* CASE Institutes. The Equipment Dealers Association and Association of Equipment Manufacturers have shown their dedication to the CASE initiative by sponsoring these scholarships. As a project of the National Council for Agricultural Education, managed by the National Association of Agricultural Educators, CASE is a curricular and professional development resource for all agricultural education teachers. I encourage you to take advantage of this resource to enhance your professional growth and student success as they move from the classroom to the workforce.

Carl Aakre is a curriculum coordinator for CASE.

Alternative Energy Sources: Is the Topic Suitable for School-Based Agricultural Education?

by Ed Franklin

Every aspect of agriculture relies on some source of energy. There are five major energy sources used in the United States. These sources include petroleum, natural gas, coal, renewable energies, and nuclear energy. Where does this energy go? According the Energy Information Association (EIA), the major energy demand sectors include transportation, residential & commercial, industrial, and electrical power. Agriculture is infused in all these demand sectors. Powering equipment and machinery, transportation of products, heating and cooling, moving water, and providing lighting are all examples of where energy is used by agriculture.

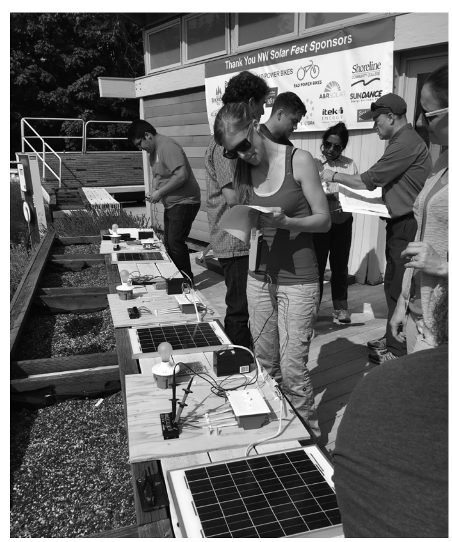
Types of Sources

Sources of energy are classified into two categories. Fossil fuels (or non-renewable sources) include petroleum (which includes diesel, gasoline, and oil), natural gas, and coal. A fossil fuel is mined or drilled from below the surface of the earth. Fossil fuels are considered finite and with continued use, will eventually become depleted. However, our traditional energy acquisition methods, processing, and distribution has been based on a culture of fossil fuels. Nuclear energy may be classified as a non-renewable source because the primary fuel source, uranium, is mined from the earth. All energy produced from nuclear power goes to the electricity-demand sector. Nuclear energy can be considered a “clean fuel” because there are no emissions released into the atmosphere. However, the handling and storage of highly radioactive fuel rods has raised questions about long-term effects to the environment. In recent years, nuclear plants have had a safe operating record. However, public perception and environmental regulations have slowed the process of permitting for the construction of new nuclear power facilities.

Renewable energy sources (also called alternative energy sources) include solar energy (both photovoltaic and thermal), wind energy, biomass energy (which includes biofuels), hydro energy, and geothermal energy. For centuries, wood has been used as a fuel source by many populations prior to the industrial revolution and continues to be an energy source (biomass) today in many countries. Many state and local governments are encouraging the use and adoption of renewable energy sources as an alternative to existing fossil-fuel sources and many utility companies producing electricity are moving away from coal-powered plants to natural gas and renewable energy sources for their production of electricity. Technology, market competition, and government subsidies have helped make alternative energy sources available to the general public. The agricultural industry has taken advantage of adopting renewable energy systems to promote sustainability and reduce energy costs.

Teaching Ideas

At this point, you may be asking yourself “Where can the teaching of alternative energy fit into my local program curriculum?” and you followed this question with, “What standards can be met by covering alternative energy?” Most of our energy is used in the production of electricity. So, in the teaching of electricity in our local curriculum we can use alternative energies as the step-off point. Begin with an introduction of energy sources. Look at both U.S. use of energy, and your local state’s use of energy. You can find this information on the Energy Information Association (EIA) site at (www.energy.gov). Solar photovoltaic energy and wind energy sources produce direct current (DC) electricity. Hydroelectric energy (energy from moving water) also produces direct current (DC) electricity. Dry cells and batteries store direct current (DC) electricity. Most of your students should be familiar with dry cells (also known as “AAA”, “AA”, “C” and “D” – cells) and 12-volt batteries used in our vehicles and agricul-



tural production and turf maintenance machinery. Solar modules do not store energy like batteries. Solar modules produce electrical power when exposed to the sun. Solar modules are composed of multiple cells. Each cell of a silicone-based solar module produces about 0.5 volt. Modules are made up of multiple cells wired in series. Solar modules typically consist of 36, 60, or 72 individual cells. Students can count the cells and calculate the voltage of the module. The amount of electric current is based on the size or area of the individual cell. Solar power is measured in Watts. A module's power capability can be found on the backside of the module. The wattage is labeled as Power max power (Pmp). Teachers can show students how to measure the voltage and current a solar module is capable of producing using a digital clamp-on multi-meter.

What Should I Teach?

Which renewable energy sources are used in your community or your state? The purpose of using solar, wind, or hydroelectric energy is the production of the electricity. Today, there are renewable energy systems available to fit the needs of the individual homeowner or producer. Landowners with access to year-round flowing water may consider the installation of a micro-hydroelectric system to produce electricity for their own use and export excess power to the electric grid. If you reside in geographic areas with consistent wind, you may consider installing (or teaching about) a wind turbine to produce electricity. The use of wind as an energy source has been used by agriculturists for years. Pumping water for livestock using windmills has been a reliable technology for decades. However, water is pumped only when the wind is blowing. Today, these older machines are being replaced with solar photovoltaic (PV) systems. If the sun is shining (and the wind is not blowing) water can be pumped from underground. Water can be pumped to troughs for livestock or stored in tanks for later use. This is a cost-effective method and a simple system with few components. There are no moving parts requiring routine maintenance. Biofuels (such as ethanol and biodiesel) are used to provide fuel for internal combustion engines. Plant-material (corn, soybeans, grasses, and algae) serves as the source. Blends of fuels with diesel and gasoline are used in areas where temperature effects the composition of the fuel in the engine. Hands-on labs can be developed showing students how to use vegetable oil to make a fuel for a diesel-powered engine. You will need to borrow a few beakers, hotplates, and stirrers from your chemistry lab.

Alternative fuels are relevant in any discussion of energy. Including alternative energy topics in your science and agricultural mechanic curricula is timely and important. Multiple opportunities for professional development in renewable energy integration into your classroom curriculum exist. Check out CASE Agricultural Power and Technology (APT) curriculum for activities utilizing wind-energy concepts. For more information on specific alternative energy source topics, refer to the list of industry websites below:

U.S. Energy Information Association (EIA) = www.eia.gov

Solar Energy Industries Association (SEIA) – www.seia.org

American Wind Energy Association (AWEA) – www.awea.org

National Hydropower Association (NHA) – www.hydro.org

Advanced Biofuels Association (ABA) – www.advancedbiofuelsassociation.org

Geothermal Resources Council (GRC) – www.geothermal.org

Database of State Incentives for Renewable Energy (DSIRE) – www.dsireusa.org

National Renewable Energy Laboratory (NREL) - www.nrel.gov

Curriculum for Agricultural Science Education (CASE) -www.case4learing.org

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The Implementation of CNC Technology into School-Based Agricultural Education Programs

by John Rasty

Educators face an incredible number of challenges. Among the greatest challenges are finding ways to motivate students, trying to keep up with the college and career readiness skills students should be learning in our programs, and finding ways to fund their curriculum. Many of the jobs our students have available to them were unheard of just a few decades ago. It is our task to always seek ways to implement new or updated content into our curriculum to keep up with the changing skill needs as well as motivate our students and get them excited about learning.

Computer numerical control (CNC) technology has worked its way into employment facilities everywhere from large-scale manufacturing to local fabrication shops or even your own home. The possibilities of CNC technology are seemingly endless as the technology has found uses in applications such as laser cutting or engraving, plasma cutting, wood routing, milling, drilling, and much more. CNC machines are used by fabricators to create parts for equipment, by manufacturers to produce endless identical parts, and enjoyed by hobbyists to craft their own projects.

Educators in all content areas love discussing how their curriculum benefits their students and how they are able to capture their students' attention long enough to deliver their instruction. I think that agricultural education teachers have distinct advantages in both curricular benefits and student engagement with the opportunity to implement CNC technology. In all my years of schooling, nothing caught my genuine interest quite like operating my first CNC machine, a plasma cutting table.

No matter which type of CNC technology you may have in your agricultural mechanics laboratory, it is important for students to first know the fundamentals of how the machine would operate manually. With machines such as CNC mills or lathes, this means teaching them about things like feeds and speeds, coolant requirements, and differences in cutting attachments. Before learning to use a CNC plasma table, students need to understand the fundamentals of plasma cutting.

With plasma tables, if the students have a general knowledge of how plasma is formed and the factors that affect cut quality (ex. height, speed, consumable wear, amperage, etc.), nearly all of the CNC technology troubleshooting issues they encounter can be worked through without needing to know the advanced inner workings of complicated machinery. Common issues in CNC plasma tables are related to the same factors that affect cut quality in manual cutting. If they first cover those basics, if they see an issue such as excessive dross accumulation, they should then know that the cutting speed is likely not set correctly.

Once students understand what a machine is supposed to do manually, many of them can probably pick up how to use the CNC machine fairly quickly. In fact, with just a short lesson on how to make basic signs on a plasma table and set up the machine, we could probably have students making their first unassisted cuts within an hour. But if all we do is quickly teach students how to take a picture on a computer and make it into a metal part, they are not going to have much more skill or knowledge than someone who can push buttons on a microwave to turn a bag of seeds into popcorn.

One of the basics that students should know to really build their skill set is a working knowledge of machine codes, often referred to as G-codes. G-codes are the lines of computer code that tell the CNC machine how and where to move. Admittedly, if you are only using CNC plasma, the amount of G-code reading or writing required is minimal. However, I have had students screw up several parts due to an error that could only be found by understanding the G-code created by the design software. G-code writing becomes much more prevalent in CNC milling.

Because of their simplicity, the codes used in CNC plasma are actually a good way to introduce students to G-code. Unlike CNC mills or similar machines that will mill, drill, tap, engrave and much more in three dimensions, plasma tables are simple in the sense that they do one job, cut two-dimensional parts. This means that they only need codes to tell the machine how to traverse and cut linearly, clockwise arcs, or counterclockwise arcs. All of those movements are designated by only four G-codes which then need to be followed by the coordinates and arc radius information if applicable.

G-codes are based off standard Cartesian coordinates, which means CNC projects can be drawn on a graph. A simple way to have students learn those G-codes is to have them graph simple designs, then write a G-code that would create what they graphed. I start my students out very simple, with just a rectangle requiring only linear movements. Then I move them to an octagon which still only requires linear movements, but is slightly more difficult to find the corner points. Eventually we move into a five-point star, which is still just linear movements, but we add a circle around it. The circle allows them to practice incorporating G-code commands for an arc. Using the points on the graph, they should be able to write a simple program that would cut each design on the plasma table.

G-codes used on a CNC mill can become much more complicated, but are also much more rewarding for the students when their complex codes work to create the part they want. CNC mills have dozens of canned cycles that use a preset G-code to perform a specific task. For example, G13 typically designates a counterclockwise pocket milling cycle, while other codes are used to drill with a pecking cycle, drill bolt patterns, tap holes and much more.

The versatility, ease of use, and relative affordability of plasma tables make them a perfect introductory machine into the CNC world. However, "relatively affordable" does not mean the machines are cheap and the price tags can scare a lot of administrators. What administrators need to understand before they lock up their checkbooks is that machines like plasma tables can turn themselves into quite a lucrative investment.

Many schools that have plasma tables or CNC wood routers, have been able to run very successful fundraisers through their classes. Classes that run their own businesses are able to not only learn about CNC technology but principles necessary to operating a business as well. It is important for schools to hear how the initial investment in a CNC machine will eventually pay itself off as the students make and sell their products.

One of my classes runs such a business. As their teacher, it is my job to get the students started by setting goals and expectations for their business. We discuss how we want to market our products, receive orders, organize the jobs that need accomplished, and how we will manage our inventory and finances. I give them a lot of freedom in how they want to run their business, but there are some things that have remained similar between the different groups I have had.

Our marketing is done mostly through a Facebook page. I am the "owner" of the page but I add students to the page as collaborators. That way I can oversee everything they do on the page from posts they make to messages they send and receive, but I do not have to be the person in charge of communicating with the customers that order from our page. After all, the students should be the ones running the business, not the teacher. This also gives the students a lot of practical experience in dealing with customers, keeping track of their orders and payments, and communicating effectively and professionally electronically.

When orders are received, the students enter them into a Google spreadsheet that all class members can see and edit. They enter information detailing the customer's name, the design they want to have made, the size, quantity, and price. They then mark the customer's order to show the progress they have made on it (ex. designed in computer-aided design [CAD] software, cut out, painted, and / or delivered) so the other class members will know what needs to be accomplished. They also use the spreadsheet to keep track of income and expenses so that they can keep an accurate account balance.

I give students the freedom to decide what to do with the money (within reason). Most of the money they make is spent purchasing more plasma consumables, metal, and paint, but they have also bought new equipment for the shop and we have started giving scholarships to the students that go above and beyond the class expectations. CNC technology, if implemented properly, has tremendous benefits in a classroom. Some of my favorite students to work with started out as some of my biggest struggles, but after getting to see their own potential through CNC technology they were motivated and excited to learn.

John Rasty is an agricultural education teacher at Sherrard High School in Sherrard, Illinois.

Arkansas Project Incorporates Agricultural-Industrial Robotics into School-Based Programs

by Jared Wyatt, Rodney Ellis and Donald Johnson

Introduction

Robots are playing an important and increasing role in agricultural production and processing. On-farm robotic applications range from drones to autonomous tractors and from weeding and spraying to transplanting and harvesting (Zhang & Zhou, 2018). In agricultural equipment manufacturing, robots are widely used for routine procedures such as welding, gluing, assembly, and materials handling (Calderone, 2016). In food processing, robots are used for meat processing, fruit and vegetable handling, food packaging, and in materials handling.

Food processing is the second largest projected growth area for industrial robotics sales behind only automotive manufacturing (PMMI, 2019). This increased use of robotics in food processing is driven by several factors, but the primary drivers are labor availability and cost, safety, and food safety and hygiene. Although widespread use of industrial robots in food processing will most likely eliminate some jobs for routine production workers, it will also create a number of high-paying, technologically sophisticated career opportunities for individuals prepared to operate, program, and maintain these robots. At Tyson Foods, the average annual salary for an automation technician is $66,900, while the average robotics technician earns $86,885 (Technical Careers at Tyson, n.d.).

Agricultural-Industrial Robotics in Arkansas Agricultural Education

Because of the need for trained automation and robotics technicians, Tyson Foods and the Arkansas Career Education Office of Skills Development (ACE OS&D) teamed up on a grant to provide ABB SMART (Software, Maintenance, and Robotics Training) packages to selected Arkansas high schools, community colleges, technical institutes, and universities. The SMART package provided each school included an ABB IRB 120 robotics trainer, a 100 seat license for Robot Studio software, two weeks of hands-on factory training, and the ABB SMART curriculum. According to Rodney Ellis, technical education liaison with Tyson Foods, the impetus for this program was Tyson's recognition of the need to develop and support industrial robotic training offered to current and prospective team members in operations and maintenance. The industry partnership with ABB, ACE OS&D, and Tyson was crucial to the completion of this project. As advanced manufacturing and processing industries in Arkansas move forward in technology, automation and robotics will continue to increase the need for advanced technical skills in the workforce.

Two of the institutions receiving the SMART packages were the Career Academy of Siloam Springs (CASS) and the University of Arkansas. The university is using the package in its agricultural teacher education and agricultural systems management programs to prepare agricultural education teachers to teach agricultural-industrial robotics and to prepare agricultural systems graduates for well-paying careers in food processing. The university is offering a full-semester course designed to prepare students to program, operate, and maintain industrial robots. In addition, university researchers will evaluate best practices in teaching industrial robotics to high school and university students.

At CASS, teacher Jarred Wyatt is incorporating the SMART program into his curriculum in several ways. Being an agricultural-industrial maintenance program that focuses on careers in manufacturing, robotics and automation is the primary focus of the CASS program. The robot is allowing students to get real life experience as an operator, being able to turn on, operate, and set up the same type of robot they will work with in industry. Students also get experience in the life of a maintenance employee by learning to calibrate and troubleshoot problems with the robot. Finally, students get programming experience when they work in the Robot Studio software that comes with the robot. They set up environments in the program that mimic the environments that the robots are in, as well as program the robot for tasks similar to those actually used in industry.

Students complete multiple tasks with the robot throughout the school year. The first is learn-

Figure 1. CASS students learning to manually "jog" the IRB 120 industrial robot using the teach pad.

ing how to manually jog the robot. Students practice stacking items in the same manner that a palletizing robot would operate. Students then move on to setting up tool center points, which gives them experience with setting up different robots in industry that are used in different tool (grippers, suction cups, welding and cutting tools, etc.) applications. After getting comfortable with manual operations with the robot, they then start moving into the automation functions at the robot station. Students are able to design programs that mimic simple operations used for tasks in the manufacturing industry. Once students have become comfortable with these tasks, they begin working with the programming software. Students use the software to write programs in the same manner that ABB programmers would do in the field.

The ABB robot is a wonderful addition to the CASS program. Being able to get hands-on experience and operate a real piece of equipment that they will potentially use in future careers puts them on a fast track to a successful career in industry. The robot is also promoting this program to a wider audience such as those students interested in engineering, where those students were not prevalent before. The robot is also a great marketing tool for the CASS agricultural-industrial maintenance program. It lends itself to more companies that are interested in hiring students in the program, solidifying that the program is giving students a wide exposure to potential careers. Finally, with the push for career and technical education (CTE) programs in Arkansas increasing the amount of certifications in their respective programs, the ABB SMART certificate is available to students.

Summary

Industrial robots are playing an important and increasing role in a variety of agricultural production, processing and manufacturing applications. This increased use has resulted in the creation of numerous well-paying jobs and further education opportunities for those with an interest in robotics and automation technologies. With the assistance of Tyson Foods and the Arkansas Department of Workforce Education, Arkansas agricultural education programs are stepping up to help students take advantage of these opportunities.

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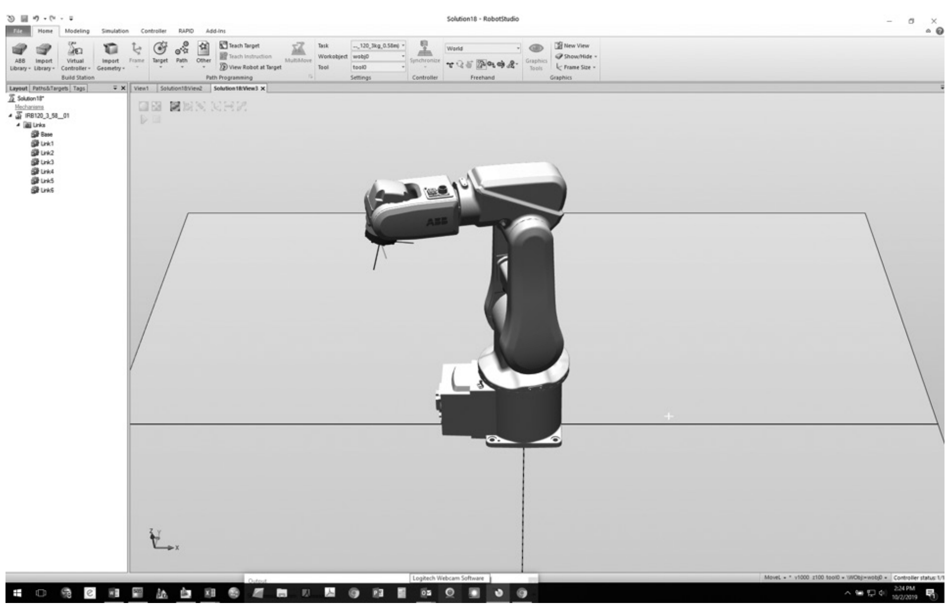

Figure 2. The RobotStudio© programming environment.

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THEME ARTICLE

Integrating Drone Technology into Agricultural Mechanics Curricula

by Jay Solomonson and Trent Taber

As agricultural education teachers, we are constantly challenged to come up with innovative ways to engage students within our classrooms. Additionally, it is our responsibility as educators to help prepare students for agricultural careers that are constantly evolving due to the ever-changing technological advances within the industry. When observing newer technology used on agricultural operations today, drones or unmanned aerial vehicles (UAVs), can serve as an avenue to improve agricultural production and efficiency. Whether it is to crop scout disease pressure in a corn field or to check cattle in a pasture, drones are not only useful but can also save valuable time and money in a farmer's operation. Consequently, drones can be incorporated within our curriculum while serving as an engaging tool in the agricultural classroom. Drones can also be integrated within an agricultural education program as a tool for marketing the local FFA chapter through dynamic videos and pictures. Most importantly, drones are a way to incorporate the next generation of standards within today's agricultural education classroom.

Engaging Students in the Agricultural Mechanics Curriculum

Agricultural education is often identified as a prominent context area for the integration of science, technology, engineering, and mathematics (STEM) content (Haynes, Robinson, Edwards, & Key, 2012). As such, it remains a premier delivery method of many different subject areas that employ many STEM facets, including agricultural technology and mechanical systems (Phipps, Osborne, Dyer, & Ball, 2008). Agricultural technology and mechanical systems (i.e., agricultural mechanics) can include numer-

ous content areas, including machinery and equipment systems, power systems, advanced agricultural technologies, and more (McCubbins, Anderson, Paulsen, & Wells, 2016). This diversity can provide numerous teaching and learning opportunities for both teachers and students, particularly as changes in the available technologies and techniques continue to expand. We need to ask ourselves how to incorporate these new technologies (e.g., drones) into our existing curriculum.

One area often taught within agricultural mechanics curricula is surveying. While this subject has been deemed important (Shultz, Anderson, Shultz, & Paulsen, 2014), it seems many agricultural education teachers struggle to engage students in this subject area. This could be due to level of mathematical applications involved, the archaic equipment used in many programs, inadequate training for the instructor, or outdated curricula. What might happen to the level of student engagement if you add drone technology to this curriculum area? Could this be the one thing to get our students engaged in surveying? Please allow me share what I did at Orion High School.

The surveying unit taught in my agricultural mechanics course at Orion High School used content designed by agricultural education teachers in the early 1990's. It consisted of concepts related to land measurement, using surveying equipment, and introductory profile and differential leveling activities using dumpy levels. The content was, as perceived by my students, outdated. Many students were, anecdotally, disengaged through this unit, citing it as their least favorite component of their agricultural mechanics course. Moreover, students indicated that the information throughout this unit was archaic, indicating frequent boredom due to the lack of rigor and relevance. While many of the skills taught within this content area are often still used within certain contexts of agricultural mechanics, the students were desirous of a new, exciting, and innovative approach to learning these concepts. In an attempt to modernize the surveying content and increase student motivation and engagement, we purchased four mini-drones and a professional DJI Phantom 3 Advanced Quadcopter Drone with a 2.7K HD video camera to use within this unit of instruction.

We utilized the mini-drones as an interest approach for the surveying unit. The mini-drones were used to introduce the concept of drone technology and spark further interest through racing. Afterward, the students conducted an inquiry-based activity during which they researched various uses of UAVs and their potential applications within the agricultural industry. This segued into a lesson on the acceptable and safe use of drones within soil and water management and engineering, as well as the relationship to the prior surveying content covered. My students were then able to apply the concepts from this unit when learning to operate the professional drone during the agricultural mechanics course.

Anecdotally, student engagement and motivation improved dramatically when the drones were first introduced within the curricula. Many of the students showed excitement about using this technology and it easily became one of the most popular components of the course, as indicated by the course evaluations. Furthermore, student exam scores in the surveying component of the course also showed significant increases over prior years' scores.

The cost of the drone we bought for this unit, the DJI Phantom 3 Advanced Quadcopter Drone with a 2.7K HD video camera, was approximately $1,000. Additional requirements include a modern, Wi-Fi enabled device to utilize as the controller / monitor. A personal iPad or smartphone, in conjunction with the free downloadable app from DJI, can be used as such. If one is not available, a 32-gigabyte (GB) iPad may be purchased for around $330.00. The purchase of an additional battery ($130), as well as a spare set of propellers ($20 per set) for the drone, is recommended as well. The mini-drones cost approximately $20 each. While their use served as an effective interest approach and were fun to utilize for practice flights, the skills and procedures used to operate them were considerably different than the professional UAV. The mini-drones didn't appear to adequately prepare many students to fly the Phantom 3, and perhaps should not be recommended for such.

Using Drones to Market Your FFA Chapter

At Cambridge High School, we used drones as an integral part of the classroom curriculum for agricultural mechanics much like Dr. Solomonson at Orion High School did. Outside the classroom, the drone has also served as a useful tool in marketing the FFA chapter. As a part of our chapter officer retreat, students organized officer spotlight videos that showcased drone footage. The students took on a leadership role in developing the videos and choosing how to capture video using the drone. The videos allowed them to professionally market the FFA program while learning a technology that is important to the future of agriculture.

We acquired the DJI Mavic Air as it was perfect for someone that had an interest in using a drone to develop quick videos or photos to market their FFA chapter. The Mavic 2 Pro starter pack costs around $900. The bundle includes a Mavic Air Arctic White drone with factory-supplied accessories, Landing Pad, camera sunshade and protector, 64 GB Memory card, Landing Gear extension, Camrise Lanyard and USB Reader. The Mavic Air controller connects to any smartphone and the controls are accessed through a free app. Each fully charged battery allows for a 20-minute flight. The drone features a 4K camera and has multiple options for capturing high quality videos. The camera's quick shot feature includes settings that allow the operator to select autonomous flights. With a simple click on the controller, the drone can capture video around any subject (group of students). The boomerang feature was used by our students to showcase the landscape of our retreat while capturing all angles of our officer team members in their FFA jackets.

We featured these videos on our social media platforms and were quickly approached by other FFA chapters as to how we acquired these "professional quality" videos. These easy-to-make videos have served as an excellent tool as we continue to market the agricultural education program and FFA chapter at Cambridge High School. Additionally, they have the potential to be a great Agricultural Communications SAE project and / or new video production project for an existing Agricultural Communications course you may already have. The opportunities to utilize this technology for your program is only limited by your imagination.

Meeting Instructional Standards

UAVs could be the next addition piece of technology that can elevate the instruction at your school. Below are some steps for you to begin pondering how a drone could fit into your agricultural education program to meet instructional standards.

Find a Drone That Fits Your Needs

There are a wide variety of drones today and they all have different uses and features. What type of drone fits your budget and accomplishes the tasks you want to complete? What type of camera do you need? For what purposes will you be using the drone?

Develop a Curriculum That Makes Your Drone Educational

Technology is great, but in order to incorporate it into the classroom it should be purposeful. What classes could use your drone as a

learning tool to develop knowledge on precision agriculture and technology? How does this technology and subsequent curriculum meet your instructional objectives while meeting AFNR standards?

Brainstorm Ways to Use Your Drone Outside of the Classroom

Although a drone has a place in the agricultural education classroom, it can be used as a creative avenue for students in their SAEs as well as in various FFA activities. How can a drone be utilized by students outside of your curriculum?

After an extensive search, there are currently limited options for curriculum in this area related to agricultural education. Your best option may be to reach out to a local community college or university that may offer an instructional program in this area and ask for assistance. We have found that these institutions want to assist you in incorporating these technologies as it helps recruit potential students into their programs. Finally, make sure that your program is in compliance with all local, state, and national laws and regulations surrounding UAVs as mandated by the Federal Aviation Administration (FAA).

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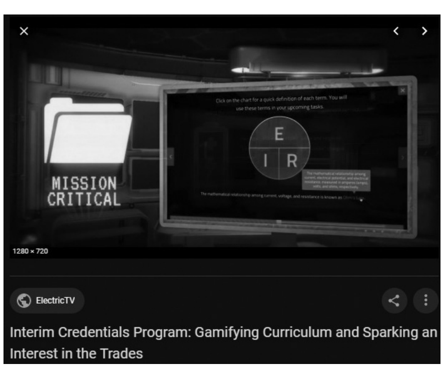
Beyond Fortnite: Smartphones in the Hands of Agricultural Mechanics

by Eric Smith

It was midafternoon during one of those perfect late-February days that Louisianans dream about. The outside temperature was 70 degrees, a light northwest breeze stirred and clear-blue skies blanketed one of the last days in 2012 sans mosquitos. On these special weather days, I always left the big roll-up door open in my agricultural mechanics laboratory, allowing sunshine and fresh air inside as a reminder that I had the greatest job in the world. The two young men that occupied the 1999 Chevy Silverado that rolled into the open bay barely survived Agriculture I as freshmen but thrived in agricultural mechanics classes as upperclassmen. They were ace hands in the laboratory. They could weld, build, and repair as well as any students I ever taught. However, they were average by most academic measures.

Amongst their laboratory-dwelling peers who preferred to "learn by doing," these two young men were leaders. They were the types that would much rather work on an old tractor than read Hemingway, prepare a speech, or employ the Pythagorean theorem. During this particular late-winter encounter (many years ago), they were early graduates with no legal hunting season open to participate, no prom date to plan, nor job to report to. They walked into my office and asked to use my tools to replace the missing air conditioner (AC) belt on that old, green Chevy. They had a brand new belt and my help to change it was not requested; they only needed some tools. I briefly wondered how they were so confident they could change the belt (secretly I wondered if I could figure it out on my own). When the bell rang to change classes and students started to filter into my classroom, I lost track of the two seniors as they eased into the laboratory. Moments later, I witnessed a scene that altered my view towards teaching and ultimately redirected the course of my entire career.



There along the side of that truck, I saw one young man down on a knee holding his smartphone so the second young man (underneath the truck) could watch a YouTube video while simultaneously performing the belt change. He was watching a tutorial and doing the work at the same time. They had the new belt on in about 30 minutes and were off on another adventure without even saying goodbye. I admit that in February 2012, YouTube (which launched in 2005) was not new to me and I often used YouTube videos during classroom instruction. But, having the Long Term Evolution (LTE) signal required to stream video from a smartphone in my rural area (31 people per square mile) was a complete game changer. Witnessing the wits of these two teenagers to use a YouTube video streamed via smartphone in real-time to solve an authentic problem while lying underneath a truck on my laboratory floor was groundbreaking for me, at least. Fast forward to today and those we teach, Generation Z (students aged 14 to 23 years), in a national study chose YouTube as their most preferred learning tool (Genota, 2018).

As of the summer of 2019, the Pew Research Center indicated that 96% of young Americans owned a smartphone; yet, only one in three schools in America allow smartphones to be used for learning during class time. If you are lucky enough to have permission from your district to allow student use of smartphones for class assignments, please do not be afraid to set up an authentic problem much like the AC belt in that old, green Chevy Silverado. For example, you could set up a learning exercise in your agricultural mechanics laboratory and have your students solve it by searching YouTube for a tutorial. It is also recommended to let your students access YouTube to search for ideas when designing a woodworking project, repairing a chainsaw, learning a new welding process, or any other agricultural mechanics topic. Many of your current students have grown up watching strangers on YouTube do ordinary things like play Minecraft, shop for groceries, or even open presents. They are conditioned to report to the video-sharing site to learn from others' trials and errors.

This is what Generation Z does and as teachers we should utilize the smartphone-streamed video to help them learn about agriculture. Check out these popular channels on YouTube to supplement your lessons in safety, welding, carpentry, small engines, and electricity:

"WorkSafeBC"- 59,628+ YouTube subscribers

"Welding Tips And Tricks" - 543,316+ YouTube Subscribers

"The Wood Whisperer" - 590,000+ YouTube Subscribers

"Woodworking for Mere Mortals" - 1,211,956+ YouTube subscribers

"The Repair Specialist"- 35,777+ YouTube subscribers

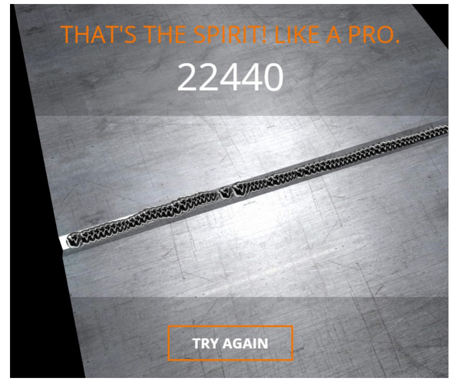
"Don the Small Engine Doctor"- 189,046+ YouTube subscribers

"ElectroBOOM"- 2,713,000+ YouTube subscribers

How long has it been since you downloaded an app? There are apps available through Google play and the Apple App Store that simulate all types of mechanical skilled trades. There are apps that professionals use to pre-fabricate welding jobs, calculate angles, populate material lists and even purchase consumables for projects. To review and recommend any of these would be a monumental task. There are apps / games that allow the player to wire electrical circuits in a barn, weld pipe, repair a tractor, and so much more. What I will recommend to you is that game-based learning is gaining traction in our field and more interactive game-based curriculums are on the horizon.

Many of you currently teach with computer-mediated software programs created by industry-based credentialing agencies that use video games as an interest approach inside their curriculum. The most recent computer-mediated learning system Louisiana agricultural education teachers have started using is called the Electrical Training Alliance Interim Credential. Interim Credential is a five-module electricity curriculum that has been gamified to attract the attention of Generation Z and allow for us to teach the same way they learn. In one particularly cool lesson, students have to apply tenets of direct current (DC) electrical theory in order to repair a spaceship that brings them back to Earth. The modules can be played autonomously from any handheld device or PC before, during, or after class. We certified 40 of our teachers in the summer of 2019 during our Louisiana Agriscience Teachers Association annual conference in order for them to begin offering Interim Credentials to Louisiana agricultural students in the Fall 2019 semester. I have seen this software in action and, in a very real way, I wish I would have had technology this cool when I was a high school student. The most technological game I played in the mid-1990's was Oregon Trail. For more information about the Electrical Training Alliance Interim Credential software, visit http://electrictv.net/videos/interim-credentials-program/.

Lastly, I have to share the easiest-to-access smartphone welding simulator I have found. As of this writing, the website is simple to access, it is free, you do not have to create an account, nor download anything in order to play. Simply go to this website (https://welding-game.firebaseapp.com/#/game/1) and start playing. Disclaimer: This



little game will never teach someone how to weld, but it does offer ample opportunity to introduce a young person to the overall concept of maintaining a steady hand or at the very least spark a little friendly classroom competition. It took me four tries before I welded "Like a Pro" and scored 22,440 points. See if you can beat that!

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Using the Miller Weld Settings Calculator App as a Tool for Higher-Level Thinking

by Bryan Rank

More years ago than I want to admit, my high school agricultural education teacher made the comment that we needed to learn to do math in our head because "you won't always have a calculator." Although I agree with the sentiment of students developing the ability to do basic math without a calculator, not having access to a calculator is no longer a valid reason for learning. Maybe we could say "in case your phone has a low battery" instead. Back then, we would also synchronize our watches with his and we didn't dare be even 10 seconds late to any pre-determined rendezvous point when we were at contests. Technological advances have given us tools such as smartphones that we can use to stay connected, find information, and solve mathematical equations instantly. Students seem to use their phones constantly. Sometimes, even when teachers ask them not to. Why not use smartphones as a tool in class? There are countless applications that can help students find information or be more organized.

Among the applications that can be helpful in the agricultural mechanics laboratory is the Miller Weld Setting Calculator app. The app can be downloaded to any smartphone for free and can be an accessible resource students can use to determine the proper settings for different welding processes. Of course, the students should use the app and then leave their phone in a safe place while actually welding. Safety first.

The Miller Weld Settings Calculator app is user friendly with easy navigation to allow users to select the process, material, and electrode or wire to be used (Rank & Wells, 2018). After opening the app, the user will first select the application for the welding process. The app includes settings for the gas metal arc welding (GMAW), flux core arc welding (FCAW), shielded metal arc welding (SMAW), and gas tungsten arc welding (GTAW) processes. In the app, the processes are described as MIG (solid wire or flux core), Stick, and TIG.

Once the process is selected, the user is asked to select the material and thickness as well as the electrode or wire diameter. For example, if stick is selected, the material options will include cast iron, mild steel, and stainless steel. After the type of material is selected, the user will be asked to enter the electrode (ex. E7018, ¼" diameter). Once the process, material, and electrode are entered, the app will provide recommendations for amperage range, polarity, and position as well as penetration depth and an electrode description. Similar to the SMAW process, when MIG is selected, the user will enter the material type and thickness and the app will provide the recommended wire size and speed, shielding gas and voltage range, and amperage range.

Obviously, students can use books to look up the settings for any process they may be using and over time they will simply remember the settings for processes they have used in practice. However, having an app that they can use anywhere they happen to be can be useful at home or work. For example, if welding is part of a student's SAE, access to the app's information outside of the school or agricultural mechanics laboratory will be necessary.

In a different context, the Miller Weld Settings Calculator App was used in an applied agricultural systems course at Arkansas Tech University (Rank & Wells, 2018). The students in the university course were pre-service school-based agricultural education (SBAE) teachers, most of whom had limited knowledge and experience with welding or metal work. The pre-service teachers were able to use the app to properly set their welders. The knowledge that their welders were set correctly allowed the pre-service teachers to concentrate on other important factors in weld quality like arc

length, work angle, travel angle, and travel speed without wondering if the settings were correct.

School-based agricultural education (SBAE) students, as novice welders, may have similar concerns about correct settings as those expressed by the pre-service teachers. Easily finding the information in a user-friendly app on their smartphone can allow students to concentrate on practicing the psychomotor skills that are essential for quality welds rather than practicing those skills with incorrect settings.

Additionally, the SBAE teacher can increase the level of cognition practiced by students in the agricultural mechanics laboratory. When I taught agricultural mechanics in SBAE, students would often ask me what amperage to set on their welder to complete a performance test. The question would be something like this, "What amperage do I need to do a fillet weld on 3/16" plate steel with 6010 rod?" The easy answer would be to just tell the student "165 amps. If it seems too hot, turn it down a bit." However, just giving an answer doesn't require the student to think or use their available resources to find an answer. By using the Miller Weld Settings Calculator app, students are able to think through what they are doing and find answers on their own which is a form of simple problem solving. We know problem solving requires higher-level thinking (Ulmer & Torres, 2007). Rather than simply answering students' questions, why not ask the students to analyze a situation and solve a problem using a readily available tool?

With the pre-service teachers in the applied agricultural systems course, I was able to increase the level of problem solving even further by having them set up their welders after all the settings were changed. Troubleshooting is a form of problem solving (Blackburn & Robinson, 2017) as well as an important skill for the soon-to-be teachers. I noticed that students tend to become comfortable using the same booth and welder in every lab session and that they would leave their welders set exactly how they wanted them so that they didn't have to change the settings each time they came to lab. On an exam day, I went in the lab prior to the student's arrival and changed the setting on the welders before they started their performance test using the SMAW process. In the lab we used Miller® XMT® 350 CC/CV multi-process welders. Since the welders are multi-process, I changed the process from SMAW to GMAW. Then I changed the polarity as well as the amperage on each welder. It was easy to see which students were actually checking their weld setting and which students just tried to start the performance test assuming that none of their settings were changed. The troubleshooting that was introduced to the performance test required the pre-service teachers to problem solve before they could even begin the welding performance test.

SBAE students and their teachers can benefit from easily-accessed information. Continuously having the information available can build confidence and provide opportunities for higher level thinking. It was a great day when I was able to tell my former agricultural education teacher that I always have a calculator and that right next to it I also have my Miller Weld Settings Calculator app.

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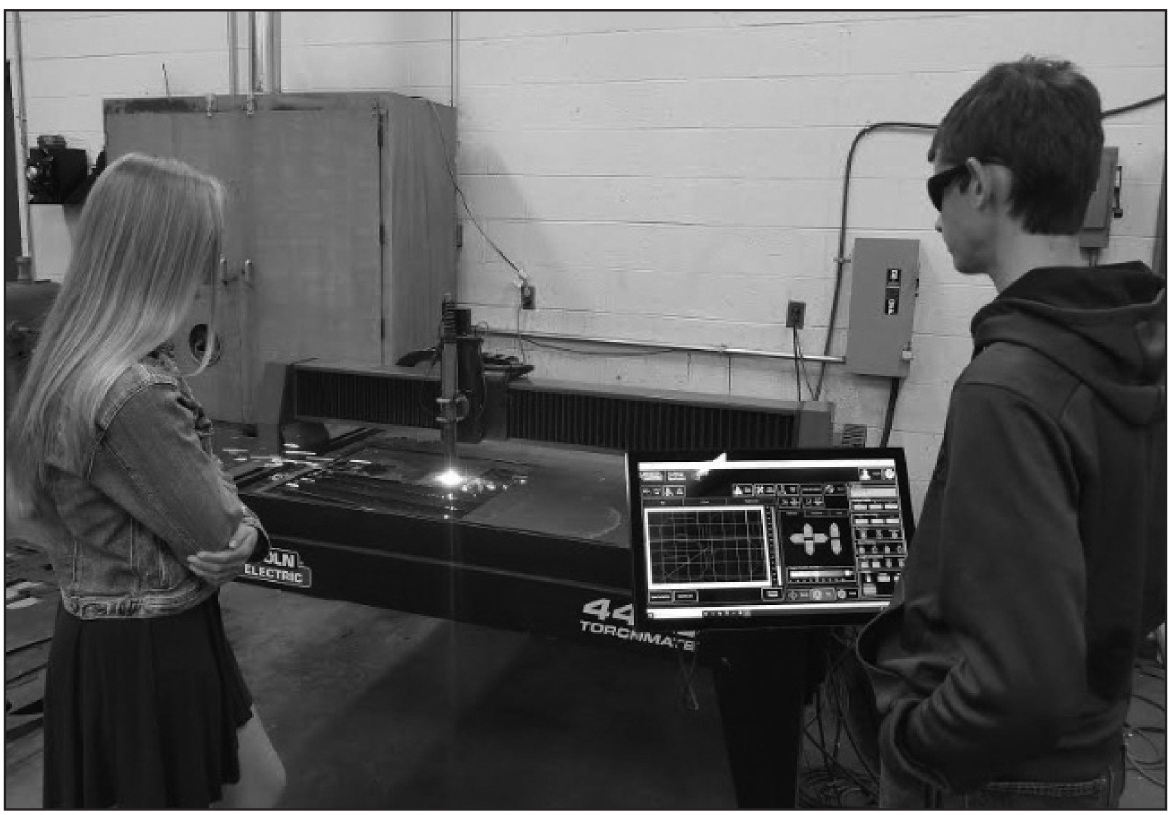
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