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STEM Integration

EDITOR COMMENTS

STEM in Agricultural Education

by John C. Ewing

The Science, Technology, Engineering, and Math (STEM) initiative has been widely talked about for many years. Schools have been promoting the initiative at all levels of education. Administrators and teachers in all areas of the school have worked to increase our students' knowledge and skills in science, technology, engineering, and math. Career and Technical Education classrooms and laboratories, and specifically agricultural education, have not been immune to working at increasing our students' achievement. And why should we be immune? Agricultural education is the application of many STEM concepts. So, the questions that are often asked related to STEM education are those that should be answered by agricultural education. Due to the applied nature of our courses, agricultural education is poised to take the lead in helping to prepare STEM ready graduates.

Questions like the two below are often asked when we discuss STEM and STEM careers:

- How can our graduates compete with the students graduating in other countries in terms of knowledge related to STEM?
- What can we do to better prepare our students to understand STEM concepts so that they can progress through higher levels of education to be ready to take jobs that are currently available, or not yet even thought of in this country and abroad?

These questions and many more like them are what encourage educators to find better ways to educate our students. As agricultural educators we can make a difference in preparing students to take on the grand challenges that lie ahead. We want our students to be critical thinkers that can solve problems that are encountered. One way that we can help our students to be ready to secure these career positions and solve the challenges ahead is by integrating STEM into all of our agricultural classes.

With a quick look at any careers website, especially those specific to agriculture or STEM, one can identify the need for an understanding of STEM concepts in agriculture. Agriculture is science. I think we can all agree that the production and processing of our agricultural goods requires a lot of science to be successful. Agriculture has always developed and utilized new technology to be more effective and efficient. One just needs to look at the advancements in equipment, seeds, fertilizers, and computer applications to know that technology and agriculture are intricately intertwined. Agriculture requires engineering knowledge and ability. If you don't believe me on this one, I will provide you with two quick examples. Set up a field trip for one of your classes to any food processing plant or "farm shop", and you will see the need for engineering concepts in agriculture! Agriculture requires a lot of math. Math concepts including calculations/formulations need to be understood by our students to be effective. Some examples that come to mind immediately are (and these come to mind prior to my first cup of coffee, so you know there are many more); adjusting soil pH, fertilizer applications, engine RPMs, pesticide applications, dosage rates, planting rates, building layout and construction, financial decision making, concrete calculations, manure management, electrical circuit calculations, and growth rates. Students can be exposed to concept after concept related to STEM in every agriculture class session offered.

Agriculture teachers need to be able to recognize these opportunities and put their knowledge and skills related to STEM concepts into their lessons. As one author points out in this issue, many times we are teaching STEM concepts, already. We just need to make it clear to our students of the connection, so that they can see the relevance to their own lives. As students learn the science within agriculture, they become a more informed citizen and better potential employee for the agriculture sector and beyond. We need students that are ready to take on the challenges facing agriculture and the global economy. By sparking that interest in our high school agricultural education classrooms, while preparing them with relevant STEM concepts in a manner that students can relate to, we are ensuring a quality workforce for all areas of agriculture.

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STEM Integration and You – A New Way to View an Old Relationship

by Catherine W. Shoulders

I know what you're thinking. Here we go, another issue telling me why and how I should be integrating STEM into my classes. If you're reading this, it's likely not your first run-in with STEM integration. You know about its value to students; you know the importance of STEM concepts in today's agricultural industries. Perhaps you have participated in or are considering participating in STEM-focused professional development, such as CASE or NATAA. Regardless of your previous relationship with STEM integration (or illumination, as one of the articles herein points out), I urge you to reconsider your role and approach to STEM instruction before you dive in to reading the articles presented here. Continue to do the same thing – in this case, reading through thoughtfully crafted articles about STEM integration with the same perspective about yourself as a teacher – and you'll get the same results as you have with previous readings focused on STEM integration. But a change in your perspective about yourself as a teacher may lead to different ideas about how to take the concepts from these enclosed articles and put them into successful practice.

Take a moment to think about yourself as a teacher. Are you committed to your students and their education? Do you view your instruction as a craft worthy of perfecting, and your own skillsets and knowledge as capable of offering that craft in a powerful way to students? Much like a doctor, are you able to gather information from students about their needs and prescribe appropriate instructional methods that meet those needs? Do you deliver instruction to your students in a way that cannot be fully replicated by just anyone holding the lesson plan? Even further, do you value the continuous process of practicing your craft, reflecting, and learning more to improve?

The answers to these questions are telling about your views of yourself as an educator; each focuses on at least one of the six characteristics shared by professionals (Shulman, 1998). Doctors, lawyers, engineers, and other professionals share the following:

1. they provide a service to society, and take on an ethical responsibility to serve their clients;
2. they are entitled to practice via the knowledge and skills they have acquired;
3. they engage in practical action, requiring that they enact their knowledge while practicing;
4. the needs of their clients lead to uncertainty, wherein their professional judgment is needed to apply the appropriate knowledge in appropriate situations;
5. there is value in continued experience, which requires they reflect on their practice; and
6. they share in a professional community (Shulman, 1998).

When you are able to answer yes to the above questions and can see your own work in the listed characteristics, you are able to view your work as that of a professional, akin to doctors, lawyers, and engineers. For the professional teacher, STEM integration can seem like an opportunity to better meet students' needs, almost as a new method of diagnosing or treating a disease might be viewed by a doctor. All new tools and methods require training, practice, reflection, and consideration of how it may be called upon to be used when an opportunity presents itself. The articles provided in this issue can provide you with new ways to view STEM integration, overarching themes to be employed within STEM integration, and specific methods to integrate STEM in your courses. I encourage you to read through them with the eye of a professional, embracing the opportunity to continue to hone your craft and meet the needs of your students.

Catherine W. Shoulders, Associate Professor, Department of Agricultural Education, Communications and Technology, University of Arkansas

THEME ARTICLE

Agriscience Integration -- Are we there yet?

by Brian E. Myers

"The practice of agriculture now offers as great a field of scientific study as is offered by the practice of medicine." (Warren, 1909, p. viii)

"All students need an understanding of basic science concepts. Teaching science through agriculture would incorporate more agriculture into curricula, while more effectively teaching science." (Understanding Agriculture, 1988, p. 11)

"Agriculture now so thoroughly combines basic and applied aspects of the traditional STEM disciplines of science, technology, engineering, and mathematics that the acronym might rightly expand to become STEAM, joining agriculture with the other fundamental disciplines." (Transforming Agriculture, 2009, p. 4)

The quotes above are but a small snapshot of the call to highlight the science of agriculture in our educational settings. The first quote is from a textbook written for use in secondary schools in the teaching of agriculture in the early 1900s. That book goes on to highlight the importance of students understanding the scientific principles underlying each of the practical applications taught in the book. It bemoans the teaching of agriculture to only those that plan to be farmers. The author is clear in his view that the teaching of agriculture is of great value even to the "city-dweller." Dr. Warren, the author of the textbook from which the first quote is drawn, was not the first to make this connection or call. I encourage all involved in agricultural education to read John Hillison's 1996 article "The origins of agriscience: Or where did all that scientific agriculture come from?" in volume 37, number 4 of the Journal of Agricultural Education (DOI: 10.5032/jae.1996.04008). In this article, Dr. Hillison does an outstanding job reminding us that teaching agriculture as a science is not a new idea.

Agriculture and agricultural education were in crisis and something radical had to be done to save it… or really save us.

For many who were being prepared as teachers of agriculture when I was, the Understanding Agriculture report by the National Research Council was taught to us as a revolutionary call to action. Agriculture and agricultural education were in crisis and something radical had to be done to save it… or really save us. However, was it a call to new action or a call to return to our roots (pun intended)? Either way, things started to happen in school-based agricultural education around the country. Titles of programs were changed from "Vocational Agriculture" to "Agriscience Education" or some variation. New textbooks and curriculum were developed and released. High school agriculture courses started to earn completers science credit toward high school graduation or in some cases college credit. Our beloved agricultural youth organization went from using its name "Future Farmers of America" to doing business as just the "National FFA Organization." Looking back at that time, we, as a profession made some great strides, yet some wonder did we really meet the call or did we just change our semantics?

In the 2000's, increased focus was given nationally to concepts like STEM and educational accountability for all students. School-based Agricultural Education was not immune from these pressures. Leaders in our profession answered these calls through the development of programs like the National Agriscience Teacher Ambassador Academy (NATAA) and the Curriculum for Agriscience Education (CASE). These programs addressed the need to not only provide our dedicated school-based agriculture teachers with the content to teach, but worked to help build up

Looking back at that time, we, as a profession made some great strides, yet some wonder did we really meet the call or did we just change our semantics?

their "teaching toolbox" with enhanced methods and techniques to complement our long tradition of "learning by doing."

As a high school teacher in the mid to late 1990s, I recall walking down the hallway of Unity High School in Mendon, IL. As I walked by the science classroom I heard the biology teacher presenting a lesson on genetics. I thought proudly to myself "I just taught that very same lesson in my animal science class last week. Man, I've got this agriscience stuff down!" But as I walked further, my thoughts changed. Unity High was a small rural high school of about 260 students in grades 9-12 at that time. We had a pretty small faculty. If the principal has two teachers and two courses teaching the exact same content, why would he keep both of us? I then realized that I didn't "have this agriscience stuff down" as well as I thought I did. I knew I needed to change. I was not hired to teach basic biology, but I was hired to teach how these science principles undergird the agriculture production practices and decision-making farmers, farmers just like my grandfather and father, engage in every day. As a university teacher educator, the job description for my very first faculty position included the task of helping my new home state of Florida integrate science into the agriculture courses. My colleagues and I at the university level have used barrels of ink writing up research on agriscience integration in the Journal of Agricultural Education and have revised our teacher preparation programs to address this need. State agricultural education staff members have worked to revise and implement new curriculum standards. Teacher educators, state staff, and professional agriculture teacher organizations – state and national – have developed and delivered hundreds if not thousands of professional development workshops on the topic. Yet the call continues to come – we need to improve the agriculture and science literacy and understanding of our students. I have to ask the question, have all our efforts failed?

As I reflect on that somewhat daunting question, I think back to the many trips I've taken in the car with my two boys from Florida to Illinois to visit family. The trip is long and the boys (and their father) often got a bit impatient on the journey. From the back seat I would hear "Are we there yet?" The reason they asked that question was a bit out of boredom, a bit out of recognizing that they had been doing good in the car for so long and weren't quite sure how much longer they could do that before giving in to the urge to aggravate the other brother, and a bit out of just wanting to know that there was an end in sight. One of the great privileges I have as a university teacher educator is getting to work with the outstanding teachers, state staff, and other teacher educators in school-based agricultural education. As we work to continue to make the profession we love even better, I often sense the same question from them about science integration in agricultural education – are we there yet? We have been working on this for over 100 years (see the quotes at the beginning of this article). I will admit I've been frustrated at times as well. But we are making progress and the data supports my optimism. Students are learning the science of agriculture and natural resources. They are learning how to make evidence-based decisions. They are learning how to communicate the science and importance of agriculture in the development of a sustainable community. We have and are making great strides to serve our students and the agriculture industry.

But we are making progress and the data supports my optimism. Students are learning the science of agriculture and natural resources. They are learning how to make evidence-based decisions.

I'm not sure we will ever get "there," where ever that is. I think we will always we working to improve our craft and practice of teaching the science of agriculture. But it is important for us all to know that what we are doing is important. We cannot give up. Our students, our profession, and the agriculture and natural resources industry are counting on us to continue the progress forward.

Brian E. Myers, Professor and Chair, Department of Agricultural Education and Communication, University of Florida

STEM, STEAM, HAMSTER: It doesn't matter what you call it, it is all problem-solving

by Valerie Bayes

When students are faced with a problem, they don't care about acronyms and titles. They care about understanding the problem and discovering how to solve it. As an educator, that can be frustrating when you're trying to guide and grow the next generation of modern agricultural professionals. The good news is that those with curious minds are perfect for careers in STEM fields, they just don't know it yet. It's our job to show them their potential and give them options for the future, and students give us opportunities to recognize their potential in their daily thoughts and actions. We just have to listen.

> The good news is that those with curious minds are perfect for careers in STEM fields, they just don't know it yet.

A few years ago, I attended the Intel Innovation International Science Fair where I manned a booth discussing STEM at Monsanto with attendees. One of my first visitors to the booth was a young woman we'll call "Amy." When asked, she enthusiastically explained the reason she was there – her science fair project.

Amy's brother, a high school football player, had several friends sitting on the bench due to concussions. Being the curious and inquisitive young woman she was, she asked herself why woodpeckers can hit their heads repeatedly against hard surfaces like trees without harming their brains. What is difference between their skulls and a football player's that allow the birds to repeatedly jar their heads without injury?

Instead of just wondering, Amy jumped into action. She dug in and through research discovered the concept of non-Newtonian fluid dynamics and the idea of semi-solids. The next question she asked herself was if she could use semi-solids to design a better, safer, football helmet.

Amy began experimenting with different materials like cornstarch and water and soon built a prototype. Impressed, her teacher suggested she enter a local science fair, where she won, moving on to regionals, nationals, and then to this international science fair.

But she wasn't satisfied with winning numerous science fair blue ribbons. Amy was on her way to the American Intellectual Property Law Association booth so she could patent her new helmet. From there, she hoped for a meeting with the National Football League (NFL).

Now might be a good time to mention, this innovative, curious, resourceful, smart young woman who identified a problem, researched on her own, built a working prototype, and had a solid plan for the future of her project, was only 13 years old!

As I picked my jaw up off the floor, I realized something. This 13-year-old wasn't worried about what she could do with this curiosity in the future or starting a career in mechanical engineering and physics. She was focused on a problem or, more specifically, solving that problem.

Additionally, Amy wasn't concerned with the labels of entrepreneurship, STEM, and public relations even though her journey carried her through all the above. She learned about the biology and physics of a woodpecker by cold-calling subject matter experts. She challenged her own creativity to create a prototype and when it didn't work, she scrapped it and tried again. She tackled what many twice her age still struggle with by presenting her project at least four times and she planned to continue talking about her project in hopes of starting a partnership with the NFL.

The potential careers don't matter as much as the desire to learn and explore.

As agriculture educators, we can glean several lessons from this young woman's story that may help us connect other young thinkers with all the possibilities the world of STEM provides.

1. **Encourage divergent thinking:** Too often, school revolves around students learning certain concepts without leaving

room for the natural, curious questions children can have. By exploring an "odd" thought about something culturally relevant to her life, Amy learned about entrepreneurship, biology, physics, public relations, and more.

2. **Leverage partnerships:** Reach out to your environmental science, mechanics, biology, home economics, and chemistry counterparts. Work together to show students how the STEM fields work together. To complete her football helmet, Amy didn't just focus on the biology of the woodpecker – she needed physics, mechanics, and home economics.

3. **Don't be afraid to reach out:** Amy cold-called university professors knowing they would have the technical knowledge she needed to solve her problem. Public and private partnerships will help expand your classroom beyond its walls and expose your students to a global worldview. Even if your school doesn't have a relationship with a certain business or university, just ask.

4. **Provide practical examples:** Amy saw a real-life problem that needed a solution. Make sure your students know how to apply the concepts you've been teaching them in practical applications. Ask experts to create problems for your students to work on and invite the expert to discuss the problem and the students' solutions with them. Allowing students to ruminate on a real-world problem can increase their interest and curiosity in a field.

5. **Change up Career Day:** Ask professionals to speak, not about their careers per se, but real world problems they have solved or are currently working to solve. The STEM fields are changing rapidly and the careers that exist today may not by the time your students enter the workforce. Instead of talking about what people in STEM do, show students real-world problem solving being done by those working in STEM.

6. **Finally, foster an environment of creativity and curiosity.** Students can't explore what they might be interested in if they aren't given the opportunity to ask questions and express themselves. So, while it is key that students know the importance of STEM and how it can help to advance modern agriculture, it is also important that we allow our students to take the path that feels right for them.

Although Amy's project didn't have anything to do with agriculture, it exhibits the same thought process involved in solving every agricultural problem. Engineering design process and critical thinking know no discipline.

Don't get me wrong, there are plenty of examples of innovative students solving agricultural problems because that is what is culturally relevant to their lives. For example, a young woman from rural India was tired of getting stung by bees on her way to school. She had also heard of pollination problems on local farms. Her solution of moving the bushes where the bees made their home away from her walk and closer to the fields needing increased pollinations has shown promising results. Bees mattered to her. Concussions for football players mattered to Amy.

In the end, it doesn't matter the students age, nationality, or academic interests. It is about students asking better questions about the world around us, identifying problems, and working to find a solution. Call it what you will – STEM, STEAM, HAMSTER (because you can't forget humanities and reading) – it is all about problem solving. By focusing on techniques for solving problems our students find culturally relevant, we will introduce them to the possibilities of careers in STEM.

Valerie Bayes, STEM Engagement Lead, Monsanto Company

THEME ARTICLE

Emphasizing STEM Content through Agricultural Education - Be a Part of the Solution, Not a Continuing Part of the Problem!

by J. Chris Haynes

Every year when I discuss the importance of Science, Technology, Engineering, and Mathematics (STEM) instruction and the emphasis of it through an agriculture curriculum rich in STEM content with my Agricultural Education pre-service teachers, I start the classroom discussion with “Be a part of the solution, not a continuing part of the problem!” As those words sink into them during classroom discussion, we go over a few startling facts:

- “U.S. students’ academic achievement still lags that of their peers in many other countries” (Desilver, 2017).
- “U.S. now ranks near the bottom among 35 industrialized nations in math” (Barshay, 2016).
- “STEM related occupations employ only 5 percent of the U.S. workforce, however, they are accountable for over 50 percent of U.S. economic growth” (U.S. Science and Engineering, 2012).
- A clear demand exists for workers in STEM related careers and occupations. The latest statistics indicate that there are 3.6 unemployed people for every job that opens in all occupational areas, however, there are two open positions in STEM related areas for every person seeking employment (Change the equation, n.d.).

All of these facts should be troubling as well as encouraging to any educator. But as agricultural educators, we have the ways and means to make a difference! As you already are aware, agricultural education is full of opportunities for students to learn that agriculture is bursting with STEM content, from the science which is found in the plant, animal, and environmental curricula, to the math, engineering, and technology that is inherent to the agricultural and mechanical technology systems courses. But how do we go about identifying those concepts in our courses that will cause the school administration to get all “warm and fuzzy” about what we do out in the Ag classroom? Well, stick around while we discuss some of the ways that you can emphasize the core curriculum content that is fundamental to agricultural education!

What Now?

Do your homework! Review the state and national standards for your course curricula and align them with that of your colleagues who are responsible for teaching the core courses in your school. I tell my pre-service teachers that the first thing they should do when they are under contract with a new school is to get to know those that will be teaching the subjects that relate to the courses we teach. You will be surprised at how willing they will be to work with you knowing that you are there to make a holistic difference in your students’ education, and not just in your own subject area. Find out what topics are to be discussed at what point in the school year and make every attempt to realistically align what you do with what the students are learning across campus.

So, what topics are ideal for the emphasis of STEM content? In agricultural education, pretty much everything! Education Week identified six characteristics of a great STEM lesson that I will reference to help you in deciding what part of the elephant to eat first.

1. Focus on the problems and concerns that are found in your own backyard.

Lessons that are best suited for focus are those that will hit home with your students, something they can say was a real-life application of their learning. Take a good look around the community, poll your students on what problems they see around them and then apply them to your instruction. Look for your community resources; County Extension Office, Ag in the Classroom, Beef and Swine Checkoff Programs. All will have resource materials that you can utilize in your classroom.

2. Select a subject that is suitable for research.

Look for a topic that has the potential for students to follow the scientific method. Allow your students to determine what the problem is and then work towards the solution, or set of solutions. Give your students the opportunity to research the issue and try their own ideas as a solution to the problem.

3. Allow for hands on inquiry and exploration.

Allow for unlimited exploration of the topic. Be sure and have on-hand the necessary materials for open-ended student exploration of the topic, so that students can work collaboratively, communicating their ideas to others, benefiting from the peer review process. Inquiry based instruction has been shown to help students better develop their critical thinking skills resulting in a deeper understanding of the subject matter, as well as an increased retention of the subject matter in your lessons.

4. Allow for the cooperative learning process.

Allow for group effort in your assignments and embrace it in your classroom. Too often we worry about what we perceive to be off-task behavior, when in reality the students are on task. Cooperative learning is the instructional use of small groups so students can work together and maximize their own and each other's learning. Build teams where students develop a more frequent use of higher-level reasoning strategies. When they are working together and expected to be able to explain their decisions to their peers, they are learning at a higher cognitive level, rather than just learning the material to pass a test. Teamwork with students can be trying at times, so don't be afraid to reach out to others in the school to find out what works best for them!

5. Build opportunities for contextualized learning.

Take advantage of the agricultural content to engage your students in learning. Too often, opportunities for learning will pass a student by when they can't make it real or see any value in the subject matter presented to them. We all know that agricultural content is rich in the sciences and math, so work to reinforce your students' science and math awareness by bridging the gap between your curriculum and the core content. Ensure that you use the same terminology the students are likely to hear in their science and math courses. The extra effort will pay them back tenfold in their education.

6. Don't be scared of failure!

The STEM content inherent to agricultural education allows for a wealth of creativity for both you and your students. Try new things! Change up the different variables associated with your assignments so that your students can embrace their creativity with the different options available to them in solving the problem. More importantly, allow them to fail and then try again. Failing and trying again allows them to learn from their mistakes and come up with solutions that they might not have thought about before. As has often been said, be the 'guide on the side', not the 'sage on the stage'!

It is not very difficult for us to see the benefits of contextualized learning through agricultural education. The different courses and subjects commonly taught in agriculture are steeped in the sciences and mathematics and allow for real-time formal and informal hands on learning opportunities that favor all different learning styles. Through plant and animal science, horticulture, environmental science, and the mechanical and technology systems, there is something for everyone in agricultural education that is suitable for reinforcing the STEM content integral in agriculture and essential to ensuring that the United States remains a leader in STEM research and innovation.

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THEME ARTICLE

Agricultural Education Saving the World: Addressing Food Security and Other Complex Issues

by Tyson J. Sorensen

Let us fast-forward 30 years from now to the year 2050. What does the world look like? Let me share one possible scenario. There are 9 billion people worldwide and urban sprawl has taken up much of the farmland that once surrounded metropolitan areas. Due to the population, the major issue of the time relates to food. There are massive shortages of food worldwide and resources are depleted. Because of the shortage of food, there are widespread famines and social and political unrest. Here in the United States, the price of food is so high that only the wealthiest of the population can afford healthy food to eat. This scenario is certainly bleak, but it can surely be avoided if we begin now to start addressing the issue of food security, which I believe is one of the biggest issues of our time (even though few people are talking about it, including us as agricultural educators).

Experts predict that by 2050, the world population will plateau between 9-10 billion people (FAO, 2009). These millions of mouths will need feeding, which will require a substantial increase in yields on less land, all while reducing the environmental impact of food production. So, how do we as a society make such a drastic leap forward? The answers can start with school-based agricultural education! I propose that school-based agricultural education can begin to address the complex issue of sustainable global food security in two major ways: 1) agricultural education can begin the training for a skilled workforce that understands and has the ability to address the issue of food security; and 2) agricultural education can increase agricultural literacy to promote innovation within food production.

> School-based agricultural education has the responsibility to educate our students and communities about the science and innovations related to food production and ultimately food security.

A skilled and motivated workforce

In 30 years, the students we currently have in our classrooms must be the agricultural leaders to address complex issues in agriculture. Currently, there is a shortage of skilled workers in the field of agriculture and STEM capable of addressing the issue of food security (Goeker, Smith, Fernandez, Ali, & Theller, 2015). If the pipeline doesn't begin with agricultural education, how do we expect to ever have enough skilled agricultural scientists to address this important issue of our time? We need to get students on a trajectory now, so they are aware of the issue of food security and are encouraged to make a difference in the world by choosing a career to address food security issues.

> The reason we talk about STEM is because we actually need people who can solve complex problems, such as sustainable global food security.

Agricultural literacy that promotes innovation

One important goal of agricultural education is to develop agricultural literacy among our students and within our communities. This is much more than just the cliché, "knowing where our food comes from." An agriculturally literate community must understand and accept innovations related to food. For example, why is it that throughout the world's history, people have celebrated innovation to solve some of the world's biggest issues, yet innovation is questioned when it relates to food (e.g., GMOs)? Studies have shown that adding innovation, like GMOs, rather than increasing animals or land is the most logical, efficient, and sustainable way to address food security (Cady, 2013; Center for Food Integrity, 2013).

Yet, it seems everywhere you turn people within your communities are fighting against this innovation, and more don't understand what GMOs even are. Agricultural literacy means people have an understanding of the products, practices, and genetics that help farmers produce more food more sustainably and safely. This understanding throughout our society will enable regulators and policy makers to make science-based policy choices and will enable innovation that is not stifled by consumers' lack of knowledge. Food security is attainable, but consumers must have open minds toward innovation and technology. School-based agricultural education has the responsibility to educate our students and communities about the science and innovations related to food production and ultimately food security.

We as a profession have great opportunity before us, but, we have to begin now to change our conversations and break from the status quo.

STEM and Agricultural Education

Why do we talk about STEM? Is it just to make us feel good that we as agriculture teachers can say "yes, we integrate STEM in agriculture?" No! The reason we talk about STEM is because we actually need people who can solve complex problems, such as sustainable global food security. These complex problems will require that students not only know the concepts of agriculture, but that they understand how to utilize science, technology, mathematics, and engineering. STEM is a multidimensional approach to solving complex problems and increasing innovation. Not just using science, but using multiple approaches and skills to address complex problems. Do you teach your students how to solve complex problems using a variety of disciplines and approaches? Do you provide opportunities for our students to be innovative in designing solutions to real-world problems? If we truly integrate STEM, that is what we should be doing.

The purpose of Agricultural Education

What is your purpose as an agriculture teacher? I suspect the common answers are: 1) to prepare students for careers; 2) to increase agricultural literacy; and/or 3) to prepare students for college. Can we be more specific about those generic goals in order to make a bigger impact in the world? I would ask, how are you preparing students for relevant careers in the 21st century? Are you preparing them to enter the 21st century workforce to address some of the biggest issues of our time (food security and nutrition, water, bioenergy, etc.)? If your goal is to increase agricultural literacy, I would ask, to what end? Why is agricultural literacy so crucial for the survival of our society over the next few decades?

The big take-home message I want to convey through this article is that as agricultural educators, we can make a significant impact in the world and in our communities by changing how we think and teach about agriculture. If we take this challenge seriously, I believe that in 30 years when the world reaches 9 billion people, your students will be up to the challenge of addressing the issue of sustainable global food security and other complex issues. If agricultural educators do not take ownership for addressing the issue of food security, who will? Who else is in a better position than you, agricultural educators, to teach tomorrow's workforce about food security and agricultural issues that will impact the world? Who else is in a better position, agriculture teachers, to encourage students to enter careers that will truly make a difference in the lives of so many people on the planet? We as a profession have great opportunity before us, but, we have to begin now to change our conversations and break from the status quo.

Suggestions for teachers

The following are suggestions for agriculture teachers towards the goal of addressing the issue of food security within agricultural education:

1. Focus on preparing students for relevant scientific and agricultural careers. Teach students about the issue of food security and encourage them to take on the challenge of finding a solution. Do students even know that food security exists and they can be the ones to help to address it?

Why aren't there enough people going into agricultural and science careers? Perhaps because teachers and counselors aren't explicit in sharing real opportunities and careers that exist. We need to learn about those careers and help our students find a passion for those careers.

2. Focus instruction around food security and make it relevant. If we are not relating the curriculum to real-world issues of importance, we are falling short of our potential. For example, when teaching about egg production we can discuss how just one more egg per hen per year can help meet the global demand, and requires 4 billion fewer hens (Cady, 2013). Almost every unit we teach can relate back to today's complex agricultural problems.

3. Encourage students to engage in the Agriscience Fair with real-world global issues, like food security, as the driving force. Today's students are surely capable of innovation to address components of food security. Instead of doing the Agriscience Fair just for the sake of it, help students focus on aspects of important global issues.

4. Engage globally. Find ways to engage in agriculture outside of your local communities and country, either virtually or in person. It is an eye-opening experience to see agricultural production and the food system of other countries first hand. Doing this will enable students to see the issue of food security first hand and understand the need for innovation, which can inspire students towards a career and goal of sustainable global food security.

5. Provide opportunities for students to solve real-world issues through case studies or actual community challenges. Case studies and collaboration are a great way to help students understand how issues are often multifaceted and complex and require much thought and knowledge in a variety of areas (e.g., economics, social, political, environmental) in order to adequately address them. This is the type experience and skill the future workforce needs as it addresses the issue of food security.

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THEME ARTICLE

A Teacher's Guide to Illuminating Science within Agriculture, Food, and Natural Resources Education

by Aaron J. McKim, Craig Kohn, Misty D. Lambert, Jonathan J. Velez, and Mark A. Balschweid

Disclaimer - this is not another sales pitch for the value of teaching science within Agriculture, Food, and Natural Resources (AFNR) curriculum. Our guess is you have already heard or read about the importance of science within AFNR Education and, by now, see the value of illuminating science within the curriculum you teach. Therefore, instead of exploring why address science, this article focuses on how to address science by introducing new and different methods. Not surprisingly, some of the "new" methods have actually been used in AFNR Education for a long time. With this in mind, let us explore three periods in the evolution of AFNR Education whereby science learning was emphasized.

The first of these periods began with the passage of the Hatch Act in 1887. From 1887 to 1917 AFNR Education within secondary schools linked the scientific discoveries of experiment stations to rural producers via school-based AFNR Education (Moore, 1987). This era of AFNR Education exemplified the illumination, and utilization, of science and its critical role within agriculture and food production systems. The second period of science focus initiated with the passage of the Smith-Hughes Act in 1917. At this time, AFNR in secondary schools transformed to be vocational in approach; however, science content and practices remained. In fact, early years of AFNR Education under the Smith-Hughes Act exemplified the science knowledge and skills required to be employed within AFNR professions (Malpiedi, 1987). The third period of science focus was catalyzed by publication of Understanding Agriculture: New Directions for Education (National Research Council, 1988) which identified a critical need for AFNR Education to re-emphasize science concepts so AFNR courses could contribute to increasingly core academic-focused graduation requirements. Since 1988, AFNR Education has emphasized the importance of science content, exemplified in initiatives like Agriscience Fairs and the Curriculum for Agricultural Science Education (CASE).

In a recent study, McKim, Velez, Lambert, and Balschweid (2017) suggested that while AFNR Education has re-marketed itself as science-focused, certain barriers prevent science content from authentically being illuminated within AFNR curriculum. Identified barriers include teacher knowledge of, and motivation to teach, science within their curricula. These limitations led authors to identify three groups of AFNR Educators: (a) science illuminators - AFNR Educators competent in, and motivated to teach, science within AFNR curriculum, (b) illumination attempters - AFNR Educators who possess the motivation to teach science, but lack the scope of science knowledge required to effectively engage students in learning science, and (c) vocational purists - AFNR Educators who, regardless of science knowledge, lack the motivation to illuminate science within their curricula. Pointing to past assessments of science knowledge and motivation among AFNR Educators, McKim et al. suggested the majority of AFNR Educators fall within the illumination attempter category.

The predominance of illumination attempters in AFNR Education should not be surprising. Teaching science, just like teaching AFNR, requires significant training and experiences. Hence, the majority of AFNR Educators have focused on developing their AFNR knowledge, experiences, and teaching skills and, thus, may lack the education and experiences required to authentically offer challenging, standards-based, science learning. Recognizing this limitation, the following explores simple and practical approaches for AFNR Educators, who recognize an opportunity to become science illuminators, to strengthen the quantity and quality of science learning throughout their programs.

Networking

The transition from illumination attempter to science illuminator requires continuous development of science knowledge. For this development, we recommend collaborating with local science teachers. Science teachers can connect you with resources and their communities of practice to obtain curriculum, laboratory ideas, and equipment. The science teacher can also serve as a resource for answering questions and helping identify potential roadblocks for students understanding concepts and developing skills. You might be hesitant – you may worry they could think you are unqualified or they could be too busy - but consider your response if this request were reversed. We are confident you would have three or four immediate ideas and would be excited another teacher was interested in your content area.

Another resource to include in your network would be local AFNR professionals. These individuals not only have a vested interest in creating science-informed students, but also understand the connections between agriculture and science because it is a part of their daily work. Connections with these partners may include inviting them for guest lectures, having students tour their facilities (with a focus on where the science is occurring), and/or partnering with them as another resource to answer your questions and build your science knowledge.

Lastly, identify those in your community who advocate for and understand the science connections that underlie AFNR. These unique community leaders may be working in local government and/or community outreach organizations. These are people who, daily, see the impact of AFNR on society and can help students establish connections between science and community impact.

All three of these resources require making intentional connections. While these have been presented as three separate resource ideas, we also suggest you consider using all three to form a community network of science experts who can boost your science knowledge and help students see the AFNR-science connections in your curriculum.

Evaluating

With your science network intact, it is time to leverage connections to evaluate how science can be better illuminated within your curriculum. We recommend this evaluation occur by comparing your approach to the science teaching strategies recommended within the Next Generation Science Standards (NGSS). A primer to explore the NGSS is provided.

The stereotypical view of a science classroom entails memorization of an overwhelming array of seemingly obscure scientific facts. The NGSS reflect a research-based shift away from merely learning about science to enabling students to figure out scientific phenomena (Schwarz, Passmore, & Reiser, 2017). The NGSS are composed of three key components: (a) use of scientific and engineering practices, (b) crosscutting concepts that unite all branches of science, and (c) a select amount of disciplinary core ideas that are necessary in order for a student to understand how and why the world works in the way that it does (NGSS Lead States, 2013).

The NGSS emphasize student engagement in sense-making about the world around them, encouraging students to become proficient in the practices and manner in which scientists think, reliably reach evidence-based conclusions, and develop and revise scientific models that address questions about the natural world. For an AFNR instructor, this shift is a key strength, especially given the prevalence of misconceptions about AFNR. By enabling students to identify and adopt valid evidence as the primary means by which they reach conclusions, fewer Americans will be susceptible to biased misinformation.

NGSS is not without limitations. Out of necessity, NGSS is focused on classroom learning outcomes and largely ignores aspects of instruction that occur outside of a standard science classroom. As such, these standards provide only partial guidance for Supervised Agricultural Experiences (SAEs) and other non-classroom based instruction. However, improved classroom science learning, in conjunction with stronger SAE experiences, should result in students more effectively prepared to use science and engineering in their personal and professional lives.

Implementing

The NGSS provide a platform from which to build a stronger portfolio of science learning within AFNR classroom curriculum. However, limitations in the NGSS require we look elsewhere for innovations to guide science learning outside the classroom context. When students utilize employment, job shadowing, and/or internships with community professionals, they are replicating what Lave and Wenger (1991) called "legitimate peripheral participation." Without opportunities for the kind of situated participation inherent in opportunities like SAEs, the prospects for deep, meaningful science learning within the context of AFNR are much more limited (Esmonde & Booker, 2017).

The AFNR Education program at Waterford, WI provides a great example of the integration of SAE. At Waterford, SAEs became a mandatory and graded component of all courses, with each student's SAE grade accounting for 10% of their final course grade. This grade was partially based on the relevance of their experiences to intended careers and course content. The educational value of these experiential learning opportunities was soon apparent to almost all involved, and initial resistance from parents and students dissipated by the end of the first year's trial. Not only did the relevance of classroom material become more apparent, but the interests of the students changed considerably as their participation evolved and expanded. Further, engaging students in authentic, community-based experiences through SAE provided opportunities for students to experience, first hand, the essential connections between science and AFNR.

AFNR Education is a premier context to illuminate science learning. In this article, we explored three methods for empowering AFNR educators to enhance the quality of science learning offered throughout their programs. By forming a science network, aligning teaching with the NGSS, and leveraging programmatic features like SAE, AFNR educators can initiate transformative learning opportunities for their students and themselves.

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THEME ARTICLE

Experiencing STEM: Using Experiential Learning to Help Students Understand STEM Concepts

by Kasee Smith

Agricultural education is built on a foundation of learning by doing. Researchers have concluded that students are more likely to learn and retain abstract concepts, like many of the concepts in STEM fields, if they learn them in an experiential manner. The structure of agricultural education makes an agriculture classroom the perfect environment to help students gain STEM knowledge; you can use this structure to your advantage as you help students learn difficult STEM concepts. To fully benefit from using experiential learning to integrate STEM concepts, it is important to examine what experiential learning is, understand methods for strengthening experiential components in STEM lessons, and explore methods to use experiential learning to differentiate STEM instruction.

What is Experiential Learning?

Experiential learning is a broad concept often discussed in current educational circles. Educators at all levels claim that their classes or programs are using experiential methods. This begs the question: what does "experiential" mean? Experiential learning is not just doing a lab or application activity while you are teaching; true experiential learning includes specific components that are designed to help increase understanding and retention. There are many different theories used to explain the concept of experiential learning. Kolb (1984) developed a theory of experiential learning that is commonly accepted and has been discussed in the context of agricultural education. Kolb described experiential learning as "a process whereby knowledge is created through the transformation of experience". This definition requires that experience takes on a larger role in learning than just completing a laboratory activity.

Kolb suggests that there are four main components in the process of experiential learning. The following table shows the four components of Kolb's experiential learning model and what those might look like in an agricultural education classroom.

Component	Basic Definition	What it could look like in a classroom
Abstract Conceptualization	Learning by thinking	Students reading or listening to a description of how a concept works and thinking through the new information.
Active Experimentation	Learning by testing	Allowing students to test their knowledge of a concept by applying it in another situation or setting.
Concrete Experience	Learning by experiencing	Students doing something tangible in order to learn how something works.
Reflective Observation	Learning by watching	Students thinking about how a concept applies to things they have previously experienced in their lives.

According to Kolb, people bring in new information through either concrete experience or abstract conceptualization and process information through either active experimentation or reflective observation. It is important to note that all four components are important to help students bring in and process information. Using experiential learning concepts is a good idea in all agricultural education courses, but is especially helpful when students are learning STEM concepts. STEM concepts are often complicated and can be highly abstract in nature. Often, students do not have a tangible reference to help them process these concepts into knowledge. Structuring STEM-based lessons using all four components of experiential learning gives students the opportunity to process abstract concepts, can increase student comprehension, and provides an easy way to improve the quality of your instruction.

Strengthening Experiential Components in STEM Lessons

Once you know the four components of experiential learning, you can incorporate them into your STEM-based lessons. Using experiential learning is most effective when students are able to complete the entire experiential learning process, moving through each of the components. The most important thing you can do to utilize experiential learning in STEM lessons is to include all four components. To assess lessons, begin by looking through the lesson plan and labeling places where the four experiential learning compo-

Often, students do not have a tangible reference to help them process these concepts into knowledge. Structuring STEM-based lessons using all four components of experiential learning gives students the opportunity to process abstract concepts, can increase student comprehension, and provides an easy way to improve the quality of your instruction.

nents are already occurring. If you identify one or more of the four components missing, revise the lesson to make sure that each component is represented.

Even if a lesson includes all components of the experiential learning model, there are steps you can take to maximize the impact of each component on student learning. With just a few minor changes to your lessons, you can capitalize on the benefits of experiential learning while teaching STEM concepts. Let us examine ways to strengthen each component in your lessons.

Many lessons naturally include abstract conceptualization. When teachers explain concepts or students read new information, they are likely bringing in information using the concept of abstract conceptualization. In fact, many lessons are composed of only abstract conceptualization. To help strengthen this component in your STEM lessons, you can:

- Use the same terminology students will encounter in core classes. Talk to math, science, and technology teachers to find out how they teach abstract concepts. For example, if you are talking about adding fractioned measurements in an agricultural mechanics class, use terms students will encounter in their math class. Saying "numerator" or "denominator" can help students transfer their learning much more than saying "top number" and "bottom number".
- Think strategically about the STEM areas included in your lesson. Students may not always be aware of the core STEM concepts they are learning. Help students understand the connection by pointing out the STEM connection. Tell students directly how lessons tie to STEM concepts.
- Ask students to explain why something happens. This helps students connect abstract concepts to the application of those concepts. It is one thing for students to know that plants wilt without water; it is another for them to be able to explain the concepts of transpiration, cohesion, and adhesion that cause the wilting to occur.

Active experimentation gives students the opportunity to practice applying abstract concepts to other situations. To strengthen active experimentation in your STEM lessons, think about the following:

- Give students the chance to apply concepts in new situations. This can be especially helpful for advanced students. Think about adding questions that stimulate students to transfer concepts to another application.
- Have students describe other situations where the concepts they are learning can be applied, ask them to explain why they think the concept applies in the new situation.

Reflective observation is the most commonly overlooked experiential component in most STEM lessons. There are several tips that can help you more completely integrate this concept to help students learn STEM concepts, including:

- Ask students to reflect on information they have learned at the end of the lesson. Many teachers do a great job of asking students to recall prior knowledge at the beginning of the lesson, but do not direct students to reflect at the end of the lesson.
- Ask students to describe how new knowledge they have learned will affect their daily lives. Allow time for students to process this information and draw their own connections.

Concrete experiences are often thought of as the application component of a lesson, but to be a true concrete experience, students should learn FROM the activity they are completing. To help concrete experiences benefit students most in STEM settings, consider the following:

- Design laboratory experiences that allow students to learn from completing the tasks, rather than using them as an application of

As you build STEM lessons, using experiential learning theory can help you differentiate instruction and meet the needs of each student.

concepts. Students should use their time in laboratory to bring in new knowledge, not just to demonstrate their understanding.

- Borrow concepts from inquiry-based learning models that can help students discover information while they are doing something. Providing students a strong immersive activity to introduce a concept provides something tangible to connect with the abstract concepts you teach.

Differentiating STEM Instruction Using Experiential Learning

No two students learn the same. Some students prefer to bring in information through abstract conceptualization, while others prefer to bring in information through concrete experience. What does this mean for you as you design lessons to teach STEM concepts? As you build STEM lessons, using experiential learning theory can help you differentiate instruction and meet the needs of each student.

Most education begins with teaching an abstract concept and then applying the concept to a set of problems or situation: we teach the material, then complete a lab to reinforce the concepts. Teachers most commonly teach a lesson, then use a lab activity to enhance student understanding of the concept. The problem with this process is that not all students prefer to bring in information using abstract conceptualization. A simple switch in the sequence of instruction could make a large difference in student comprehension.

Some students prefer to bring in information through a concrete experience. One method for differentiating STEM instruction is changing the order of experiential components. Consider starting your instruction with a concrete experience, having students reflect on what they did. Follow with teaching the abstract concepts, and allowing students to explore other areas where the concept may apply. This change from the typical sequence of instruction in a lesson could be a solution to helping students who prefer to bring in information through concrete experiences to learn abstract concepts. Because the majority of people prefer to bring in information through a concrete experience, this change in sequence could help your instruction meet the needs of more students.

> Consider starting your instruction with a concrete experience, having students reflect on what they did. Follow with teaching the abstract concepts, and allowing students to explore other areas where the concept may apply.

Concluding Remarks

Incorporating STEM concepts in your lessons can seem like a daunting task. Using experiential learning theory allows you the opportunity to strengthen your instruction and help your students capitalize on the benefits that are already built in to agricultural education. A quick analysis of the STEM-based lessons you teach could reveal places where experiential learning components are missing or could be strengthened for greater student learning. Working to strengthen experiential components in your lesson could give your students the extra help they need to ensure your class is a place where they truly experience STEM.

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THEME ARTICLE

Bridging the Gap Between the Academic Languages of Mathematics and Agriculture

by Rachel Ralston and Christopher T. Stripling

The Math-in-CTE pedagogy was created as a way for Career and Technical Education (CTE) teachers to enhance the mathematics naturally found in their curriculum (Stone, Alfeld, Pearson, Lewis, & Jensen, 2007). This pedagogical strategy is comprised of seven elements that can be used to design and deliver a math-enhanced lesson. Within these steps, the teacher should seek to bridge the gap of academic language found in CTE and mathematics gradually throughout a lesson (Stone et al., 2007). Academic language is defined as the language of a discipline that students should learn and use to engage in a content area in a meaningful way through academic vocabulary and discourse (Stanford Center for Assessment, Learning, and Equality, 2016). Academic vocabulary are the words or phrases used within a specific discipline, such as agriculture-related words like seeding rate and PSI, and math terms like probability, frequency, and area (Bardwell, n.d., para. 8; Sweetwater District-Wide Academic Support Teams, 2010). Academic discourse is the way one talks, writes, and structures communication (SDWAST, 2010).

While academic language of mathematics may happen naturally in a math-embedded agriculture lesson, intentional use of academic language has many benefits in the classroom. One benefit is improved metacognition resulting from students thinking about and explaining their approach to problem solving (Donovan & Gore, 2005). Another benefit is teachers become more learner-focused when they seek to understand the reasoning behind students' methods to deepen instruction (Donovan & Gore, 2005).

Learning to solve problems is an important component of mathematical understanding; however, a student's ability to apply skills to solve problems are hindered without a basic understanding of the vocabulary (Kovarik, 2010). When teachers use quality strategies for students to learn vocabulary, students move from using everyday words to using academic language in a curriculum area (Hattie, Fisher, & Frey, 2017). Two vocabulary supports that agriculture teachers can incorporate into their classrooms are word walls and graphic organizers. Word walls are ongoing and organized displays of academic vocabulary words in which students can reference throughout instruction. During discourse with other students or the teacher, students should be reminded to reference the words on the wall (Hattie et al., 2017).

Graphic organizers may also be employed to show relationships between words, concepts, or ideas (Hattie et al., 2017). An example of a graphic organizer is a T-Chart, which is a two column organizer used for comparisons. T-Charts can be used to present a visual of math and agriculture vocabulary, formulas, and example problems with math and agriculture on opposite sides of the T (PA CTE, 2018).

Teachers can also use discourse to bridge the gap between mathematics and agriculture academic language by posing purposeful questions that focus rather than funnel student learning (Hattie et al., 2017). Teachers should ask questions that encourage students to see mathematical concepts more visibly through their own thinking (Hattie et al., 2017), as well as to promote the use of the academic vocabulary presented in a lesson. Funneling is a strategy of questioning that is a more teacher-centered approach to guiding the students down the path that has the correct answer (Hattie et al., 2017). While thoughtful funneling questions have a place in the classroom, teachers do a significant amount of the cognitive work through hinting, which can create a shallow illusion of student learning when students guess correctly (Hattie et al., 2017). On the other hand, focusing questions ask students to do the cognitive work by encouraging them to figure problems out themselves (Hattie et al., 2017). For example, a funneling sequence may ask, "How do I find the area of this trapezoid? Do you see the rectangle and the triangles? I can just add them up. How can I find the area of the rectangle?" (Hattie et al., 2017, p. 92). However, a focusing sequence would ask, "I want to know the area of this trapezoid, but I'm not sure how to find it. Any ideas? Where should we start?" (Hattie et al., 2017, p. 92). Focusing questions widen the possibilities for student learning, whereas funneling questions narrow student thinking (Hattie et al., 2017).

Intentional prompts and cues may also strengthen classroom discourse. Prompts are questions or statements that teachers use to remind students to think backward into what they already know in order to think forward (Hattie et al., 2017). There are several different kinds of prompts including background knowledge, procedure, and heuristic (Hattie et al., 2017). Background knowledge prompts reference content that the student has already encountered but may have forgotten (Hattie et al., 2017). Procedure prompts refer students back to set rules that are important to the concept but may be lost because of a misconception (Hattie et al., 2017). Heuristic prompts are used to encourage students to find a way that works for them to solve a particular problem, such as suggesting the student draw a visual representation for a word problem (Hattie et al., 2017).

Cues offer a more direct approach in drawing attention to relevant information that is needed for students to move forward in their mathematical and agricultural understanding (Hattie et al., 2017). Visual cues help to guide students' thinking or understanding through the use of graphic hints such as highlighting where students may have made mistakes. (Hattie et al., 2017). Verbal cues are variations in speech that teachers can use to draw students' attention to something specific, such as accentuating importance, restating a student's answer, and changing tone, speed, or volume of voice to emphasize a point (Hattie et al., 2017). Lastly, gestural cues are body movements or hand motions that teachers can use to draw attention to a concept that students are missing, such as pointing to or placing thumbs on either side of a specific part of a math problem (Hattie et al., 2017).

In summary, the importance of academic language can be best analogized as a masonry project in an agricultural education classroom. Complete academic language is the product of engaging students within a context in a meaningful way through academic vocabulary and discourse. In this instance, academic vocabulary can be represented as bricks which are created through methods such as word walls and graphic organizers. Academic discourse is the mortar that creates a frame in which to hold academic vocabulary and is solidified when teachers and students interact through purposeful questioning and intentional prompts and cues. Perhaps methods such as word walls and graphic organizers, purposeful questioning techniques, and intentional prompts and cues could be used to strengthen the supports outlined in the Math-in-CTE model such as posters, presentations, and handouts, in order to deepen student understanding and bridge the gap between academic language of mathematics and agriculture.

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THEME ARTICLE

An Innovative Approach to Floral Design

by Catherine A. DiBenedetto

It's that time of year again. The students in your horticulture or floriculture classes are getting excited about Valentine's Day! They have been planning a fundraiser to sell roses and carnations and they are ready to become entrepreneurs or in some cases play cupid as they "match make" throughout the school. With spring quickly approaching, other school and community events call on your agricultural education department for a variety of their floral needs. How do you respond? Is this a stressful time? Do you have the content and technical knowledge required to become a "part-time" florist? Are you able to connect the curriculum you are teaching in your courses to align with the needs of the school and community?

When we think about preparing to teach a unit of instruction in floral design, some of us enjoy being creative and partaking in the opportunity to teach design principles, others dread having to be artistic and would rather skip this unit, sell a few flowers, make a few fundraising dollars and move on. If you have had the chance to take a floral design course, you know there are many different types and styles of arrangements, numerous containers and supplies and an abundant supply of flowers and plant materials that you may or may not have covered in your plant and tool identification unit. Another concern may be the resources and expenses related to teaching floral design. Where do I buy fresh cut flowers? How much money do I need to budget? What supplies should I purchase? How much profit can we make? How much instructional time do I invest? Let's face it, floral design can be overwhelming and leads you to ask, "how do I decide where to begin and what to teach?"

One component of the floral design unit that I believe often goes overlooked is the most important. Aspects that directly relate to science, technology, engineering and math (STEM). Yes STEM, not the part of the plant defined as the main body or supportive stalk, but the hard core science, technology, engineering and math, STEM, which can be taught in addition to incorporating the principles of design, plant identification, and not to mention making some money on a possible fundraiser while meeting the needs of your school and community.

Did you know that many people are not familiar with the term 'horticulture'? Is enrollment in your horticulture career pathway decreasing as your animal science numbers skyrocket? Look what just happened there….. horticulture (the cultivation of plants) versus animal science. We need to put the science in horticulture and reference the science behind the industry. Horticulture is more than simply the cultivation of plants. Your students, parents of your students, guidance counselors, fellow teaching colleagues, administrators, and community members need to better understand the career potential that enrollment in the horticulture career pathway can have on preparing today's youth to become ready for life and work in the 21st century. In today's world where developing STEM skills are required for students to be college and career ready, we need to provide opportunities for students to explore the science throughout our floral design unit. There are a sundry of approaches to take when using STEM to help students bloom in your horticulture career pathway!

Classroom and Laboratory

Instructional Topic Related to Floral Design	STEM Skill Developed
Storage and Conditioning of Fresh Cut Flowers	diversity of living things, application of science and technology, problem solving, predict and draw conclusions
Exploring the International Flower Market	engineering principles, mathematical reasoning, estimation, ecological awareness, life processes
Harvest and Distribution of Cut Flowers	application of science and technology. scientific reasoning, engineering principles
Effects of Ethylene on Cut Flowers	application of science and technology, scientific reasoning, data analysis
The Role of Floral Preservatives	application of science and technology, scientific reasoning, problem solving
Translocation of Water in Plant Tissues	application of science and technology, scientific reasoning, problem solving
Proper Water Temperature for Fresh Cut Flowers	application of science and technology, scientific reasoning, problem solving
Proper pH for Fresh Cut Flowers	application of science and technology, scientific reasoning
The Color Wheel	numeric and geometric reasoning skills
Determining the Cost of Floral Design Work	mathematical calculations, percentage/ratio markup, data analysis, problems solving

Following is an outline of possible STEM topics that might not immediately come to mind when planning your floral design unit. I encourage you to connect the topics through all three aspects of a comprehensive school-based agricultural education program. In addition, consider how many of the STEM skills will assist students in applying what they learn in their core academic coursework. Use a few of these lessons to impress your administrator during your next walk-through observation or teaching evaluation.

Supervised Agricultural Experience Project (SAEP)

When we place students in a SAEP that is related to horticulture, typically students are working for a landscaper where they learn small equipment operation and mow lawns or mulch plants and pull weeds. Some may work in a florist or nursery and garden center as a sales representative or floral assistant. How often do we consider pushing our students to learn about the STEM behind what they are experiencing in each of their placement opportunities? Where would you find a plant pathologist, entomologist or plant geneticist in these placement SAEPs? Challenge your students to go beyond recording their hours and skills that usually list what they did to push them to become proficient in WHY what they did is important as it relates to the STEM skill they are experiencing.

Career Development Events (CDE)

In addition to preparing your students for the Floriculture, Nursery and Landscape, or Forestry CDE, have you considered the opportunities for students to create an Agriscience Fair Project directly related to the science that is involved in harvesting or shipping cut flowers? What about the science behind why some hydrangea flower colors change after they are planted? Why are some hydrangea flowers blue and others pink? When we purchase "fresh cut flowers" what determines how long they last? These are all innovative research questions that our students can explore and experience the STEM behind the horticulture industry while learning valuable research skills by applying the scientific method.

FFA

Sometimes doing what we have always done and keeping with tradition is what makes an FFA Chapter feel like a family. Family demographics are changing and we want to attract a diverse population of students to engage in our programs. I challenge you to consider new and different ideas to keep your program on the cutting edge. For example, consider a new field trip. One in which a larger majority of your students might have a chance to engage in something new. Is there a sustainable/organic farm in your community? Is there a wholesale florist or greenhouse production facility close by that you might be able to tour? Have you checked with your county extension service to find out if there are any opportunities through a Master Gardening Program that you might be able to collaborate on to engage your students in research or a community service project that helps apply the STEM concepts you are teaching in your curricula?

What about a different type of fundraiser? How could your students learn something new and different that allows them to gain more skills related to STEM? Do you have a hydroponic system sitting in a box in your storage area? Dig it out, engineer a design with your students and have them develop a marketing plan to grow and sell a new crop at your spring plant sale.

What it all boils down to: please do not misunderstand my purpose in focusing our actions to prepare our students with STEM skills they will desperately need to succeed in the 21st century workplace. I am by no means discounting the hard work and labor – back-breaking labor is required in the horticulture industry. In fact, I spent half of my career working in the horticulture industry and that is why I am so passionate about providing opportunities for today's youth to experience the plant science industry, an industry that is struggling to attract young, intelligent minds. In each instance of the work that I embarked upon, understanding the Science- principles of irrigation, plant nutrition, environmental factors; Technology-innovative marketing tools, equipment to improve productivity; Engineering- landscape architecture, "hardscaping", hydroponic systems and Math- accounting for business, cost of goods sold, profit margins, calculation of estimates, fertilizer requirements, and measurement, I developed STEM skills that prepared me to successfully fulfill the responsibilities of my jobs in various facets of the horticulture industry. I challenge you to cultivate opportunities for your students to experience the STEM in horticulture and watch your program and your students become nourished and BLOOM!

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Teaching STEM in Agricultural Mechanics

by Joey Blackburn

School-based agricultural education may be one of the most diverse disciplines in public education. As a high school agricultural educator in a single teacher department I can remember helping students write speeches to earn FFA degrees, planting vegetables for the upcoming plant sale, nose printing sheep for the county fair, and managing an agricultural mechanics laboratory. Often, these and many more activities encompass the normal day for an agriculture teacher. Agricultural mechanics, as a sub-discipline of agricultural education, is equally diverse. Agricultural mechanics often includes content areas such as metals and welding, carpentry, electricity, plumbing, small gasoline engines, energy systems, and even soils in some states. It is understandable why some teachers can feel intimidated when tasked with teaching agricultural mechanics and the push to incorporate science, technology, engineering, and math (STEM) into more courses can seem like a daunting task.

So how can you, the local agricultural educator, teach STEM within your program? I believe the first step is recognizing STEM concepts exist within the content you are already teaching. In fact they always have. STEM, as an educational initiative, first came to light in 2005 when U.S. Representatives Vernon Ehlers (R-MI) and Mark Udall (D-C) set up a STEM Caucus within Congress (Loews, 2015). By 2008, STEM was a common term used through the educational world (Loews, 2015). However, these concepts of STEM have been important within agricultural education for many years. Stimson (1919), True (1929), and Stimson and Lathrop (1954) each discussed topics such as agricultural arithmetic, agricultural biology, agricultural chemistry, agricultural engineering, and agricultural physics. These are content areas we easily recognize as STEM.

Once we recognize that STEM principles exist within the agricultural mechanics curriculum, the next task is determining how to best teach the agriculture content while highlighting the desired STEM concept. One method that has shown to increase STEM achievement, without reducing technical knowledge, is the 7-Element Approach to Contextualized Teaching and Learning (CT&L) (Stone III, Alfeld, & Pearson, 2008). CT&L is grounded on the premise that students learn better when taught in context. Further, CT&L is designed, purposefully, to increase students' ability to transfer knowledge. Transfer of knowledge, when students apply knowledge gained in the classroom to real-world situations, is often considered the top of the mountain in terms of educational achievement. Transfer of learning, as a cognitive concept, has been related to problem solving (Schunk, 2008). The ability to identify and solve problems has been identified consistently as skills needed in the workplace (Robinson & Garton, 2008; Slusher, Robinson, & Edwards, 2010). Teaching methodologies like CT&L may have the potential to increase students' ability to transfer knowledge and solve problems that may make them better future employees.

To optimize success of CT&L, Stone III et al. (2008) recommended agriculture teachers partner with STEM teachers to form a community of practice focused on increasing student achievement. Teachers should meet to determine which STEM concepts naturally occur in the curriculum. The STEM teacher may recognize topic areas that are not familiar to the agriculture teacher, thus allowing the teachers to discuss strategies to best teach the concept. This allows the agriculture teacher to gain a better understanding of the STEM concepts and may also allow the STEM teacher to gain authentic examples to utilize in his or her classes.

Stone III et al. (2008) then outline the 7-Element approach to CT&L as (1) introduce the agriculture lesson (i.e, interest approach), (2) assess the STEM awareness related to the agriculture lesson, (3) work through an example embedded in the agriculture lesson, (4) work through related examples, (5) work through non-agriculture examples, (6) provide opportunities for students to demonstrate their knowledge through increased rigor, (7) formally assess the students. These elements incorporate cleanly into the classroom as the foundation of this method rests on what we recognize as effective teaching – development of interest, assessing prior knowledge and experiences, introducing content, and assessing learning.

Let's look at an example. I taught an Agricultural Structures course where the main project of the year was building a portable building. The students were tasked with every aspect of creating the portable building, from drawing plans to framing to painting. How could I have utilized CT&L in this project? One example could have been early in the project when we were discussing dimensions like square feet. A 7-Element CT&L lesson could be planned as:

1. Interest approach for the lesson –building motivation for the lesson
2. Assess Current Knowledge of STEM Concept – what do they students already know about square feet? Can they calculate it?
3. Work through the STEM Concept related to the lesson – how do we calculate the square footage of the building we are going to build?
4. Work through the STEM concept in related content areas – have the students calculate square footage of other agriculture structures, perhaps our greenhouse, raised garden beds, or livestock facility.
5. Work through the STEM Concept in non-agriculture examples – have students calculate square footage of the classroom, their home, the cafeteria, etc.
6. Let students demonstrate their knowledge and increase rigor – this is where you challenge the students, while bringing the lesson back to the original context, perhaps they are required to calculate the area of irregular shaped buildings.
7. Formal assessment – assessing the students' knowledge of the STEM concept and the agriculture content.

Utilizing the 7-element approach can be a viable method for increasing students' STEM knowledge in the context of agriculture. As can be seen in elements three, four, and five, the students are led through a process that purposefully requires them to transfer knowledge to new situations, first in a related content (i.e., near transfer), then in a less related content (i.e., far transfer). Purposefully pushing students to transfer knowledge into new situations has the ability to create deep, long lasting change among the students. This opens the door for students to become effective and efficient problem solvers.

Concerns that I have heard from agriculture teachers across the country are that they are afraid the push for more STEM will end agricultural education at their school and they want to be agriculture teachers, not STEM teachers. However, Stone et al. (2008) were very purposeful in their discussion that the idea is for agriculture teachers to highlight STEM concepts in the curriculum, not for them to become STEM teachers. I believe the CT&L approach is a means to ease these concerns. STEM concepts are present in the agriculture curriculum and CT&L is simply a method that highlights those topics.

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ARTICLE

Effective Grouping Strategies for Cooperative Learning Activities in an Agricultural Education Classroom

by Ashley Coutta and Catherine DiBenedetto

If we all think back to one of the most miserable experiences we had in a classroom, as students, we can guess that a large portion of these experiences stem from involvement in group work. Group work, or cooperative learning, is words that strike fear into students and teachers alike; however, much of this apprehension of cooperative learning can be combatted if the right environment and logistics surround the activity.

As teachers, we understand the importance of cooperative learning in a classroom. If we draw from Bandura's Social Cognitive Theory, we see just how important social connections are in the classroom, and how those connections within a classroom help shape the learning which takes place in our classroom. Furthermore, if we look at Vygotsky's constructivist approach to learning, we are able to understand how our ability as teachers to allow our students to construct their own knowledge both from their peers and their environment is an important process for them to experience. Not only does cooperative learning allow for discovery and inquiry, it also allows students to form their own autonomy of their learning. Cooperative learning gives students the opportunity to plan, control, and assess their own learning, skills which are vital for post-secondary life. If teaching and learning theories inform us about the value of utilizing cooperative learning in the classroom, how do we incorporate this teaching method without causing unnecessary stress and concern from our students? One of the main reasons group work tends to be looked upon negatively can be answered by the Social Interdependence Theory which suggests, "that the effects of cooperative learning are largely dependent on the cohesiveness of the group."

For teachers to provide positive and enriching social interactions between peers in the classroom through cooperative learning, it is imperative that an encouraging and positive environment be generated to facilitate the activities. One aspect of this environment is the strategy in which teachers use to group students in the class. While there are many ways to group students within a classroom, we suggest looking specifically at five different grouping strategies including: self-selected, random, systematic, geographic, and intentional. Each of these grouping strategies are useful, but only when they are accompanied with the right activity and time frame.

Consider the example: "Okay class, I want you to get into groups of three and wait for my instructions." How often in a classroom do we allow students to self-select their groups? While student self-selection is a quick and easy method for the teacher, often, this is where the negative effects of cooperative learning lie. While students may personally "prefer" this method, research has proven that this method tends to put pressure on our most unengaged students. From personal experience, groups in which the students were allowed to choose their own group members usually exhibit off-task behavior, and generally perform more poorly than those who are not self-selected. When allowing students to self-select groups, it is important that task is something that occurs in a short time frame and is not dependent on differing ability levels. An example would be a "ticket-out-the-door" or "think-pair-share" activity whenever a desired performance is not required and you are generally checking for understanding.

Much like self-selected random grouping follows the same general rules. Random grouping is any grouping strategy in which there is no real order or any strategy for grouping. We have all had those days where we utilize random grouping. "Okay, you, you, you, and you get into a group of four," an example that would be an adequate representation of random grouping. One could argue that this may actually be more beneficial than self-selected grouping because in the back of teachers' minds there is more than likely a slight amount of thought being put into "random" grouping.

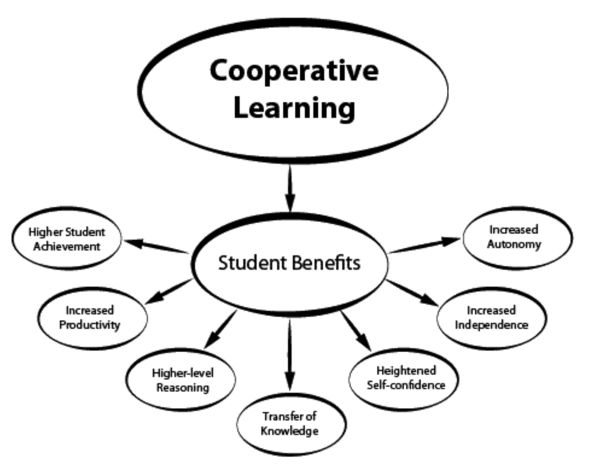
Following along the same lines as self-selected and random grouping is grouping based on geographic location. This method is often seen in classrooms simply based on the ease and timeliness of this strategy. While research does not recommend this as the most effective method of grouping for cooperative learning activities, it is a useful option when completing activities in which timeliness is a priority. Examples of this could be quick in-class discussions or checks for understanding, which were mentioned previously. Based on personal experience, sometimes it is much easier and quicker to have students group up based on geographic location if the activities themselves will take less time than using a specific grouping strategy would. Standard rule of thumb, if it will take longer to have students move and group up than the actual activity will take them to complete, group them based on geographic location and conserve instructional time.

Systematic grouping falls more closely to what research suggests as the most effective means of grouping for cooperative learning activities. Systematic grouping is any grouping strategy in which there is a specific way in which you are grouping students, but that grouping is still randomly achieved. A prime example of systematic grouping is, "count off 1, 2, 3," and having students form groups based on their given number. While this approach does have a systematic approach, it does not ensure that ability levels and diversity in the classroom is split evenly between groups as intentional grouping does.

Intentional grouping is most effective because as research states it is formed, "heterogeneously, with a representative sample of all the learners in the classroom" (Borich, 2017). This means that the group will contain a, "mix of higher-/lower-performing, more verbal/less verbal, and more task-oriented/less task-oriented learners" within a single group (Borich, 2017). This is the most effective grouping strategy for cooperative learning activities because it allows information to flow between students who have the information to those who may not have the information. It also provides an environment where students will have differing perspectives, and will cause students to feel the desire to share between each other. In this scenario, even students who are not normally engaged, may feel more inclined to participate in group activities. Not only does the environment of a diverse group lend itself to student involvement, but if a group task is situated in a way that all students must be involved in the task it will tend to draw even the most unengaged students in. Groups should reflect the diversity not only within the classroom, but outside in the community as well to provide the most effective cooperative learning environment.

In addition to what research and theory states with regard to how valuable cooperative learning is to learner autonomy, cooperative learning is also an important skill for students to gain in order to be college and career ready. Teamwork and the accompanying skills associated with working collaboratively are skills that are necessary for most post-secondary endeavors our students will face. Cooperative learning encourages and builds, skilled communication, self-esteem, and strengthened peer interactions, which are all necessary skills for post-secondary education and the 21st century workplace. Figure 1 provides a conceptual model that represents the benefits students are exposed to by working in cooperative learning environments that are properly selected and planned effectively. By using effective grouping strategies within our agricultural education classrooms, we are not only creating a positive cooperative learning environment, but are creating well-rounded students who will have the necessary skills required of them to be successful in college and in the workplace.

Figure 1. Concept Map: Student Benefits from Cooperative Learning



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