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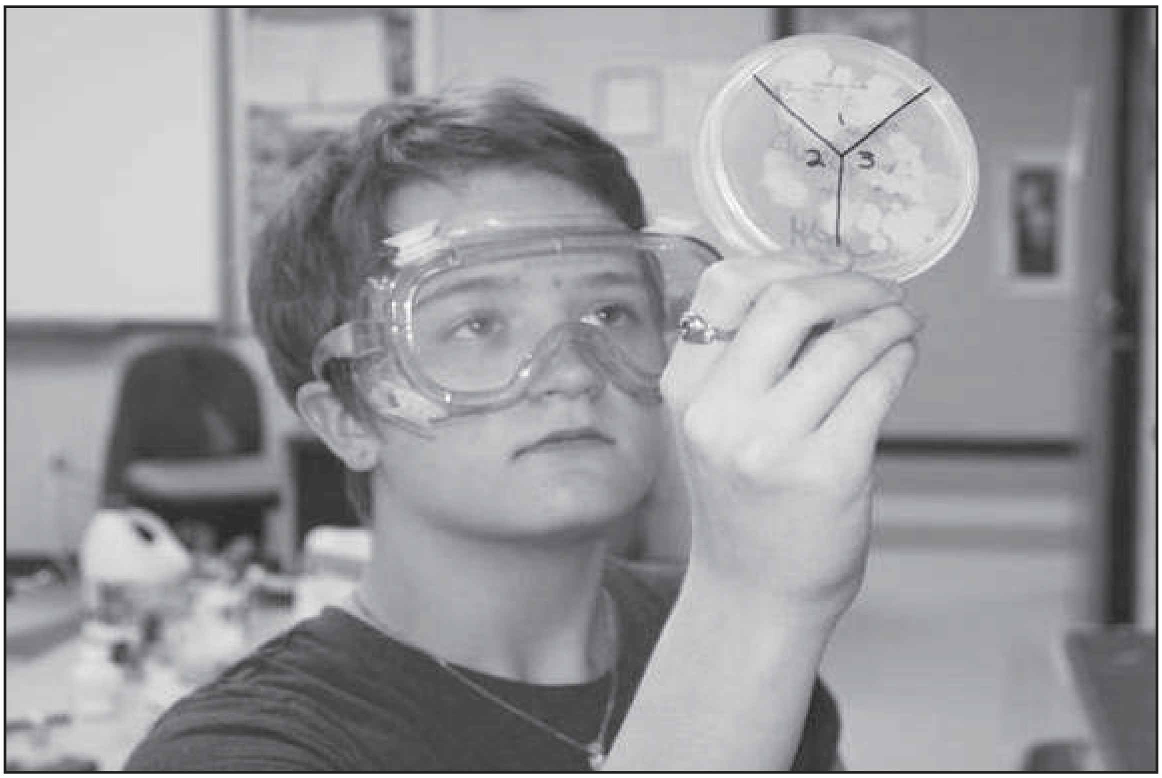

USING AGRICULTURE TO TEACH STEM

EDITORIAL

Agriculture: The Original STEM

Agricultural education teachers have been teaching science, technology, engineering, and mathematics since the late 19th century. Our curriculum has included the scientific aspects of agriculture, the latest technological advances, engineering concepts needed to construct buildings and equipment, and math skills needed in day-to-day farming applications. Agriculture students were successful because they learned STEM concepts in the context of real life agriculture practices. Hopefully the lessons learned in agricultural education can be applied to other areas. That is if they teach STEM concepts in the context of real life examples, their students will enjoy the same level of success.

Dr. Harry N. Boone, Jr., is a Professor at West Virginia University and Editor of ***The Agricultural Education Magazine.***

THEME EDITOR COMMENTS

Living in Interesting Times

by Rebekah B. Epps

I was recently reminded of the Chinese saying, "May you live in interesting times." While this saying is often attributed to a curse of living in times where you experience much trouble and chaos; I don't think that the curse can hold true for those in agricultural education. Most recently we have been living in the interesting times of how to emphasize science, technology, engineering and math (STEM) within the context of agriculture. While it is definitely interesting, it is not a process that has to cause chaos or trouble.

The need for more STEM integration is obvious. According to the US Bureau of Statistics; in the next five years, the number of STEM related jobs will increase twice as much as those in other fields. The United States is not preparing enough students who are entering STEM careers to meet the demand. The US Department of Labor claims that of the twenty fastest growing career opportunities, fifteen will require extensive preparation in science and math.

In 2005, a report entitled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (National Academies Press, 2005) addressed the concern and awareness of having enough qualified people in the careers of engineers, mathematicians, and scientists for the US to remain relevant in the areas of research, innovation , and technology. From this report came four recommendations:

- Improve K-12 math and science education in order to increase interest in math and science
- Strengthen and sustain the US commitment to long-term basic research
- Develop, recruit, and retain top students, scientists, and engineers
- Ensure the US is the premier place for innovation (Lantz, 2009)

Knowing these recommendations and the need, it is essential for agricultural educators to better understand and be able to use strategies to incorporate STEM through agriculture further into their courses.

Throughout this particular issue of *The Agricultural Education Magazine*, you will be able to identify some of the long history of applying science through agriculture and how it is still being utilized today. Readers will be able to understand how to better incorporate STEM strategies in their classroom by learning how veteran teachers have made the transition from traditional production agriculture courses to more science based courses. Other teachers share strategies for navigating the acronym alphabet soup and how STEM can be another additive to the soup.

I feel that it is our responsibility to further incorporate STEM into agriculture courses in order to remain relevant while preparing our students for the ever changing work demand. Remember these are interesting times, but they don't have to be filled with chaos and trouble. Enjoy this issue!

Dr. Rebekah B. Epps, the March - April Theme Editor, is an Assistant Professor in the Department of Community and Leadership Development at the University of Kentucky.

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Cover Photo: *A student looks at a bacteria culture that was taken from Critical Control Point during a lab. Photo courtesy of Dexter Knight. For additional information turn to page 18.*

Back Cover: *Photos 1 & 2 courtesy of Dexter Knight. For additional information turn to page 18. Photo 3 courtesy of Lisa Konkel and Rick Henningfield. For additional information turn to page 9.*

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STEMing Back: Early American Agriculturally-Based Elementary Science As a Model for Today

by Veronica I. Ent. & Robert J. Michalow

The superior work and interest of general [integrated] science pupils is not likely due to duplication and memorization and may, therefore be due to specific training values and attitudes that are carried over the span of years (Carpenter, 1930). Harry A. Carpenter, arguably, could have been speaking about the importance placed on elementary STEM (science, technology, engineering, and mathematics) today and its value in preparing young adults. Surprisingly, Carpenter the author of America's most popular and widely used 1940 Rainbow Series, *Adventures in Science* was a visionary who supported the elements of STEM before its time. Additionally, he supported the connection to *nature study*, sometimes termed *practical agriculture*, with elementary-aged children. *Nature study* integrated agriculture education into the sciences while attaching content to a story of the science explorations of children. For each grade, the *Adventures in Science* series, took students on a journey integrating *nature study* to teach children about the world in which they lived, including agriculture education. This article examines the trends of American agriculturally based elementary science prior to Sputnik and the parallel to today's guiding principles of elementary STEM curricula. Could the design of the 1940 *Adventures in Science* series be a model for today?

Prior to 1940, most early elementary science education was encapsulated in the modern movement of *nature study* some of which was taught as a component to *practical agriculture* and *geography*. According to Kern (1906) the new agriculture elementary instruction our children receive is to be in the fields of chemistry, soil, physics, vegetable life, biology and botany. Kern (1906) supported the assertion of *practical agriculture* as a discipline paired with *nature study* and taught to encourage the country child to embrace the environment, willingly work for daily bread, instill the love of country, and embrace other virtues. He dispels fundamental curriculum that concentrates on lofty ideals, but instead encourages the atmosphere of real life in the fields. Kern (1906) continues to quote from the 1905 Report of the Committee on Industrial Education for Country Communities that agricultural instruction should be specific, definite, and technical allowing for investigation and experimentation. Throughout Kern's reference, the principles of *nature study* and *practical agriculture* are asserted as trend beginning in the 1900s.

Kern's 1906 movement was not sustained into the 1940s (Robertson, 1942). While *nature study* was introduced as a fundamental to elementary science, built on plant and animal life, natural forces and phenomena as related to man, Robertson stated that it was so integrated into other aspects of school activity that its identity was lost. As a result, in the 1940s, many researchers claimed that unless segregated, *nature study* and *practical agriculture* was not science, it was a spirit (Robertson, 1942). Proponents of nature study partly refuted this idea and encouraged *nature study* to be integrated not only as an elementary science but also as a life enriching discipline. During the peak of *nature study*, which occurred in the 1920s, the curriculum encouraged caring for livestock and pets, cultivating food, and instilling kindness, humaneness, and appreciative feelings toward all living things. It was delivered in a preferred "informal" fashion rather than extracted as an isolated discipline (Dorris, 1928).

Carpenter's Adventures in Science series.

The title, *nature study*, fell out of favor by 1940 due to the belief that it was dated and value-based terminology. References cited by Robertson in 1942 support the removal of *nature study*, which researchers criticized due to its lack of rigor because of the poor preparation of teachers. In the late 1940s, proponents of elementary science believed that removing the title *nature study* and replacing it with *elementary science* would increase respect for the discipline as the term was more aligned with contemporary secular culture (Miller, 1948).

After removing the *nature study* stigma coupled with the trends leading to the new age of machines and industry after the second world war, support for elementary science was well on its way to being adopted nationwide (Miller, 1948). This began the insurgence of textbooks, curriculum guides, and teacher training to prepare elementary children in science. Surprisingly, while the title *nature study* was no longer used, the modern elementary science curriculum of the 1940s maintained the same underlining principles (Fisher, 1949). Additionally, the principles were similar to the 1906 *practical agriculture*, as discussed by Kern, and showed unique parallels to the guiding principles of elementary STEM-based approaches in today's schools.

As mentioned at the beginning of this article, a contextual analysis of a popular 1940, pre-sputnik elementary science curriculum, *Adventures in Science* written by Harry A. Carpenter reveals that the agriculturally-based *nature study* of that period had more theoretical elements akin to today's elementary STEM than what many of today's contemporary science educators may believe.

As outlined by Morrison (2006), today's elementary STEM education invokes an inter-disciplinary approach to learning where in-class academic concepts are bridged with out-of-school opportunities. Through it, the hope is that students "want to" be involved in science rather than "having to" be involved.

Introductory STEM concepts lead to success in secondary science courses. The early introduction creates an awareness of STEM fields and occupations and provides problem-based learning that interconnects STEM subjects. Although STEM education is a relatively new title, all of the above mentioned components are evident in Carpenter's *Adventures in Science* series. Science content, including a significant amount of agriculturally based content, is interwoven into in each chapter to bridge real-world scenarios to outside-the-classroom phenomena [of the 1940s].

Starting with the second grade book, *Adventures in Science with Bob and Don*, Carpenter's personalized story-telling writing style stimulates student interest in "wanting to" do science rather than "having to" do science. More precisely, at the beginning of each chapter or theme, Carpenter tells a story involving two children and how they explore and question the natural phenomena around them. Yet another example, *Adventures in Science with Ruth and Jim*, Carpenter (1948) discusses the construction of a "cold frame" (engineering) using the best materials (technology) to get an early start on one's garden (science: agriculture). Furthermore, Carpenter discusses soil conditions (science: agriculture), type of seeds to use (science: agriculture), and a watering scheme (science: agriculture) in order to promote the highest yield (technology).

Consistent with today's STEM approach, the process of scientifically thinking and questioning as encouraged by Carpenter in the 1940s is the same. Table 1 presents an example of how instructional events that occurred throughout the *Adventures in Science* series align with today's popular events in elementary agriculture education.

> The connection to agriculture opens doors to a more meaningful and seamlessly blended curriculum.

In addition, Carpenter's literary style impacted classroom instruction. It was discovered in one of the books that the names Bob, Don, and others were crossed out and replaced with hand written names. One can assume these were names of the children in the classroom, making science more meaningful. Of the sixteen chapters in the sixth grade book, six chapters deal specifically with agriculture and agricultural stories that are used to capture the students' imagination and interest are interwoven into the material. Throughout the entire series, Carpenter integrates STEM concepts based upon the adventures of children with whom students have become familiar (Carpenter 1939, Carpenter 1940, Carpenter 1941, Carpenter 1944, Carpenter 1948a, Carpenter 1948b).

In the introduction to *Adventures in Science with Ruth and Jim*, Carpenter states "students are now several years older, have more practice in observing, experimenting, and solving problems scientifically." The elementary level skills referred to by Carpenter are the same elementary

Table 1
Comparison of STEM Agricultural Education as it Existed in the 1940s and Today.

Carpenter, H. (1940) *Adventures in Science* 1940s STEM Agricultural Education	National Organization of Agriculture in the Classroom Present Day STEM Agricultural Education
Chapter XV, p. 281 – 297, Jack and Jill Botany: Analysis of plants and their roots system and how location impacts growth Ecology: Adaptation of animals in order to increase chances of survival Technology: Water purification and milk pasteurization for a safe drinking supply Engineering: Design sidewalks, bicycle trails, railroad crossings, and safety using explosives Biology: How germs and spores cause diseases Health: balanced diet, exercise, cleanliness	Does the amount of room a plant has for roots make a difference in how big a plant will grow? Plant seeds in a variety of different-sized containers using various soil-less material What environmental conditions do plants (and animals) need to adapt in order to reach their full potential? Plant seeds in same-sized containers and choose an environmental condition and measure the impact of the variable.
Chapter XII, p. 253 – 270, Ruth and Jim Botany: Class garden project and discussion related to the differences in plant growth to soil quality Ecology: Soil quality of different habitats Technology: Soil quality improvement Engineering: Engineering techniques used for soil conservation Biology: Benefits and harms of bacteria to leguminous plants	How do different types of fertilizers affect plant growth? Fertilizers contain different amounts of the nutrients nitrogen, phosphorus, and potassium. Apply them to groups of the same plant to determine how different fertilizers change how the plants grow? Are different plants affected in different ways by specific microorganisms? Some microorganisms and plants form mutually beneficial partnerships. Grow both legumes and non-legume plants with and without the bacteria.

core STEM processing skills that are emphasized today. These skills are needed for student success at the secondary level (Morrison, 2006). Throughout the series, Carpenter stresses observation skills (both in and out of the classroom), experimentation (with and without experimental design) and problem solving (to help explain natural phenomena including agriculturally based ideas). For example, Carpenter describes how food and water is needed for a child to grow, and then compares that to plant growth and a need for soil, water and sun. Later in the series, the students observe several plants and how leaf damage from a caterpillar impacts its growth. A discussion follows where students offer specific examples of the differences in food intake between producers and consumers. Finally, students are given an opportunity to prove their findings through an experiment with two plants. Carpenter promotes students as problem solvers who are able to define questions/problems, to design investigations, collect/organize/manipulate data through observations, and draw conclusions, which are the same elementary goals of today's STEM education.

Morrison (2006) outlined the manner in which STEM education promotes a program of study that prepares students to be competent, capable citizens in a technology-dependent society. Even though the applicable technology has changed over the past 60 years, Carpenter promoted the then current 1940s ag-

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STEM's Top 10

by Laura Hasselquist

We LOVE acronyms in education: SPED, ELL, PLC, etc., and let's not forget some of agricultural education's unique ones like CDE and SAE. So, when I saw the acronym STEM its importance and impact was initially lost. However, when you start to analyze the science, technology, engineering, and math (STEM) concepts that we teach each and every day it is amazing how agricultural education has and will continue to lead in this field.

A few years ago, I decided to start highlighting the STEM concepts in my classes. It was then and still is a learning process, but it is vital to continue to show how Ag Ed is an essential part of a student's educational career. As I was looking over my small animal care class in an effort to incorporate more science in pet care and ownership, it dawned on me that STEM is not about incorporating MORE science; it's about highlighting the science that is already there. It is small changes that have a tremendous impact on your students. For example, instead of just discussing different dog breeds, incorporate how different breeds evolved over time and how humans have influenced them through breeding.

Reflection is always a good thing in education. When we take a moment to step back and see where we have come from, we can truly begin to appreciate the journey. STEM incorporation does not need to be a complex endeavor; in fact, it can be broken down into manageable tasks. If I had to start all over again, here are my tried and true STEM Top 10.

10) We already do this! Don't get intimidated.

When first confronted with the possibility and necessity of implementing STEM in your classroom, it is so tempting to come up with a laundry list of limitations. Perhaps the most notorious is "I don't have time," which can't be farther from the truth! Agriculture is the applied and integrated science. How often do we take biology, chemistry, or physics concepts and apply them to real life situations? Have you ever had the experience of a student suddenly saying, "We talked about this in biology and now I get it?" No matter what you teach from agricultural mechanics to zoonotic diseases, there is some science in there. Incorporating STEM to your classroom isn't about doing more, it is about making little changes to bring out and emphasize those concepts already in play.

9) Don't add new materials, work with what you have!

When implementing STEM, the simplest and easiest way to make the greatest impact is to look at your established curriculum and materials to see where the hidden STEM gems are. Once you have found those activities, take time to analyze them for the key concepts and think about how you can further draw them out. Minor changes, such as incorporating a small reading assignment or even changing a question or two can have a tremendous impact. It is a great time investment to go through your existing materials and make those little changes for major impact.

8) Start Small

Ag teachers are incredibly busy and it is so easy to start with good intentions and become quickly distracted and discouraged. When starting the STEM incorporation, set a small reachable goal; maybe it is to revamp one lesson per unit or maybe it is to have two more STEM lessons per quarter, or only focus on a single class. Whatever your goal is, make sure you take the time to make it happen. By starting small, it is easy to focus your time, efforts, and energy to making the desired changes. Another benefit of starting small is you are able to build your STEM confidence and comfort level. Not every lesson you redo will be an automatic and complete success. Doing it in chunks makes things much more manageable for you, especially if the lesson doesn't go as planned. Going slow allows you to revisit those mistakes in a timely manner (before you have forgotten what went wrong) and make the needed changes for next time. It is much easier and less frustrating to struggle with STEM incorporations in one class or unit than in all your classes. Starting small helps you conquer the learning curve.

7) Use your resources-Work smarter not harder

In this field, we are blessed with so many wonderful individuals who are willing to share their time, talents, ideas, and expertise with anyone who needs it. The National Association of Agricultural Educator's Communities of Practice is a fantastic resource where you have access to Ag teachers from across the country. Take a minute or two to search Communities of Practice to see what great activities are out there. Still unable to find what you want? Reach out to the Ag teacher down the road to get their opinion. Looking for ideas and inspiration can lead to some great dialogue with your science department. Who knows, they may even come to you with a question in the future. You don't have to reinvent the wheel, take advantage of your resources.

6) STEM doesn't come from a kit

It is so tempting to say that STEM materials aren't in your budget, think again. Yes, kits and modules are great but they are just a small way to help highlight the STEM ideas in your classes. There are so many fantastic websites out there that have resources about activities that are economical and impactful. Pinterest has some great ideas. The National Science Teacher Association (NSTA) has some fantastic magazines that highlight labs and activities that can be done for a very small portion of your budget. Many of the NSTA labs use materials that can be purchased at the dollar store or the local grocery. If you do happen to use a kit, it is more than likely you can restock the materials yourself and it probably will cost less money.

5) Try the lab first!

The Cardinal Rule of teaching is to always read the reading or watch the video before turning your class loose. The same principle applies to labs and activities. Going through the lab will help you understand the concepts a little better and it may give you ideas about follow up questions to ask your students or possible resources to use. Experiments and activities aren't always going to turn out the way they were planned. The test run allows you to help recognize potential problem areas the students might have and how you can avoid them. Occasionally instructions can be incredibly hard to follow. By completing them ahead of time you can rewrite them if needed. Trying the lab is definitely worth your time.

4) Control the chaos

Labs, experiments, and activities are incredibly fun and engaging for the students, but it can be a real pain (both literally and figuratively) for the teacher. Until classroom procedures and routines are put in place, the lab setting can be incredibly stressful. Take time to plan your work and work your plan—it makes a huge difference. Instead of having the materials set out all over the room and having students go and collect them, put the group's lab materials in a numbered basket they grab at the start of the activity. This can also help reduce the occurrence of missing items. A quick visual survey can usually indicate if a group is missing anything. Students seemed to have an unending supply of questions during an activity. Everything from "what are we supposed to do" to "where are the supplies" are the common questions. When you limit how many questions a student can ask the teacher, they are forced to think critically and use their resources (maybe it is rereading the directions or asking a classmate for guidance, but they do it.). At the start of a lab, each student is given a few index cards. The number depends on how many questions they can ask. As they go through the lab and ask questions, each card is handed in. Students rarely run out of cards. They use them wisely.

3) Get (Post-Activity) Organized

If an activity went well, chances are that you will use it again. Take the time now to set yourself up for success next year. When you are done put all the supplies in a container of some kind and be sure to label it. Also include a list of the materials in the kit and anything that should be purchased or prepared for the next time. In the future, you can pull out the container, layout the supplies and complete the prep work and you will be all set to go. Planning ahead really does save you time.

2) Be patient with yourself

Change will not happen overnight nor may you feel like you are progressing as fast you want. Think back about learning to ride your bike. Could you just hop on and pedal down the driveway? Of course not, it took training wheels, practice, guidance from mom and dad, and a whole lot of patience on your part. Remember, highlighting STEM is a skill too, why would you expect success to come any differently?

1) Stick with it

Making the effort to highlight STEM in your lessons will not always be easy, fun, or comfortable, but do not give up. One week everything could be great and the next could be completely miserable, but as you progress and develop self-confidence things will get easier. Persevere, you can do it and your students will benefit.

Of all the acronyms we use in education, STEM may have the most meaning for agricultural education. Making the STEM change is an ongoing process, but it does not need to be overwhelming, following a few simple steps can make a world of difference. So many of our lessons and curriculum are loaded with STEM content, taking the time to highlight it will take time and effort, but the benefits are worth it.

Laura Hasselquist is the Agricultural Sciences Instructor and FFA Advisor at Chippewa Falls Senior High School.

Creating STEMinded Thinkers in Agriculture

by Lisa Konkel and Rick Henningfeld

Ever have one of those days when your students are using an electronic balance and they've been assigned to measure a small amount of material. They continue to pour the material into the weigh boat way past the logical amount. You watch with fascination as they are not questioning their actions. You approach the student and ask "think you have the right amount?" Their response is "the balance still says I'm short." You slowly reach over and change the balance from pounds to grams and find they have maxed out the scale. They are confused as to what has happened and you are not surprised because it is not the first time that a student isn't prepared in lab skills for your class but you are more concerned about the fact the student never questioned the machine. Where was the common sense? What were they thinking? Were they thinking?

As career and technical education teachers it is our responsibility to prepare students for the future workforce. A growing sector of the workforce in agriculture is in the agricultural sciences. Because of this reality, we have adopted an equation as our agricultural education philosophy at Big Foot High School (see Figure 1).

In recent years, our FFA chapter has had the opportunity to visit and tour multiple agriscience companies throughout the nation. At each site, our students ask the employees what their background is with agriculture and overwhelmingly the answer is none. Imagine what could be done if the people who are engineering the science and technologies that drive agriculture had an understanding of production agriculture? Wouldn't that be exciting if our agriscience programs were the seeds to initiate that growth? To produce the workforce that allows agricultural companies to hire students with practical agricultural experience and knowledge is what is exciting about agricultural education today. Some in our profession see agriculture education as black and white, with a clear line between agriculture and science. At Big Foot High School, we see our profession in a world of gray, where the lines are constantly crossed just as they seem to be with current agriscience company employment.

In our modern world with the fast pace of technological advances it is difficult to keep ahead of the curve. STEM concepts have always existed in education, however we need to increase focus on teaching students how to think in these areas because these concepts are changing at an increased rate. So now we call it STEM, because industry is demanding a workforce that can think in these advanced areas. To put this into perspective, ask your parents what the highest math class they could have taken in high school, perhaps algebra. Now think of the highest math when you were in school, probably calculus, and what exists today with AP and college courses for high school students. This increased level of understanding is coming from industry and pushing down through the departments of education and then to individual districts. So administrations want to get "a good grade" and if we can help them achieve this, they will take notice. Not only will our programs be known for our community service and work ethic, we will also be known as the academic progressives of the school.

When we discuss our program with other agricultural educators and the direction we have chosen to take our curriculum, many are interested but also apprehensive. Some of these apprehensions include: 1) increased rigor will decrease student numbers; 2) limited budgetary funds to support STEM additions; and 3) time limitations. We had the same apprehensions, but philosophically believed

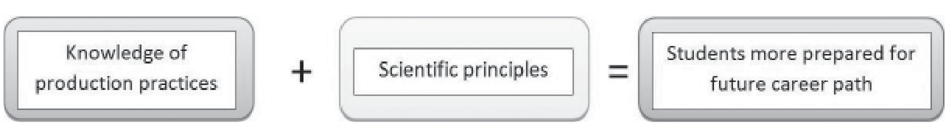


Figure 1: Big Foot High School's Agricultural Education Philosophy Statement

this is where our program needed to go. Below we address these concerns and how they played out in our program

Concern: Increased Rigor Will Decrease Student Numbers

Because we are an elective, some in our profession fear adding "too much" rigor and that the rigor will cause students to choose "easier" electives. We found that just the opposite occurred. As our rigor increased so did our numbers. In fact, our courses have more diverse students than ever. When we increase the STEM in our classrooms; students, administration and community members will start to see the application of our content area. We draw in the high achieving student that wants to be pushed academically and the practical thinking, hands-on student into the same learning environment. A cool thing about our programs is that we can have a kid in the top 10% of their class and in the bottom 25% and the experience we offer in the agriscience classroom levels the playing field. One student may have the production background that makes all of the science concepts very applicable, while the other needs to gain that production understanding to really see how the science is changing the world around them.

This change does take time. This is not the time invested, as will be addressed below, this is just the passing of time. In the early years of teaching increased STEM concepts at Big Foot, it was not uncommon to have parents come in and say "How can my kid be failing Ag? Nobody fails Ag!" That is no longer a conversation here. This was a culture change – and cultural changes take consistency, persistence, and time. Perhaps starting anew does not sound exciting at this point in your career, but it does not have to be difficult, and it does not have to all happen at once. Start slow! Instead of trying to do an overhaul of every class at one time, perhaps incorporate one inquiry lab in each course where the students work through the scientific method to test a variable. For example, if you teach seed germination, let the students design a lab where they pick a variable and apply it to seeds. Then collect data and develop a conclusion explaining why the phenomenon they experience may have happened; or start incorporating STEM concepts with a freshman class and progress with them changing each courses curriculum as you go.

Concern: Limited Budgetary Funds

When our agriscience changeover took place, our department was half-time and given $600.00 a year budget. Over the course of the next ten years the program became a two person program with a $13,000.00 budget. The changes will be slow but when you look back after several years the difference will be immense. At Big Foot it all began with writing grants for large equipment purchases. Most of this equipment we still have today. Glass wear and basic scientific equipment was borrowed from the science department. But small purchases were put in the budget each year and now that money is used to cover yearly breakage. Because we were not familiar with all the protocols and labs available, we started by ordering kits on different concepts. These initially are expensive but you get everything you need and then you have the information needed to make the kits yourself much cheaper.

For example, to extract DNA from cells you need 65 degree water and detergent to break down protein and lipids of the cell membrane. I now purchase woolite and dilute it.

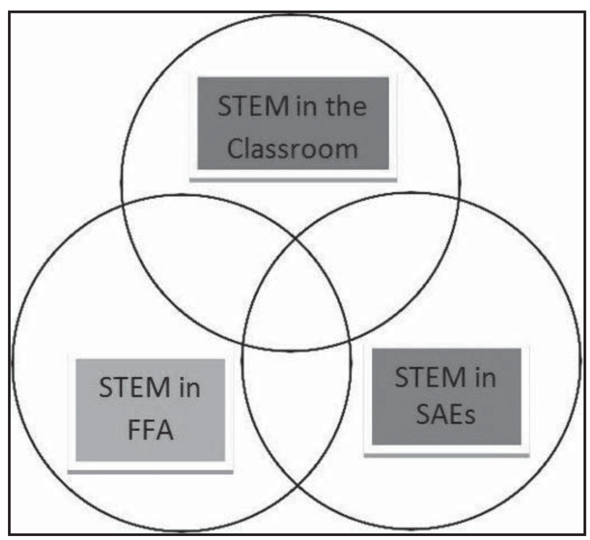


Figure 1: Big Foot High School's Three Circle Model

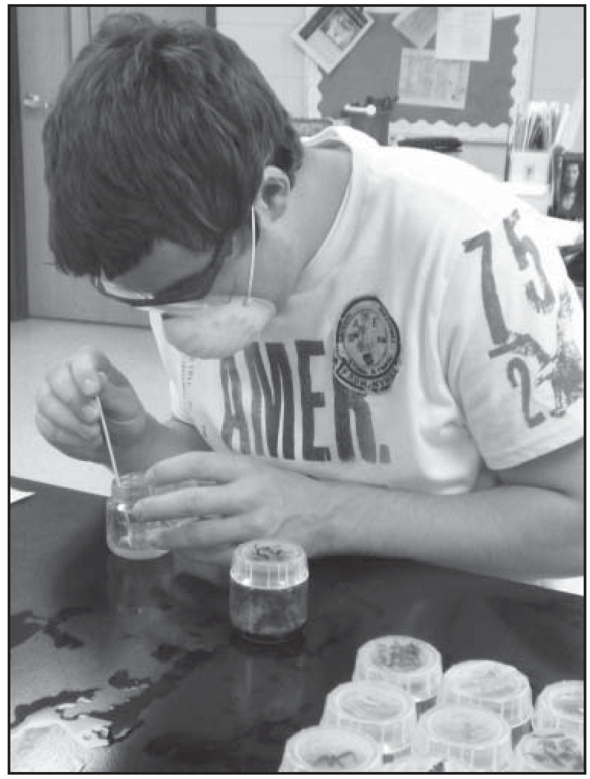
No kit needed. Because students design their own labs now and have experimented with different DNA extraction protocols, we now have many variations on how to remove DNA depending on the source material. These basic labs and more advanced labs increased our student enrollment in agriculture and with more students I can justify more budget.

Concern: Time limitations

Most of us consider a good day in ag education when we just keep our head above water. So the thought of finding more time to do anything seems virtually impossible. We would be lying to you if we said that incorporating agriscience isn't going to require some research in areas outside our comfort zone. However the time factor does not have to be overwhelming. There is no shame in begging, borrowing or stealing from those who have already invented the wheel.

Another time concern is in how do we prep for all of these labs? Our answer to you is you don't. You have the students do it. At Big Foot students make their own agar, media, chemical solutions and they do all the math and conversions themselves. Does it work 100% of the time? Absolutely not. But now their mistake has become a great teaching moment. Once you have inducted a group of students with these new philosophies, they feel ownership in their lab success and now can be your T.A. (teacher assistant) to open up time for you to learn more content. Your students will be so engaged in their learning that it is not uncommon your discipline issues start to disappear.

In our classrooms we cannot teach a student how to farm, just like we cannot teach them how to do research and development of new agricultural technologies. What we can do is create experiences that teach them how to think from the perspectives of an agricultural producer, researcher, and consumer. If we turn out students that can think and have an understanding of production agriculture and scientific principles, our industry will benefit. Hopefully, the logical, questioning, THINKERS created will no longer rely solely on the electronic balance screen and their mind will fix the problem before it's even noticeable.



As more students are further removed from production agriculture, we have a few truths to acknowledge. One being that we must stay true to our production roots to make sure our citizens understand production practices that progress our industry. The second being that we have to prepare students for science, technology, engineering, and math jobs that currently and will continue to exist in the agricultural industry. Our three-circle model of agricultural education has adapted for this future demand by acknowledging agriscience SAEs that are verified through proficiency areas and inclusion of degree hours, and creating a number of FFA contests, like the agriscience fair, to help prepare our students. The classroom piece needs to align as well.

Just imagine what could be done if the people who are engineering the science and technologies that drive agriculture had the ability to think through the application of their technology in workable production agriculture practices? Amazing things would happen, and we as STEM based agricultural educators can help foster these future thinkers.

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An Alternative Approach to STEM Education

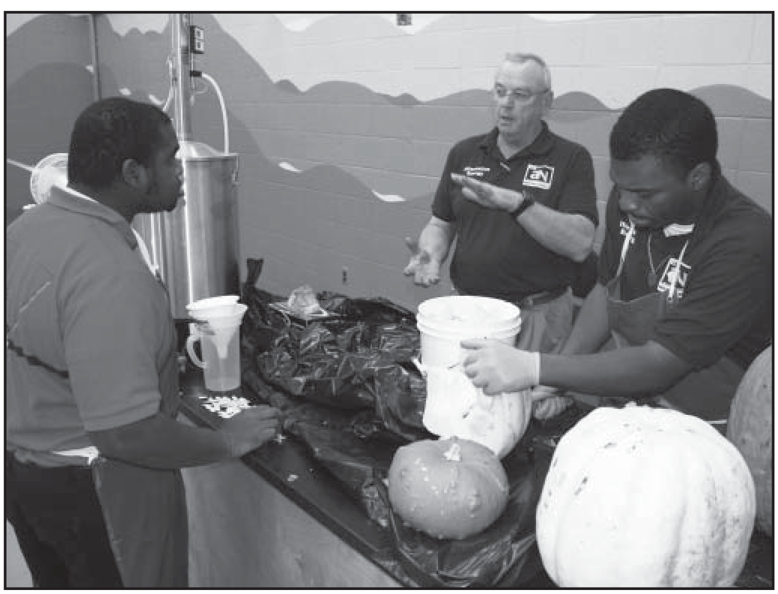
by Chaney Mosley and Richard Brown

As I walk into Richard Brown's teaching lab, sounds of a carving knife meeting a tabletop resonate. Students donning liquid proof aprons, surrounded by pumpkins, stand around the table carefully slicing the pumpkins into small squares and harvesting seeds. This would possibly be a normal scene, were it not mid-December, long after jack-o-lanterns should have been carved for Halloween. So I ask, "What are you doing?" A student gives a sideways glance and replies, "We're cutting up pumpkins to convert sugars into ethanol." He continues picking out seeds. Of course, stupid me, what else would they be doing? From the onset, it is clear that this is not your typical agricultural education program. On the contrary, this is the *Alternative Energy* program in the Academy of Public Service at Whites Creek High School (WCHS) in Nashville, TN – an alternative approach to both agriculture and science, technology, engineering, and mathematics (STEM) education.

WCHS is home to just under 1,000 students, 84% of whom are African American, 14% White, and 2% Hispanic, Asian/Pacific Islander, or Native American/Alaskan. The evolution of this agriculture program tells an interesting story of teacher rejuvenation, student opportunities, and business partnerships, driven by the Metropolitan Nashville Public Schools (MNPS) district wide STEM education initiative.

Teacher Rejuvenation

This is Richard Brown's third year teaching in the Alternative Energy program, the only one of its kind in Tennessee. Brown has been teaching agriculture for 40 years. Three years ago he was asked if he would be interested in moving to a different school in the district and starting a new program that focused on alternative energy. "After 37 years of teaching, I had become complacent with traditional agriculture because I'd taught it for so long. It was no longer interesting for me to teach, and I, probably, was not making it interesting for the students. I was burnt out," Brown said. He continued, "It sounded interesting, so I moved schools and this new program revitalized me. I always wanted my last years of teaching to be as rewarding as my first years, and they are!"



Nick Atkins (left) and DeQuentin Heard (right) prepare to harvest ethanol from pumpkins under the direction of agriculture teacher Richard Brown.

During the infancy of the program, the school purchased modern equipment, including a mobile demonstration lab housed in a trailer that Brown takes to area schools to educate others about alternative energy production. High school curriculum for this program did not exist, so Brown worked with Dr. Cliff Ricketts at Middle Tennessee State University to write the curriculum. "I stumbled along the way," Brown said. "At first, I envisioned including everything, but realized that was too much. So, I've cut back and focus on eight different areas of alternative energy. I was able to pull a lot of information from traditional agriculture classes because most programs are somewhat associated with alternative energy in some way, such as electricity or conservation. It was easy to incorporate existing curricula into what we were doing."

Aside from writing the curriculum, Brown acknowledges that recruiting students to the program can be a challenge - "This is not a program where students can see the immediate rewards because job opportunities straight out of high school in this field are limited." To attract students, Brown uses go-karts for test vehicles with various fuels and hosts open houses for interested students and parents. Brown said that parents of interested students ask their kids, "What are you going to do with that after high school?" admitting that it can be a difficult question to answer. "We have to present ourselves in a way that students are interested and that they also see the benefits and opportunities. Students in this program need to be prepared to enter a two or four year post-secondary program to prepare themselves for careers associated with alternative energy," he said; and they are.

Student Opportunities

DeQuentin Heard is a senior and has been in the agriculture program since it started. Nick Atkins is also a senior in his third year of agriculture. While both students have different college and career aspirations, they agree that the alternative energy program has significantly impacted their future plans. Their knowledge of alternative energy is evident and their passion is contagious.

DeQuentin plans to attend the University of Tennessee at Knoxville and major in Biosystems Engineering. When asked why, he said, "I wanted to tie in creating alternative fuels with post-secondary education…I've always been interested in the environment, and being able to apply that interest to a career is an attractive opportunity." He continued, "I've been able to do things that others haven't at Whites Creek – there are only so many people who are able to do what I do and UT Knoxville has the best opportunity to continue with that."

Nick is debating between Cumberland University and Middle Tennessee State University, but he is confident in one thing – "I want to major in Biochemistry." He reports that the alternative energy program reinforced his passion for biology. "This program has helped in science classes as well. I'm currently taking AP Biology and knew a lot of things that others did not know in the class. Other students asked how I already knew certain information and I think the teacher was impressed," Nick said.

Richard Brown explains how the mobile alternative energy lab is used to teach students across the district about his program.

Focusing attention back to the pumpkins, Nick explained, "We know we can take sugars from plant crops, not food crops, degrade the sugars and break away glucose chains to get glucose by itself and then use heat to convert glucose into ethanol." When I ask how, he continues, "We use an ethanol distiller to get the ethanol to its purist form; we get the impurities out of ethanol and mix the ethanol with gasoline to discover the best ratios to make greener fuels. Ethanol production is important to the future because we need to stop depending on foreign oil and we need to be more competitive in America, so if we use a source of energy that we get from renewable resources we will be more resilient." I nod my head, in both agreement with his statement and amazement at his awareness.

The students have experimented with switch grass grown in a school garden, raw sugar, rice, and of course, pumpkins. Beyond fuels, they have also worked with wind power, electric power, and solar power, among other alternative sources of energy. Students in the program are able to make real world connections with what they are learning through the meaningful business partnerships that Richard Brown has built.

Business Partnerships

According to Brown, the Alternative Energy program has three major business partners who regularly interact with students and provide guidance for the program. These are LP Building Products (a leading manufacturer of high quality building materials and sustainability efforts), Brown & Caldwell (the largest engineering consulting firm solely focused on the U.S. environmental sector), and Waste Management of TN, Inc. (a leading provider of integrated environmental solutions). "We're going to be involved in an exciting project with Waste Management," Brown said. "They are converting some of their fleet to run on compressed natural gas, so my students will conduct research to determine advantages and disadvantages of that conversion and present findings to Waste Management."

Dawn Cole, Manager of Community Affairs for Waste Management of TN, Inc., is also excited about the partnership and upcoming project. She said that one reason Waste Management was interested in working with the program was because of her company's focus on education. "We really want to be known as true partners with the educational institutions that we work with, both K-12 and higher education, not just a vendor, and the alternative energy program at Whites Creek ties in with our transformational change message at Waste Management as we become an environmental services company along with being the largest waste hauler and recycler in North America." Cole indicated that going into the school and working directly with Mr. Brown and his students was a "great way to teach them about our business and the importance of finding value in the trash we pickup, recycling and reusing the waste, and creating something from it." Engaged business partners teach problem solving and critical thinking skills in a real world context, and these are skills that employers look for. Cole said, "On the surface, Waste Management's partnership with the alternative energy program may seem like an odd marriage, but it is really a perfect fit because of the direction both industries (waste management and agriculture) are going; alternative energy is an emerging career field and as demand grows for professionals in the industry, it will be more and more important to expose students to the career option before they make college decisions."

Rigor, Relevance, and Readiness

The time is ripe for integrating STEM programs into agricultural education. As the baby boom generation nears retirement, the STEM labor force will be significantly impacted (National Academy of Sciences, 2007). Further, as the notion of *going green* continues to gain popularity, it is critical that various industries meet this desire with practicality. *Green* initiatives and technology are not going away, thus creating a need for educating students about these issues in secondary agricultural education and an opportunity to integrate high academic rigor into curricula.

Brown said that collaboration with general subject teachers is important to maintain rigor across all disciplines and ensure relevancy for students. He collaborates weekly with an interdisciplinary team at his school and has a strong relationship with the science department, specifically. As an example of collaborative efforts, Brown described, "Last year we worked with the physics class to conduct experiments with windmills and solar panels, setting them up outside to measure how much power they could generate, and then engaged in discussions about practical implications for what we discovered." Contextual learning such as this fosters student engagement, brings lessons to life, and makes learning real, which increases retention and promotes knowledge transfer.

When students complete the alternative energy program at WCHS, they are ready for college and career decisions. Brown has partnered with Nashville State Community College, Tennessee State University, and Middle Tennessee State University to provide dual credit / dual enrollment opportunities for his students. These higher education partnerships allow students to learn more about post-secondary opportunities and highlight career preparation options after high school, which are critical to ensuring that students are ready for college and a career.

Over the last ten years, thousands of cutting-edge, STEM-intensive CTE programs have launched in schools across the nation (McCharen & High, 2010). Agricultural education is an excellent platform for the continued emergence of these types of programs. The potential for positive impact demonstrated by the alternative energy program at Whites Creek High School highlights how and why STEM education is a natural fit for agricultural education.

References

McCharen, B., & High, K. (2010). Career and technical programs of study and early indicators of retention in the College of Engineering. *Association of Career and Technical Education Research*. Retrieved from http://www.public.iastate.edu/~laanan/ACTER/ 2010/manuscripts/CareerandTechnicalProgramsogf-Study_Final.pdf

National Academy of Sciences. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Retrieved from http://www.nap.edu/catalog/11463.html

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Teaching Students to Support Agriculture While Highlighting STEM Concepts – It's Easier (and more fun) Than You Think!

by Catherine W. Shoulders

Would you buy meat grown in a lab? Would you prefer to buy organic or traditional foods? Do you think glow-in-the-dark tobacco would be beneficial to society? Do you think GMO labeling is necessary?

Regardless of your answer to any of these questions, the questions themselves each share commonalities: they are controversial, they impact the agriculture industry, and they require knowledge of STEM concepts to be fully understood. While highlighting the STEM concepts in your agriculture classes can be viewed as a chore by both the teacher and students, using questions like these to set up relevant, highly rigorous units can make the learning process more valuable and enjoyable for everyone. The questions themselves are merely the tip of a complex, teaching-focused iceberg: Socioscientific Issues-based Instruction.

Don't let the name intimidate you. Aspects of socioscientific issues-based instruction have been used by agriculture teachers for decades, making the overall teaching method one that can be successful in the agriculture classroom. This article will focus on the teaching practices and common challenges of socioscientific issues-based instruction, as well as some examples of topics and related content areas that you may want to incorporate into your classroom. First, let's tackle the name and what it really implies for agricultural education.

Defining Socioscientific Issues-based Instruction

SOCIO – The topics focused on in class have a social component. They may be found on the news or in magazine articles, brought up by parents at the dinner table, or the focus of recent legislative efforts.

SCIENTIFIC – The topics are scientific in nature. They require knowledge of scientific concepts, thoughts and behaviors of scientists, and an understanding of the evolving nature of scientific theories. Through the issues, students explore "science in-the-making" as opposed to historical science with generally agreed-upon concepts (Latour, 1987).

ISSUES-BASED – Content is taught through a legitimate controversial issue that is relevant to students' lives. The issues are multifaceted and require students to ask questions and gain a better understanding of multiple disciplines, such as science, math, and history. The ultimate goal of the instruction is that students make an educated decision on the issue based on the content they learn.

INSTRUCTION – Teachers must prepare to guide students through a unit that focuses on learning content through the issue presented. Ideally, instruction should be student-centered and based upon student inquiry, as student questions must be addressed (although not necessarily answered) in order for students to make educated decisions about the issue.

> Students should act as knowledge contributors rather than just knowledge receivers.

Teaching through Socioscientific Issues-based Instruction

Guiding a class through socioscientific issues-based instruction requires some reorganization of the class units. After choosing an issue that is relevant to the class and meets the above definitions, teachers should organize the course content into units that reflect the multiple dimensions of the issue. While identifying and organizing units, teachers can highlight specific STEM concepts that they feel can easily be incorporated into the instruction. The number and duration of units is at the discretion of the teacher – after all, you know your students best.

Teachers should plan to incorporate technology and different media frequently into lessons. As students have questions about specific dimensions of these current, controversial issues, finding answers in traditional textbooks or prefabricated lesson materials may become difficult.

Because the lessons should foster student inquiry, teachers should be prepared to invite students to act as knowledge contributors rather than just knowledge receivers. A refreshing aspect of socioscientific issues-based instruction is that teachers often get the opportunity to learn about an issue with their students rather than fulfilling the traditional role of knowledge-deliverer. However, teachers must also be aware that the limitations of science and of their own knowledge may lead to more student questions than answers. In socioscientific issues-based instruction, that's ok – if all aspects of the issue had correct answers, it wouldn't be a controversial issue!

Finally, assessment should take numerous forms throughout the unit. Students' knowledge should be applied and measured through traditional tests, but more authentic skills such as experimentation, argumentation, and decision-making should be practiced to keep the end goal of making an educated decision in students' minds.

Recognizing the Challenges

No teacher is perfect; every lesson can be improved upon to increase student learning and interest. However, when guiding students through socioscientific issues-based instruction, being ready for common challenges can help make your first attempts with this teaching method more successful:

Students want the "right" answer. Today's standardized-test driven school system has conditioned students to look for and value the "right" answer. Because socioscientific issues-based instruction focuses on students making their own decisions about controversial issues, many of the questions you pose may have multiple correct answers, or no "wrong" answer. Students may become frustrated when they are asked to develop something that is required to make a decision later instead of immediately getting their answers reaffirmed as "correct." This change in student thinking about their products requires patience and guidance, but can pay off by some quality student decision making in the long run.

Students are not accustomed to connecting thoughts through more than one unit. Socioscientific issues-based instruction requires students to fluidly connect thoughts and content from multiple facets of an issue through several units of instruction. Most classes ask students to remember content for a test, after which the content is rarely revisited. Teachers may need to guide students through this mental connection process through specific class activities until students become accustomed to the different method of unit organization.

Conversations may go awry. Because of the controversial nature of socioscientific issues and their presence in society, most issues have a moral component through which teachers must tread lightly. Students are encouraged to allow inquiry to guide their thought process and learning, and some of their questions may not be in line with topics that the teacher was planning on including. While students should be encouraged to ask their questions, teachers can avoid potential awkward moments during class by establishing an appropriate response to questions that lead discussion away from school-friendly topics.

Issues and Content

Below are some examples of socioscientific issues that can be used in agriculture classes, with applicable units and STEM concepts that can easily be highlighted through them. These examples can be expanded upon to include a vast list, as many of society's current issues and problems focus on aspects of the agriculture industry (National Research Council, 2009).

Issue: The refusal of some countries to use of golden rice to reduce their people's hunger

Ag/STEM Concepts: human nutrition, transgenic crops, genetic engineering, crop costs, global economics

Suggested Units: Plant anatomy, plant reproduction, genetic engineering, global crop production, human nutrition

Issue: The US ban on horse slaughter

Ag/STEM Concepts: industry economics, animal nutrition, animal health, human health, public policy

Suggested Units: Equine industry and economics, animal welfare, agricultural law and policy

Issue: The creation of lab-grown meat to replace traditionally harvested beef or poultry

Ag/STEM Concepts: genetic engineering, tissue culture, animal welfare, livestock nutrition, industry economics, public policy

Suggested Units: livestock industry economics, environmental impacts of the livestock industry, food safety, meat cuts and quality, genetic engineering

Issue: The purchasing of strictly organic foods

Ag/STEM Concepts: agricultural economics, pesticide residues, water quality, integrated pest management

Suggested Units: Food safety, human nutrition, agricultural economics, crop management, livestock management

As with any method of instruction, the theory of socioscientific issues-based instruction is complex; this article is intended to supply the basics concepts of the teaching method. If you are interested in utilizing socioscientific-issues based instruction to increase the relevance of STEM concepts to your students' lives and refresh your class with a new way to go about teaching and learning, please contact the author of this article at cshoulde@uark.edu, or at the very least, conduct your own internet search to learn more.

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STEMing Back: *(continued from page 6)*

ricultural technology. For example, the idea of soil conservation with the use of green mature cover crops, crop rotation, organic fertilizers, contour plowing, windbreaks, and soil erosion control. Ironically, these practices are still used today.

Although science, technology, engineering, and math have made significant advancements in the past 60 years, the focal points of today's STEM education have been evident in our instructional pedagogy as early as the 1940s as seen in Carpenter's *Adventures in Science* series. Although Carpenter may not have realized the model he presented, he did give a foundation for integrated agricultural science into the elementary classroom. Today's elementary agricultural studies educators can look to early science curriculum to help guide modern agriculture education as a part of STEM. While mathematics was not evident in the *Adventure of Science* series, concepts of problem solving and logic were. The series expertly links agriculture to the topics of science, technology and engineering. While today's elementary STEM education is still evolving, the early connection of disciplines, including agriculture, for elementary students have opened doors to a more meaningful and seamlessly blended curriculum in the present day.

References

Caldwell, O. W. (1942). Harry A. Carpenter. *Science Education* 26, 153–156.

Carpenter, H. A. (1930). Success in physics and chemistry in relation to general science and biology. *General Science Quarterly* 14, 589–599.

Carpenter, H. A., Bailey, G. A. & Baker, M.L. (1939). *Adventures in science with Judy and Joe*. New York : Allyn and Bacon.

Carpenter, H. A. (1940a). *Adventures in science with Bob and Don*. New York: Allyn and Bacon.

Carpenter, H. A. (1940b). *Adventures in science with Jane and Paul*. New York :Allyn and Bacon.

Carpenter, H. A. (1941a). *Adventures in science with Doris and Billy*. New York :Allyn and Bacon.

Carpenter, H. A. (1941b). *Adventures in science with Jack and Jill*. New York :Allyn and Bacon.

Carpenter, H. A. (1948). *Adventures in science with Judy and Joe*. New York :Allyn and Bacon.

CMP. (1949). *Adventures in Science* book review. *Science Education* 33, 77–78.

Dorris, A. V. (1928). *Visual instruction in the public schools*. Boston: Ginn and Company.

Fisher, L. R. (1949). Guiding principles in curriculum making for science in the elementary school. *School Science and Mathematics* 49, 631 – 638.

Kern, O. J. (1906). *Among country schools.* Boston: Ginn and Company.

Miller, D. (1948). The place of elementary science in the curriculum. *School Science and Mathematics* 48, 379–387.

Morrison, J. (2006). *Attributes of STEM education*. TIES STEM Education Monograph Series. retrieved http://www.tiesteach.org/assets/documents/Jans%20pdf%20Attributes_of_STEM_Education-1.pdf.

Robertson, M. L. (1942). Emerging curricula in elementary science, *Science Education* 26, 178–186.

STEM and Agricultural Education…… A Natural Fit

by Dexter Knight

Why STEM and why now?

Science, technology, engineering and math or "STEM" education has been and continues to be a "buzzword" in educational circles for the past few years. Due to low assessment scores for the United States, STEM has been at the forefront of national discussion for good reason. Let's face the facts….the United States has been lagging behind in science and math for several years now. According to a Paris based group, the Organization for Economic Cooperation and Development (OECD) in 2009 the U.S. ranked 17th in science and 25th in math scores out of the 34 countries in their particular study. While I could devote several reasons as to why I feel this is the case, I would much rather focus on career and technical education's role in that task.

There are several worthwhile initiatives that our federal government and private industry have started in an effort to bring this topic to the forefront of educators and the public alike. Our leaders in Washington have promoted STEM education in 2009 with "Educate to Innovate" (whitehouse.gov) designed to move students from the middle to the top in science and math education. Exxon Mobile has promoted STEM education through "Let's solve this" (letssolvethis.com), designed to get the United States back in the lead in math and science. Whatever the initiative educators choose to accomplish this task, they must consider the single most important factor: the student and their ***INTEREST*** in math and science. This is not easy work by any means. This type of education is tailor made for each individual student; it is arduous, time consuming, and takes dedication on behalf of the student as well as the teacher. However a wise college professor of agricultural education once said, "The key to cooperation is to understand why," (Dr. Charles Byers, Professor Emeritus, University of Kentucky). If we teach "the why this is important" to our students, they will learn the concept and tie it to their own individual interest (i.e. SAE, research, career plans, etc.). Now, we have a model for true engagement on behalf of the student. The student will be in charge of the learning more than the teacher. This is somewhat similar to many training models that agricultural education pre-service teacher programs here in Kentucky have used in the past (i.e. problem solving method based on student's interest).

> *The key to cooperation is to understand why. Dr. Charles Byers.*

Project Based Learning

For the last eight years I have served as the principal of a locally operated career and technology center, Jessamine Career and Technology Center or JCTC, in Nicholasville, KY. We are nestled in the center of the Bluegrass Region of Kentucky, ten miles south of Lexington. Our community has a rich rural and agricultural heritage, all the while serving as a place of residence for families who work in Lexington. Our school district has a very diverse, heterogeneous group of students who excel in many areas of their educational experience from arts and humanities, sciences, and many of our career and technical education pathways. Since the inception of our center eight years ago, project based learning programs have been a part of Career and Technical Education (CTE). From engineering to biomedical science, project based learning is where students use "real world" problems and challenges to develop a deeper understanding of the subject matter; thus, creating a more inspired and engaged student. Our agricultural education program had a rich heritage of excellent teaching and student organization activities through FFA. While we continue to honor our rich production agricultural principles, our next step was to take an agricultural project based learning concept and use in the agricultural education classroom.

Curriculum for Agricultural Science Education

Being a former agricultural education teacher, I knew that for years we, as professionals, had an obligation to our students to teach them that the agriculture field was more than just production. While we continue to honor our rich production heritage, the careers in agriscience alone add a substantial number to the over 200 careers in agriculture. With the "science of agriculture" being so broad there was a need to help teachers find a way to teach the science. This in turn, would give them confidence in their pedagogical practices in teaching science much like their peers in that field. (Along comes the Curriculum for Agricultural Science Education or CASE). CASE's primary objective is to help students understand science concepts "through the lens of agriculture," while improving student performance in math and science. The difference with CASE was the fact that the instruction was inquiry based and content emphasized with a number of lab, project, and problem based activities. We had already seen this improvement with one of our interdisciplinary courses, Agribiology. Students in this biology based course taught with agricultural principles had statistically significant higher scores on the End of Course assessment than their non CTE counterparts in biology. What a concept? The "academy" approach to learning in simplified form really does work.

What can CASE do for your students?

As an administrator it was an easy transition for me and for our teachers to be a part of the CASE initiative. This professional development initiative through the National Council for Agricultural Education had already been hosted in our school for two consecutive years; so I saw firsthand the hard work the staff and teachers in attendance had been a part of during the two week intensive training. That coupled with our successful project based engineering program, CASE was an easy sell for me. These courses were already the talk of our community and had truly helped brand who we were as a school in the very beginning. Although the curriculum in engineering and CASE is somewhat "canned," it is a good "canned." There was latitude for teachers to deviate from the plan and incorporate curriculum geared towards the community and students' needs and interest. CASE curriculum and professional development fashioned after our engineering and biomedical courses with project and science based instruction works. The curriculum and activities taught in the professional development provide a link between some of the most difficult science concepts and the students' own individualized "real world" learning. This was evidenced by students' work in classroom Agriscience fairs, which came out of our CASE and interdisciplinary courses. Students designed their project based on the scientific method, formed a hypothesis, conducted research, and presented their findings to a group of judges. Our students excelled in this setting and as I stated previously, performed better on science concepts than students in the "regular" science courses. The teacher becomes the facilitator and students are more in charge of their own learning.

Conclusion

There are a multitude of programs out there for STEM education, including CASE. For Career and Technical Education in the United States we are certainly at a "crossroad" for our professional development, pedagogical techniques, and curriculum in many of our states and local communities. However you view education, especially Career and Technical Education the time is right in our country for CTE to truly "shine" through this national initiative. CTE has, like a great company, had to reinvent itself in the past few years in order to survive. In my opinion, we as professionals in Career and Technical Education, in terms of our ability to contribute to the overall core academic and career success of our students, need to be united in this goal by committing to STEM education. Should we choose to take the more difficult path and assist in this effort, CTE will be forever viewed as a valuable educational component for all students, regardless of their career.

References

Organization for Economic Cooperation and Development. (2009). *US Teens lag as China soars on international tests*. Retrieved from http://www.bloomberg.com/news/2010-12-07/teens-in-u-s-rank-25th-on-math-test-trail-in-science-reading.html

Educate to Innovate. (2009). Retrieved from http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Let's solve this. (2012). Retrieved from http://letssolvethis.com/

Curriculum for Agricultural Science Education. (2010). *About Case*. Retrieved from http://www.case4learning.org/about-case/vision.html

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Transitioning to STEM in Agriscience

by Aaron Geiman

An Informal History of STEM and Agriscience

It is October 1957. The scientific world quietly listens for the faint "beep, beep, beep" of Sputnik I, as it makes the historic journey. The Russian orbiter is mankind's first artificial satellite of Earth. Stirred to uneasiness by the event, the United States scrambles to find early success in the newly formed National Aeronautics and Space Administration (NASA). Soon after, President Kennedy calls for a strengthened focus on space exploration, resulting in a nationwide, concerted effort to educate America's youth in math, science, engineering and technical skills. By the end of the 1960s, the effort pays off; man has left his mark on the moon. But the efforts toward expanded scientific knowledge and technical training for all youth are not limited to aeronautics; agriculture sees its share of advancements as well.

In 1970, American agricultural scientist Dr. Norman Borlaug receives the Nobel Peace Prize for his work to feed the world's ever expanding population. He is dubbed "The Man Who Saved a Billion Lives," because of his work with improved varieties of wheat. In the preceding decades, Dr. Borlaug, and others educated by the expanding scientific and technical education movement, recognized the need for improved crop varieties to meet population needs. Their efforts in plant breeding, land management, and pest control lead to a worldwide "Green Revolution," averting global famine.

Both historical narratives illustrate how the determination of scientists and technicians helped to meet the wants (space exploration) and the needs (food) of society. Additionally, both narratives hint at the importance of scientific and technical education for providing capable minds to meet the challenge. While these narratives are historic, they are also prescient for the future of Agriscience…

STEM Education and Agriscience Today

In the past half-decade, the American educational system has shifted focus toward science, technology, engineering, and mathematics (STEM), mirroring the shift of forty years earlier. The strongest reason for the renewed focus is to prepare more American youth to enter the highly technical fields needed to address perpetual and emerging global issues. It is no surprise that the world supply of fossil fuels will be depleted within the next century, spurring the need for scientists to develop sustainable, highly efficient, alternative sources of energy. Further, data supporting mans' influence on climate change prod the development of scientists and technicians to remedy carbon dioxide imbalance, declining forest ecosystems, and melting polar ice. Finally, and most bluntly in the face of Agriscience, is the need to bolster world food production by more than seventy percent, to meet the needs of NINE BILLION people by 2050. As Agriscience Educators, it is not only our responsibility to prepare our students for a highly technical career market by increasing their STEM thinking capacities, it is also our responsibility to the world to prepare scientists that will bring forth another Green Revolution. Who knows, one of us might prepare the next Norman Borlaug for planet Earth!

Strategies to Increase STEM Thinking in the Agriscience Classroom

While many traditional agricultural education programs are driven by curricula bent on memorizing and regurgitating agriculturally relevant facts – breed identification, tool identification, botanical names – there are some that have transitioned their pedagogy to parallel that of successful STEM programs. Transitioning to STEM thinking in agriscience does not always mean teaching new content. Often, to increase STEM thinking means teaching less content, but to a much greater depth and with a different focus. Here are some strategies for incorporating and improving STEM thinking in the Agriscience classroom.

Believe that Less is More! Visit any teachers' lounge or faculty room, and one will hear the age-old educational chant, "there isn't enough time to get through the content before the test." American students underperform because they haven't received all of the content…WRONG!!! The Finns and Koreans have proven it. By teaching less, but to a greater depth, these educational powerhouses have improved the scores of their student across the board, even on questions taken from content to which the students were *never* exposed.

Take a critical look at your curricula. Ask yourself, "What content is *essential* for all?" The likely response will be a set of common, core concepts that transcend most content. Trim the curricula to reflect the newly identified knowledge and skills, and teach those to great depth, using agricultural topics as the context for the learning. As you proceed to deeper understandings, it is likely that your students will not balk at unfamiliar content. Because they possess a deep understanding of the core, they will step up to the challenge. Further, many of the problems of tomorrow do not exist today, so it is imperative that we prepare students to step up to unknown challenges when they appear.

Develop Math and Science Skills. As you trim content, you will likely find that many of the essential, core concepts that remain are deeply rooted in math and science; in other words, agriscience is inherently STEM. During the early phases of a STEM program, focus on developing students' mastery of those. Do not allow students to back down from mathematical challenges or highly technical scientific processes. Instead, foster their understanding by adjusting the context around the central concept. The agricultural context is replete with examples of scientific concepts.

Fortitude, Endurance, Perseverance. The pursuit of STEM concepts is not always easy. For students to attain true mastery of the deep math and science found in STEM, they must have a stick-to-it nature. They must not shy away from challenges, or even failure. To foster this mentality, the STEM teacher must not only model the "never-quit" attitude, but must also provide numerous opportunities for reteaching. Like the one-on-one interactions we give our CDE participants while practicing for a contest, we must provide equal interaction for students practicing for their career, by extending ourselves beyond the normal boundaries of the classroom. To allow students the opportunity to let assignments go unfinished means allowing them to develop the belief that society will accept unfinished work. STEM thinking is "Never Quit!" thinking.

Inquiry-Based Thinking. As agricultural STEM students become comfortable with the deep, underlying truths of math and science, as illustrated through agriculture, and as they develop the desire to find answers regardless of the obstacles, introduce and welcome them to question the natural world. Like a two year old asking "Why is the sky blue?" or "What makes the moon glow?," the growing scientist asks questions about the world. Take time to set up relevant scenarios, in which students see opportunities to ask questions and to pursue solutions. For example, following the study of the environmental growth factors for bedding plants, allow students to address "what ifs" about one of the factors. "What if the soil moisture level were maintained at 10% more than recommended?" "What if the photoperiod were halved?" The pursuit of answers to intrinsically derived questions will internalize concepts and content more effectively and efficiently than most other pedagogical strategies.

Process versus product. As students grow into scientists that analyze the world around them, by applying a core set of mathematical and scientific concepts, it will become evident to the teacher that no answer key exists by which students can be assessed. Deep, late-program STEM education focuses on process rather than product. To think as a STEM educator, one must first accept that there can be numerous, acceptable solutions to a deep problem. Consequently, educators must not evaluate the solutions presented by students, but look at how students arrived at their solutions. It is the process of thinking that is demanded in today's world. The ability to address new, unfamiliar situations and to generate plausible solutions is an aptitude that students will need in order to develop new strategies for energy use, environmental stabilization, and global nutrition.

Conclusion

As I reminisce about the early years of my career, I think of the pontifications of an elder mentor who frequently reminded the younger staff of the "educational pendulum;" the shifting focus of education between academics and career-based learning. "It shifts every twenty or thirty years." As a student who experienced an educational focus toward academics in the 1990s, and a teacher focused on career-based learning for the 21st century, I see the merits of both. More importantly, I see the coalescence of both in the STEM education movement - a coalescence that is necessary to produce problem-solvers needed for the world of tomorrow. Agriscience education has the fortune of both foci – rigorous academic content, rich in math and science concepts, and career-based education, replete with a mixture of technical and soft-skills development. It is both our privilege and responsibility to transition from traditional fact based agricultural education to aggressive, thinking based agriscience education.

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Aaron Geiman is an Agriscience Educator at North Carroll High School in Hampstead, Maryland.

Using STEM in Agriculture Mechanics

by Aaron J. McDonald

STEM. It's one of the newest hot topics if you are in education. Many professional development sessions lately have been devoted to it… but what is it exactly? And furthermore, how does it relate to agricultural education and how do we get on board with it? It's really quite simple. STEM is an acronym for science, technology, engineering, and mathematics. It is a major movement to get these topics taught on some scale in each and every classroom, be it an English class or a small engines class. The idea of STEM, however, is not a new idea to most agricultural educators. It's something we have been doing for a long time and without a major nationwide initiative.

As a tenured teacher, STEM topics have been part of my curriculum since I began teaching at Jackson County High School in 2004. My major focus has always been on the mechanical side of things, so the engineering aspect comes naturally to most of my class material. Anyone who has ever taken a welding class, small engines, construction, ag power, or structures class knows how big a part engineering plays in these classes. However, it may not be as apparent how the rest fits in. I do many projects with my students throughout the year and these topics come up frequently in class. Let's take it letter by letter and you can see for yourself how STEM fits in the agricultural classroom and see some examples of how this agricultural educator incorporates these principles:

"S" stands for science in this acronym. In the realm of agriculture, science plays a major role. It is obvious for many classes how this fits. An animal science class spends much time on anatomy and physiology of how animals bodies work; a direct correlation with biology. Many times I have students say to me, "We just talked about this in science class, but not quite this in depth!" However it may not be as apparent in a mechanical sense. In my small engines class for example, we spend time talking about fuels and how they work. The students must find chemical formulas for the different fuels, gasoline, diesel, methanol, ethanol, kerosene, etc. Once they do, they then discuss the process of how an engine uses this fuel, what is burned off, and what is left behind. We also spend a great deal of time discussing propane as an alternative fuel, and have even converted several engines to operate on propane.

"T" means technology. This one is almost too obvious. Technology is constantly changing in every aspect of our lives. We no sooner get the newest gadget and then a month later the next version is available. We try to stay on top of technology in agricultural education. We want our students to be able to go out into their field of study after graduation and be on top of the game. My classes get full-on instruction in the latest updates in technology as it relates to that particular class. We use computer programs to make landscaping easier, calculate feed rations, and even take care of our greenhouse operations. However, in the field of agriculture mechanics, we still use technology to a great extent. The newest tools and equipment that are being used in the field, new testing equipment for engines, even computer-based certification testing is now available and being utilized. Just this year, the state of Kentucky has accepted a certification program through agriculture mechanics as a "career ready" mark for agriculture students. This particular certification is through the Engine and Equipment Training Council or EETC is not computer-based, however it has encouraged some of my students to further pursue certification with Briggs and Stratton, which is computer based. This year, so far, I have had 4 students passed certifications in my classes, two through EETC, and two have begun testing with Briggs and Stratton. It is also my understanding that several other schools are beginning this testing process as well. Studies and surveys have shown that technicians are in short supply and demand will continue to increase. The average salary in a STEM-related job is $74,958, a number that grabs the attention of many of my students. The website www.stemconnector.org shows that in Kentucky alone, there will be an estimated 74,000 job openings in STEM fields by the year 2018, reflecting a Labor Department predicted 34% increase. Being only 5 years away, that is in the near future for many of our students.

"E" is for engineering. Engineering has been a part of agriculture mechanics classes for as long as anyone can remember. Many older generations still relate stories of building something in ag class and using it on the farm. My father, in fact, still talks about building a farm trailer in class and is proud to point that fact out as he still uses it today! In my mechanical classes, we make it a point to do at least one major project per class that requires using some degree of engineering. Right now, we have a major project happening that is actually being spear-headed by the University of Kentucky, called STEAM… an acronym that adds an “A” for agriculture into the STEM acronym. This project has our students building a vehicle to use a particular engine to meet criteria laid out by the University staff and the Kentucky Department of Fish and Wildlife. Obviously, in order to complete this task, all aspects of STEM must be used, including a dose of agriculture.

“M” reflects mathematics. Math is an area of great concern in many school districts around the state. According to www.stemconnector.org, Kentucky ranks near or at the bottom of almost every area that scores mathematics, including ACT and National Assessment of Educational Progress. In every possible class, math needs to be taught and reinforced at any opportunity. In ag mechanics classes, we regularly use basic math in many instances. Many ag classes have a math component. Animal science classes teach calculating feed rations, horticulture classes teach fertilizer application rates. In agriculture mechanics classes, I teach measuring tape reading, calculating concrete requirements for a project, figuring board feet for wood projects, as well as recently adding the reading of precision measurement tools, such as micrometers, calipers, and dial indicators. Using these tools, especially in small engines, requires reading very small increments of measurement, then adding together the results of the reading for a precise measurement that gets down to the tenths, hundredths, thousandths, ten thousandths, and in some cases hundred thousandths. Albeit not incredibly complex math, it reinforces at least the basics that are needed in real-world applications.

STEM is undoubtedly an important set of skills to be taught in our schools. In the field of agriculture, however, it is already a part of what we do. The jobs that will be created and needed in the very near future will require science, technology, engineering, and math, and many of those jobs will require some postsecondary education. We as educators must do our part to see that our students carry on with their education. Between 2008 and 2018, Kentucky will need to add 330,000 jobs that will require some education above high school, and 617,000 jobs in total. It is also estimated that 54% of all of Kentucky’s 1.1 million jobs that will require some postsecondary training. Student interest in STEM-related careers has been on the rise since 2005 and is now as high as it was prior to a decline in interest from 2001-2005. A rise in popularity like this is promising not only to agriculture programs, but hopefully will be promising to entire schools.

STEM jobs are leading the pack as far as needed jobs, and if our students want to be assured employment, we must continue to incorporate STEM into our agriculture classes. New and innovative ideas are what is going to keep our students interested in continuing their education and looking into the growing field of STEM-related careers, including agriculture. From the point of view of this agriculture teacher, STEM is part of the everyday curriculum and will continue to be as long as agriculture continues along its current path.

Aaron J. McDonald is a teacher of Agriculture at Garrard County High School in Lancaster, KY.

Transitioning to STEM in Agriscience *(continued from page 21)*

References

Commission on Effective Teachers and Teaching. (2011). *Transforming teaching: Connecting professional responsibility with student learning.* Retrieved from the NEA website: http://www.nea.org/assets/docs/Transformingteaching2012.pdf

Garber, S. (2007). *Sputnik and the dawn of the space age*. Retrieved from the NASA History website: http://history.nasa.gov/sputnik/

National Air and Space Museum. (n.d.). *Milestones of flight: Sputnik I.* Retrieved from the National Air and Space Museum website: http://airandspace.si.edu/exhibitions/gal100/sputnik.html

Nobelprize.org. (2012). *Nobel peace prize 1970: Norman borlaug.* Retrieved from the Nobel Prize website: http://www.nobelprize.org/nobel_prizes/peace/laureates/1970/borlaug-bio.html#

US Department of Energy. (2001). *International energy annual, 1999.* Retrieved from the Energy Information Administration website: ftp://ftp.eia.doe.gov/international/021999.pdf

THEME ARTICLE

STEM Concepts in My Agriculture Classroom: Opinions and Suggestions on STEM and its Incorporation

by Andrew "OP" McCubbins

TSTBAAFE! If you haven't figured it out by now, the random string of letters obviously stands for "there seems to be an acronym for everything." In education we are, or should be, used to acronyms in our daily lives. We should also be used to an ever changing challenge within education. There is constantly a "next big thing" in our world and we must continually adapt to meet whatever the requirements are for the aformentioned next big thing. While I constantly attend meetings or training pertaining to each next big thing to know how the system is supposed to work, I was extremely excited for the announcement of the push for 21st Century Skills and the support of STEM concepts in the classroom. My excitement comes from the aspect that agriculture education already does all of these things. We teach these concepts through our curriculum and reinforce them with the National FFA Organization. Our students, in my opinion, are exposed to all of these on any given day as a student enrolled in agriculture education classes.

Agricultural education is important. We all know this or else we wouldn't be teaching agriculture. Whether the school administration or district as a whole knows this is the important question. I am sure we have all had students at some point or another, who seems to struggle in some of the core content areas. Students struggling in math or biology are what I see most commonly. Yet, when that student is in my classroom, working on an assignment that has deep roots in mathematical or biological principles, they do just fine. I am in no way saying I am a saint to the realm of education, I am just willing to go the extra step to provide real world connections for content covered in my classroom. This extra step for real world connections hits close to home for me, as I was a high school student who struggled in math. My agriculture teachers took this extra step to help solidify the importance of math concepts across the board. Again, I am no expert in mathematics, but I understand the principles and can easily master mathematical problems because I know how to connect them to the world around me.

Successfully incorporating STEM concepts inside my classroom is not a single handed job. I work closely with math and science teachers in the school. My educational studies did not focus on either of those subjects. While I know how to address standards, I find it easier to help our learning community as a whole with the assistance of someone who did focus on those subjects. One example for instance is in my Landscape Design and Sports Turf Management course. We study construction principles, turfgrass selection and installation procedures, soil profiles, and much more. Anyone who has any experience at all in Landscaping and Sports Turf management realizes exactly how much math is involved in almost every aspect of that industry. My students calculate yardage of lawns, poundage of seed needed to cover the lawn, and water application rates to freshly planted lawn. For these exercises, I work with a math teacher in order to help drive home those principles inside my own classroom. While it may not be necessary, it is beneficial, as it shows those educators the importance of agricultural education. An example of a problem completed by my students can be found below.

You are planning to spend no less than $2,000 and no more than $7,000 on your landscaping project. Useful information- $55 per ton of rock and $103 per tree.

a. *Write an inequality that demonstrates how much money you will or are willing to spend on the project.*

b. *For the first phase of the project, imagine you want to cover the backyard with decorative rock and plant ornamental trees. Twenty-nine tons of rock is needed to cover the area. What is the maximum number of trees you can buy with a budget of $2,850? Write an inequality that illustrates the problem and solve. Express your answer as an inequality and explain how you arrived at your answer.*

c. *What number of trees would be a solution to the inequality in part b? Justify your answer.*

The problem found above was in no way created solely by me. I worked with a math teacher and an Internet search to develop the problem covering concepts that a majority of students struggled with in their math classes. Agriculture classes, being an elective course, somewhat means that the students are interested in the content covered. When you pair up content that students are interested in with content or concepts they do not enjoy so much, it eases their minds, at least in my experience. The students struggled at first but eventually mastered the concept. Mastering such concepts helps them in more than just my class. It allows them to see the connection of concepts to the real-world, and allows them to be successful in those concepts within the walls of their math class. This method of incorporating STEM concepts in my classroom works well but does require some front end work.

Another method I use to incorporate STEM concepts in my classroom is by utilizing the CASE curriculum. I attended my CASE: Agriculture, Food, and Natural Resources training in the summer of 2012 at the University of Kentucky. This curriculum is the real deal as far as incorporating the 21st century skills and STEM concepts that we hear so much about. After attending this training I discussed all aspects with a few of the science teachers and they seemed pleased at how the curriculum is set up. The fact that it follows the same standards that they follow was also a reinforcing factor for support. The students enrolled in my Introduction to Agriscience course, which is the course where CASE is utilized, are grasping those STEM concepts quicker. I cannot count the number of times a student has approached me to inform me that they did well on a science exam because they connected a lab we completed to a similar concept covered in their science class. The course demands that students become critical thinkers and to analyze problems instead of me spoon-feeding them information. It helps the freshman outgrow the middle school mentality and become prepared to be successful high school students in all of their classes. Speak with your administration about the benefit a training like this can have on your program as well as the school to try and acquire funding. There are many routes one can take to have this training paid for, and I encourage all agricultural educators to take those steps.

The importance of agricultural education and Career and Technical Education has never been more relevant than it is now. With new accountability measures in place, we all have a job to do. Accountability measures should be addressed by an entire school, as a heavy load is more easily carried when distributed among many. It is our job as agricultural educators to take responsibility in our students' success on standardized tests such as the ACT or Plan. I say this because we can help aid in several aspects of those tests. Along with the new measures, Career and Technical Education now plays an even more important role in school accountability as well. The new accountability measures have a spotlight on students who are "college and career ready." With the successful implementation of STEM concepts through each of our courses we are preparing students to be college and career ready. When this is proven through our students passing state assessments or obtaining industry certifications, our importance is validated.

In closing, agricultural education has and always will easily incorporate STEM concepts in the classroom. I don't feel that it is anything new; we just have a new task at hand; showing our administrators that we are important and that our curriculum is relevant and rigorous. We have to show the administrators that we too play an important role in student success, even if our classes are not considered core content.

Andrew "OP" McCubbins is the Agriculture Education Instructor at Campbell County High School, Alexandria, KY.

Left: Richard Brown explains the importance of wind power to prospective students and parents at an evening showcase of his program.
Right: Student looks at properties of water during a lab in Ag. Biology; each test tube substance weighs differently and the student used the inquiry lab to determine how each substance would react.

THEME ARTICLE

How I Teach STEM in My Agriculture Classes

by Tim Ray

STEM (science, technology, engineering, and mathematics) education is not new. STEM has been around for a very long time, but has recently been brought to the forefront of education. Agricultural education has been teaching STEM for as long as we have been teaching agriculture, we may not have called it STEM or realized we were doing it but trust me it is there. Whether it is on purpose or because of the nature of agricultural education STEM is present nearly every day in all of our classrooms. I have been teaching STEM in my classroom since before they came up with the acronym. I cannot imagine teaching agriculture without incorporating science, technology and math. Engineering sometimes take a little imagination but it is certainly not difficult to do.

Science is the easiest and I would bet most prevalent in agriculture classrooms already. Look at our class titles and try to hide the science. Plant science, food science, animal science, forest science, agriculture science, I know I teach more than one course with science in the title and I bet most of us do. Agriculture by definition is the occupation, business, or science of cultivating the land, producing crops, and raising livestock. Science is what we do, who we are as an industry.

I teach using CASE (Curriculum for Agriculture Science Education). CASE allows me to purposefully teach the science concepts that naturally occur in agriculture every day using hands on, inquiry based instruction methods. Not only are my students exposed to more science, but it is in a way that is easier for most of them to understand and grasp.

Examples of science abound in the agriculture classroom. Osmosis and diffusion are difficult concepts for some students to grasp. Using CASE, the students are able to actually see both processes occur before their very eyes. Using corns starch, corn syrup, iodine, water and a semi permeable membrane they can watch as diffusion of simple sugars occurs and as osmosis occurs the semi permeable membrane swells. Using technology we are also able to show them with data that molecules are moving across the membrane. Another example is photosynthesis in plant science, the act of plants creating chemical energy from sunlight. The science that allows most life on the planet to exist, right there in the agriculture classroom, the best part is students are experiencing it not just seeing it in a book or writing a report on it. They are growing plants in a greenhouse and watching how environmental conditions can impact growth. My students live it as we grow plants for a Mother's Day Plant Sale. The sale is the culminating activity but it gives the students the drive to complete one of the best examples of hands on education I can provide. Look at all of the science involved in growing many different types of plants in a confined area, with limited resources. My students not only apply science concepts they learned in the classroom that influence management decisions but also learn marketing, timing, teamwork, and so many other skills. These skill are what make my students successful in the workplace, no matter what that workplace is.

Animal science provides many other examples of agriculture using science to raise animals for food, fiber, or companionship. I teach nutrition, genetics, anatomy, physiology, and classification of animals. I have many students that raise market animals for our county fair and auction. What better way is there to apply the science of genetics and nutrition?

Technology surrounds us. It is virtually impossible to teach in today's world and not use technology or teach technology in some way. I may go a little overboard in this area. I use technology a lot and force my student to as well. In my classroom, paper is non-existent. We are completely paperless. Assignments, record books, applications, proficiencies, scholarships, you name it: I have an app for that or a website that will do what good old paper and pencil or poster board and pens will do. I believe it is my job to expose students to as much technology as I can. They are living in world full of it and they will have to be able to manipulate it for just about any career they are going to have when they leave my program. The grocery store, restaurant, gas station, bank, doctors office, they all use technology to accomplish their jobs. Our students must have the ability to use and manipulate technology to be as successful as we hope they will be. In my classroom we use technology every day ranging from the laptops to access the web to using Labquest devices from Vernier to collect data with for a lab or project we are working on. My students get so used to technology I think they are not sure they are using it sometimes. It becomes so common to them it becomes second nature, that is the way I want it. If they can handle all of the different apps, websites, and sensors that I throw at them, I think they can handle whatever their career is going to toss at them.

Technology is present in the agriculture shop as well. We use a plasma cutter rather than a cutting torch to cut metal for welding projects. We have a saw stop table saw that uses technology to eliminate table saw injuries. Technology is also present in the small engine lab where we use newer engines to teach engine theory that can applied to the newest engines in cars, trucks, and tractors.

Engineering is most present in my agriculture mechanics classes but can be found to some extent in most of my classes at different levels. In my Introduction Agriculture Mechanics classes, after students are through safety and have a basic understanding of the tools and how to draw, plan, and construct basic projects; they are given the task of designing and building a rubber band powered car. They are responsible for the complete design, drawing, procedure and construction of the car from materials available to them from a previous project. It always amazes me what they are able to accomplish with a single rubber band's power. By allowing students to experiment and not giving them pre-prepared plans they are left to experiment. Out of a class of 28 or so I am always impressed at the different approaches to the problem and how they solve it. Many use basic plans and concepts but there are always a few that really exceed expectations and fly past the goal of ten feet with a single rubber band.

Math is present everywhere we go. It is a fact of life, one that I welcome and enjoy. I have many activities that apply some basic math concepts in very concrete ways that help students to better understand. In the agriculture shop is one of the hardest places to get students to use math, but it is the most important and easiest place to do it. Fractions are the hardest thing we deal with. Measuring and adding fractions can be tough. I spend about a week or so on measuring and building confidence in students to believe that they can measure and use fractions. At the end of the week we play a game where they get to line up small pieces of wood with fractions written on them. The goal is to line them up from 1/16 of an inch to one inch by 1/16 inch increments in the correct order. I make a contest out of it to see who can accomplish it the fastest. I have students go in groups of four at a time, the fastest one moves on in a tournament style until we determine the fastest in the class and they compete against me. Even when the first student is done, I make sure every student completes the task and if for no other reason they have visually seen all of the fractions in one inch and start to see the relationship and pattern that exists.

Math in the classroom is evident as well. Balancing rations, figuring fertilizer ratios, ordering media to fill the containers in greenhouse, germination percentages, the list goes on and on.

Agriculture education incorporates more core academic areas than any other subject in the school. We do this my nature, always have, always will, it is who we are as and industry it is what has and will continue to make us the innovators of education. I am sure I was teaching STEM before STEM was being talked about. I will continue to teach STEM after it is done being talked about because it is good for kids and it is so key and instrumental in what agricultural education is that I cannot imagine teaching agriculture without science, technology, engineering, and math.

Tim Ray is the Agricultural Science and Technology Instructor at Dallas High School, Dallas, Oregon.

Upcoming Themes

May-June

What We Learn from Research about "Teaching Agriculture"

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July-August

Stories About Teaching and Learning

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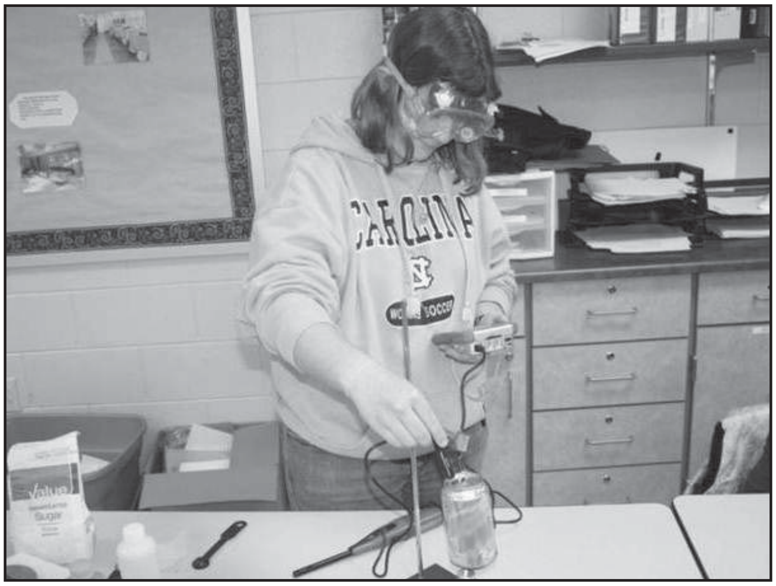
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