Monday, November 16, 2015

Guest Blogger Series: Systems-based Learning

Editor's Note: This blog is part of a series of guest contributors from the National school-based agricultural education family. Mr. Craig Kohn is an instructor at Waterford Union High School outside of Milwaukee, WI. He has is heavily involved with state and national ag ed initiatives, including the new AFNR standards, the National SAE Renewal Taskforce, and is on a focus advisory group for the National FFA. Prior to becoming an ag instructor, Mr. Kohn conducted research in fields of medicine, ecology, and education at the University of Wisconsin - Madison, where he earned degrees and licenses in agriscience, education, agricultural education, and biology education. Mr. Kohn also has a license to teach environmental science. He will be starting a doctorate in Curriculum, Instruction, and Teacher Education at Michigan State University in 2016. Mr. Kohn was raised on a dairy farm in northeastern Wisconsin near Green Bay, where he raised dairy, beef, swine, horses, goats, and chickens and was actively involved in environmental and ecological experiences on his home farm.

As I am writing this on our way home from the National FFA Convention in Louisville, I am regularly checking on the score for the Wisconsin Badgers football team. Football often makes a great analogy for many other aspects of life because it resembles the reality of much of our day to day existence. It is a complicated network of interconnected factors resulting in an ultimate outcome that is either failure or success. To anyone with a passion for this game, a traditional physical education unit on football can sometimes be frustrating because our understanding of this intricate system is often measured (at least in part) by something as mundane as whether or not we know the width of the field in which all of this occurs. I think it is fair to say that for many students with a passion for the game, units on football in physical education sometimes fail to compare to the excitement and challenges of actually playing the game.

Many of the subjects we teach at the secondary level are reflective of this phenomenon. All too often, instructors try to teach their subjects as a series of unconnected independent facts when, in reality, the true nature of the subject that they teach is more like a system of interconnected and often-changing factors that cannot be distilled into something that can be measured by a multiple-choice test.

Nearly every aspect of adult life is part of a system. For example, when you get behind the wheel of a car, there are thousands of combinations of circumstances that govern how you can safely and effectively get that automobile from point A to point B, and this process can change from day to day. It's not enough to know that turning a key, shifting some gears, and pushing a gas pedal enable a car to move. This is precisely why classroom instruction in a driver's education course is always immediately followed by behind the wheel experiences that last for weeks. While learning to drive a car must begin with the fundamentals of the car itself, none of us would want to get on the highway with a generation of students who learned to drive solely from a textbook and a multiple choice exam.

As agricultural instructors, our subject matter entails one of the most complicated networks of systems on the planet. Consider the multitude of factors that go into the seemingly-mundane process of turning a kernel of corn into the dinner that someone will consume. The conversion of this kernel into a stalk that will become food is

governed by a multitude of factors including the billions of base pairs in its DNA, the interactions of widely and rapidly changing weather patterns, ecosystem services such as decomposition and pollination, the expertise of the producer, the functions of the machinery, the rise and fall of market prices, always-changing government policies, the presence or lack thereof of wildlife, consumer preferences and opinions, the economic productivity of the United States and its 300 trading partners, and many, many more factors. Agriculture is perhaps the most complex system on our globe and there is almost nothing in the existence of modern humans that has not affected how a corn kernel becomes the next meal.

We teach a complicated subject, a subject that is complicated because it is the result of the interplay of multiple systems. By definition, a *system* is a series of interconnected factors and influences that result in an identifiable outcome. A system can be a dynamic thing to teach, and a systems-based curriculum can engage students because it can turn what seems like an incredibly-complex and volatile series of events into something that is comprehensible and predictable.

The problem is that traditionally, teachers taught rules, definitions, and individual concepts rather than systems. Many of our experiences as students in agricultural education likely reflected this constrained educational philosophy - memorize these breeds, learn these statistics, label these parts, memorize these terms, etc. Had our education ended with just the classroom, we would have ended up with a terribly-constrained education. Hopefully, you as a teacher (or a future teacher) incorporate FFA and SAEs into your own instruction because these opportunities provide students with the chance to experience the complexity of the systems that comprise agriculture and much of life.

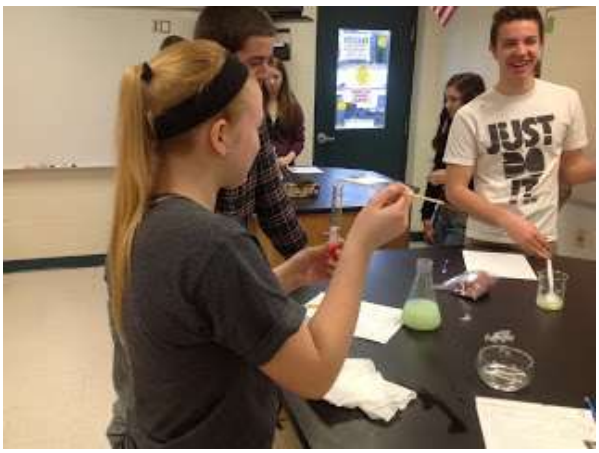
However, there is absolutely no reason as to why systems cannot be taught in the classroom. While we as instructors should begin at an appropriate level for our students' learning needs, we need to advance to the highest levels of Bloom's Taxonomy by teaching in a manner that utilizes these systems.

So how do we do this? I certainly don't have all the answers but what I can do is describe how I approach this complicated task of teaching systems. I don't always succeed, but I have experienced that uniquely-wonderful moment of seeing when my students have finally "gotten it" and have seen clear evidence of students understanding the big picture, which gives me reason to believe that maybe what I am doing is along the right track.

When my freshmen students enter my introductory classes each fall, I begin by giving each group of 4 students two trays of soil and a petri dish of radish seeds. The task for each group is simple: change one of the trays so that those radish seedlings grow taller than the other untreated tray. Whether it be a treatment of diluted Gatorade, mixing in coffee grounds, extra lighting, a weak solution of adrenaline, or whatever hypothesis their young minds can generate, each student attempts a novel method of growing a taller group of radishes. Unsurprisingly, most fail in their quest to grow a bigger radish.
However, it doesn't matter whether they succeed or not. What matters is that I've gotten my students into the game of agriculture. They don't care about definitions or concepts. They want to know if their treatment of diluted Red Bull somehow made their plants grow taller.

The beauty of this approach is that questions naturally arise. After some obligatory laboratory safety, we begin considering the carbon cycle. We try to determine how it is that this tiny seed can become a much larger radish plant. We focus on how carbon dioxide in the air is combined with water in the soil to make mass of the leaves and stems and roots that we can physically touch. Students soon begin to understand that all of agriculture is really just finding ways to directly or indirectly convert water and carbon dioxide into food, fuel, and fiber. They begin to comprehend that a regulated carbon cycle is what enables all life on earth to exist because all life is carbon-based. To understand this, they must know the difference between an element, molecule, cell, tissue, organ, and more. While terms are taught, they are taught in a manner that represents a larger idea, and this context makes what would otherwise be mundane material feel relevant, necessary, and interesting.

My students then are introduced to the nature of the chemical energy that powers all cells. They learn how the sugars produced by the plant during photosynthesis provide the hydrogen protons that turn ATP Synthase to make ATP in the mitochondria, and that oxygen removes this hydrogen so that the process can continue. They comprehend that the more ATP that is produced, the more that cells can function and the more that cells can divide. They connect increased ATP production to increased crop and animal production. They see that all living things are connected in their need to produce ATP, and their evolutionary strategies largely stem from this need. They learn that breathing lungs, beating hearts, digesting stomachs, and almost every bodily function in some way relates to sustaining the nonstop ATP production that in turn enables bodily growth and productivity.



They then move on to photosynthesis and focus on how those plants cells produce sugar. They connect the necessity of water, sun, and carbon dioxide to the production of sugar. They grasp why aerated soil and plentiful supplies of nitrogen, potassium, and phosphorus are necessary for those plants to grow and their cells to function.

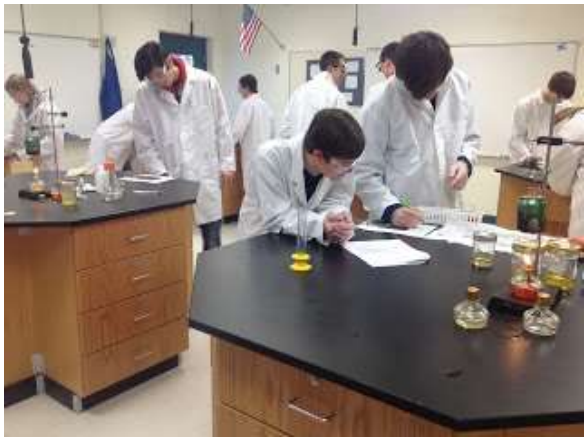
Comprehension of these three systems (the carbon cycle, cellular respiration, and photosynthesis) then enable a student to understand practically any process in agriculture. Once they know the "rules" of living organisms, there is nothing in agriscience or environmental science that they cannot grasp. From plowing a field in fall to installing ventilation fans in a barn to the application of fertilizers to the concerns related to climate change, all of the considerations that are a part of agriculture begin to make sense when viewed through these systems. These systems provide students with a framework to understand their observations and answer their questions that arose as they worked with living organisms and natural processes in inquiry-based labs. My students are playing the “game” of agriculture and because of this, they want to learn the "rules" that explain why what they are observing is happening.

When these introductory students return in the spring, they learn genetic systems and can understand and comprehend how we can use DNA and inheritance to change how cells function to improve the efficiency and productivity of plants and animals. For the rest of the year, we use the system of DNA to understand every level of biotechnology from Mendel to genomics to cloning.

Students in my other ag courses rely heavily on systems as well. Veterinary students learn how to check vital signs as a method for assessing how to address emergency responses. Students in Agribusiness begin by mastering economics and learn how opportunity costs and benefits affect decision making. Students in Natural Resources

consider how biodiversity and extinction affect ecosystem function in order to grasp why specific management decisions are made. Students in Landscape Design learn all about how balance, emphasis, transition and other elements of design affect whether a presentation will be appealing or appalling to the eye. Systems govern every class I teach because they enable my students to learn and answer their own questions long after I have faded into the distant recesses of their memory.

While I would never go back to a method of teaching that did not involve systems, it also true that there are disadvantages to this approach. First and foremost, it is harder to teach. Most of us did not experience this kind of instruction as students, and so it can be hard to know what it should look like when it's effective. It requires far more interaction and inquiry because students need to *experience* the systems to appreciate their complexity. Often this means writing your own curriculum from scratch. Having designed and written over a dozen classes myself, I can attest that it can be hard to find effective and appropriate examples of systems- and inquiry-based education that work in different classroom environments.



Finally, it can be very hard to assess a student who has been taught in this way. While a multiple choice test can be a great formative assessment to check for progress, it is a terrible option as a final assessment for a unit. Just as we wouldn't want a student driver to get a license after only passing a written test, we want students in our subject to be assessed in a "behind the wheel" manner for whatever subject we're teaching. In my classes, this can involve authentic assessments such as diagnosing a veterinary disorder by performing a physical exam on a cow, creating and critiquing a landscape design project for the school, or producing and evaluating biodiesel in my laboratory. Over time I have found ways to lessen my dependence on written exams and have tried to reduce the excesses of rote learning in my program, but it remains an ongoing battle.

Ultimately, if we are successful at teaching systems, we should be preparing our students to apply their knowledge and skills in order to understand and address legitimate problems. I have long since forgotten the mundane facts I memorized in high school and college, but I find myself constantly applying what I know about the systems to the experiences that I have each day. Agricultural education provides phenomenal opportunities to help students understand the function of the world at large due to its close relationship to systems in biology, ecology, economics, engineering, medicine, and much more. The key is for each instructor to know and grasp the endless opportunities at their disposal to teach using these systems. By going beyond rote facts and memorization to teach students to comprehend and use the systems embodied in agriculture to solve problems and create solutions, you will provide an education that will remain with your students long after they have left your classroom in a manner that embodies the greatest ideals of agricultural education.

People are often concerned about how excited I get about teaching techniques, and I can talk forever about curriculum and instruction as well as my own teaching experiences.

If for some reason that sounds appealing to you and you want to discuss this further, or if you have any questions, feel free to email me at ckohn@waterforduhs.k12.wi.us .

All of my curriculum can be found (and downloaded for free) at wuhsag.weebly.com . Changes and updates are made regularly to this website so feel free to check for new versions of the material.