# Problem Solving Approaches in Agriscience Education

When I was in the 7th grade, we were asked to deliver an introductory speech about ourselves for an English class assignment. My best friend Paul introduced himself as someone who was very fluent in English, which he claimed proved that he was very smart because he had been told that English is a very difficult language to learn. While Paul was really just trying to be funny, his remark was actually pretty insightful. English is a notoriously-difficult language. Most native English speakers don’t even question the fact that the words “thought”, “through”, “though”, and “tough” each look similar but sound completely different, nor question the absurd reality that the words “bologna” and “pony” somehow rhyme.

Even though other Western languages like French or Spanish tend to be easier to learn than English, most native English speakers find it far more difficult to learn a second language. I personally took French in high school for two years. While most of my English was learned without a teacher licensed in the subject, most of my French was learned with a trained and highly-experienced professional for about an hour a day over the better part of two years. Today I can barely get beyond “Bonjour!” and would certainly not be prepared to visit a French-speaking region. However, were I to spend even just a week in Paris, I would probably be more fluent in speaking French than I was after two years in a French language classroom in the US.

The differences between the ease of learning our native language and the difficulty of learning a second language can be attributed to many factors, but one of the most important to consider is the difference between *acquisition* and *learning.*

**Acquisition, Learning, and Literacy**

James Paul Gee, in his 1991 work, “Rewriting Literacy”, made a clear distinction between acquisition and learning. Gee defined *acquisition* as the process of gaining skill or knowledge subconsciously through exposure as well as trial and error. According to Gee, this is very different from *learning*, which is an intentional process of gaining conscious knowledge or skill from a teacher. We unconsciously acquire our first language in a manner that seems almost effortless, but we almost always have to struggle to learn a second language (unless you were fortunate enough to grow up in a multilingual household).

Gee makes the case that much of our knowledge and skill comes through a combination of unstructured acquisition and intentional conscious learning. Driver’s education is a classic example of this. In most driver’s education programs, you begin in a classroom where you learn the fundamentals such as where to place your hands on the steering wheel, how to read road signs, and how to parallel park. We all know quite well that this intentional conscious learning is far from enough to fully prepare a student for the realities of driving a car, which is why the vast majority of students will also take part in numerous hours of behind the wheel with an instructor and a parent before getting their official license at age 16. If teenagers could just take a multiple choice test to get their license without the actual driving experience, our roads would be much more terrifying.

Agriscience education is no different than language, driver’s education, or any set of knowledge and skill that is to be gained by a student. If anything, agriscience courses are even *more* dependent on the combination of these two forms of education because much of agriculture depends on *both* knowledge and skill. Whether it be performing sutures to close a wound, using a microscope to identify a pathogen, collecting soil samples for testing, or delivering a marketing presentation, students in agricultural courses can only be fully prepared for careers and their personal futures if they can gain knowledge through both acquisition and learning. In fact, if you consider the three-circle model of agricultural education (classroom and laboratory learning, personal preparation, and career experiences), two of these three circles are more about gaining education through acquisition than from learning.

James Paul Gee would probably be very happy about this, as he argues that we tend to be more proficient in regards to knowledge and skill sets when they are gained through acquisition instead of learning. However, learning in a classroom setting results in more conscious awareness of the knowledge and skill that have been gained, making what occurs in the classroom and laboratory setting just as important as what occurs in immersive career experiences and personal growth opportunities. Nonetheless, a student’s classroom experiences can be enhanced by combining a mixture of learning and acquisition through strategies such as the problem-solving approach to teaching.

**The Problem Solving Approach**

The Problem Solving Approach is a method of instruction with origins going back to the work of John Dewey. If you are unfamiliar with John Dewey, you should get pretty familiar with him if you intend to work in the field of education because his work and philosophy serves for much of the basis of modern education. The problem solving approach tends to consist of four major themes:

1. **Engagement**: the lesson or curriculum reflects a real-world consideration that is recognizable in the lives of students.
2. **Inquiry**: students must use curiosity, exploration, observation, and hypothesis formation to create answers for questions that may or may not have a right answer (or may have multiple right answers).
3. **Solution building**: the teacher in these lessons acts as a coach, enabling students to work in teams to make accurate observations, identify patterns, and develop rational models to explain an unknown phenomenon (this, by the way, is the basis for much of the practices that serve as a major component of the Next Generation Science Standards).
4. **Reflection**: once students have addressed an unknown situation in a manner that results in a plausible explanation based on evidence, logic, and critical thinking, the teacher again acts as a coach to elicit their reasoning, challenge their assumptions, and refine their analysis in a manner that both allows students to recognize gaps in their logic and breaks in their comprehension of core concepts in the material.

It should be noted that all of these components reflect a *student-centered* model of education. Traditionally, we think of the teacher as a repository of facts and information, a person who identifies when a student is wrong and re-directs them to the “correct knowledge”. Look at any multiple choice exam or teacher’s edition of a textbook and you could easily be forgiven for thinking that this is how education is supposed to work. I assure you, there are certainly more effective ways to be an instructor.

While there are many reasons to teach in a student-centered manner, among the most notable is that almost all students only have teachers in their daily lives for about 12-17 years. Individuals who were taught in a teacher-centered model are pretty much screwed for the rest of their lives because they consistently relied on an ‘expert’ to tell them what was right or wrong. This would be just fine if you could learn all of the facts in the world by the time you were 18 (and assume that no other facts would be discovered), but the fact of the matter is that you continue to be exposed to new information and ideas throughout your entire life! Good teachers therefore make themselves increasingly unnecessary by teaching their students how to make observations, propose questions, develop hypotheses, analyze evidence and arguments, and determine the validity of a conclusion. Good teachers enable their students to constantly ask themselves how they know they are not wrong even after they graduate. By utilizing a student-centered model of education, you can enable a student to make sense of the world even as new information and discoveries occur in their lives.

Furthermore, the problem solving approach enables a deeper comprehension of knowledge and a greater development of skill because it tends to entail a combination of acquisition and learning. Not only do students develop a conscious awareness of the knowledge and skills they have gained through their education but they have a better command of that knowledge and skill because it was developed in a manner reflective of real-world situations. If students can further immerse themselves in a career-based experience through FFA, an SAE, and other similar opportunities, they will enter the workforce with career-ready levels of knowledge and skill.

**Student-Centered, Problem Solving Approaches in the Classroom**

Without knowing any particular terms for these ideas, I began my career as a high school agriscience teacher with similar intentions. I had realized that there were stark differences between the education I had gained through acquisition on the Wisconsin dairy farm on which I had been raised and in the classrooms in which my old-school teacher-centered education had occurred. When I was experiencing a real-world environment through my acquisition-based education on the farm, I was unconsciously gaining expertise in a set of career and life skills that would remain with me for the rest of my life. However, I was not experiencing the same level of benefits in my high school classrooms. When I became a teacher myself, I yearned for my students to have the experiences that I had once had on our farm. In my opinion, the perfect classroom was an environment where the lessons could be not just learned but *experienced* as well.

As a new teacher, I worked tirelessly to create the types of environments where students could gain knowledge and skill through both learning and acquisition. I built pens, cages, and coops and filled them with cattle, chickens, ducks, rabbits, and a persnickety classroom cat named Tiffany. I regularly utilized our school forest and greenhouse, developed landscaping gardens, and created a working department office that was run by students. Using corporate donations, salvaged lab equipment, and as many grants as I could apply for, I renovated a spare room into a functional, modern scientific laboratory and made a point to use it at least once a week for any applicable class. As much as possible, I tried to force the real world through the doors of my classroom and into the lives of my students.

However, facilities alone do not make a student-centered, problem-solving, inquiry-based curriculum. To do this, I set up a curricular model that I taught in four phases:

1. **Awareness** – high school students need some kind of knowledge base before they can fruitfully engage in inquiry (because if you don’t know what you don’t know, you can’t be expected to do much inquiring). After an introductory activity in which I probed for their prior understanding (and misunderstanding), I provided students with a specific set of notes and guided worksheets to develop their knowledge base so that they could determine what questions to ask.
2. **Interaction** – once students reasonably had the knowledge they needed to ask good questions, I provided them with problem-solving opportunities in which they could formatively assess their understanding of this knowledge and apply it in a real world scenario. This wasn’t a cookie-cutter lab where they blindly followed steps as if they were baking a recipe. These were truly inquiry-based experiences in which students had to make predictions, propose a rationale for their hypothesis, collect data, and explain the patterns in their data using models learned from classroom material.
3. **Mastery** – in the interaction phase, students were guided and coached by their teacher to reach a point in which they could reflect and come to a logical conclusion. The mastery phase was the time for me as the instructor to ‘fade out’ and see if these students could achieve similar results in a less scaffolded and less structured setting. This typically served as part of their summative exam, ending their lesson in a real-world manner.
4. **Career Preparation** – in preparation for their eventual college- and career-goals, my students developed career-and-college portfolios, took part in 15 hours of career experiences outside of class, and took part in an exit interview in which they connected the lessons learned in class to what they intended to do after high school. This component was pure acquisition-based education and provided a chance for their classroom-learned knowledge and skills to be applied.

What I have just described also happens to be very reflective of the structure of the 2015 AFNR National Standards, which are organized in three levels.

* The broadest level entails the **Common Career Technical Core (CCTC) Standards** – these are standards that apply to all types of CTE courses.
* Within the CCTC standards are the **Performance Indicators**. These are the “actual standards” as we typically think of them, and reflect what the National Council for Agricultural Education (or “The Council”) believes to be the specific content necessary for proficiency in a given agricultural course.
* Finally, each Performance Indicator has **Sample Measurements**. These sort of look like what we would assume are the standards, but are actually more like *suggestions* for what a teacher could provide in their curriculum to satisfy the Performance Indicators and the 2015 AFNR National Standards as a whole.

The sample measurements are also reflective of problem solving approaches in education. These measurements are organized into three columns, with the leftmost column being the standards pertaining to *awareness* (terms, vocab, concepts, etc.). The middle column includes the *intermediate* concepts, which involve the application of the basic knowledge for a given Performance Indicator. The rightmost column includes the *mastery* concepts. These tend to focus on having students make predictions about unknown situations, apply lessons in a manner similar or identical to a workplace situation, or utilize large amounts of content to reach a conclusion. Notice that Mastery does not consist of perfect memorization of terms or concepts; this is still the Awareness level (the most basic of the three). Mastery can only come about when a student is able to apply their decision-making skills in a real-world scenario, often in a group-based situation that involves hypothesis formation, data collection & analysis, and communication of interpretations.

**Examples of Student-Centered, Problem Solving Approaches**

It took me the better part of a 10-year stretch in classrooms to reach a point in which I felt comfortable about my effectiveness with these methods and ideas (let alone to even realize that they existed). My work was far from perfect but my descriptions below might help you to get a better grasp of what I am describing.

One of my more-effective examples of using a problem-solving approach was in my introductory Agriscience course. This two-semester course focused on the scientific method, the carbon cycle, cellular respiration, and photosynthesis in the first semester, and on genetics and biotechnology in the second semester. This might sound very different from an introductory agricultural course in other schools, but the point was to enable my students to understand the systems that serve as the basis of all of agriculture, food and natural resources. Agriculture at its simplest is really about the acquisition of biomass in a manner that is productive for human needs. Photosynthesis serves as the source of all carbon for carbon-based life & biomass, respiration is the process in which these organic carbon molecules are used to produce the cellular energy (ATP) that is necessary for acquiring and building that biomass, and genetics pertains to how these processes can be made more efficient and productive. In short, if a student can understand these three processes, they are then capable of developing a deep comprehension of all factors, decisions, and considerations in any field of agriculture.

The unit on cellular respiration was a challenging one to teach, especially to a class primarily made up of freshmen in high school. As with all my lessons, students began with an **Awareness** portion of the material. After asking how the breakfast they had consumed an hour earlier became the energy they needed for the rest of the day (and making them aware of the gaps and misconceptions in their thinking), I allowed for time for students to independently complete a set of notes. Once students had developed a base of knowledge from which they could start the inquiry process, I provided them with the first example of **Interaction**; students had to work on dry erase boards in teams of four to develop five ways in which they could engineer the cells of cattle to produce more ATP, enabling the animals to become more productive. After a sufficient amount of time, I brought the students back together and randomly called on groups using a set of dice. Regardless of whether their ideas were right or wrong, I asked them to explain their rationale behind the ideas they proposed. I used another randomly-selected group to critique their ideas. We as a class came to a consensus about each idea, and my coaching ensured that they reached the right conclusions without “telling them the right answer” by questioning their responses so that they could see their own gaps in logic and knowledge. The most powerful tool I had in this phase was the phrase, “Tell me more…what are you thinking?”

After a quick multiple choice quiz to a) make sure that all students were at a level of proficiency necessary for moving on and b) to make sure that students took the time to ‘cement’ the knowledge in their mind, we moved on to the **Mastery** level. In the week that followed, students were challenged to determine the changes to cellular respiration that resulted from different kinds of carbohydrate “feeds” and explain these differences using their base knowledge from the previous week. To do this, students used yeast cells and measured the differences in the CO2 production during the respiration of different kinds of carbohydrates (sugar, starch, and fiber).

Students began with a cookie cutter lab so that they could become familiar with the equipment and protocols. They then redesigned the lab by changing an independent variable (e.g. adding caffeine, increasing the temperature, using fiber instead of sugar, etc.). They made their predictions about what effects the changes would cause, proposed rationales for their reasoning, collected data, identified patterns, and proposed models based on their prior material to explain their results. By the end of the week, they worked in teams completely unassisted by their instructor. Their reasoning was developed and critiqued within and among their groups. They applied their reasoning to other scenarios such as cattle or corn, knowing that their model organisms were representing the same cellular processes that occur in essentially all living organisms. While their education on the topic began as learning, it concluded with acquisition, ensuring that they could reach mastery while also being consciously aware of the specific set of knowledge and skill that they were mastering.

Other classes worked in a similar manner. My vet students first debated how and when sutures became necessary for a wound to fully heal before completing independent notes on the topic of suturing. This was followed by videos and demonstrations of me performing suturing, concluding with each student performing and practicing suturing on bananas. Students in my Agribusiness course discussed and then completed notes on the principles of marketing, followed by addressing hypothetical marketing scenarios for a business, and concluding with developing a marketing plan for their own future business that they could create while they were still in high school (which some did). Students in my Natural Resources class followed notes and discussion of habits with predictions and calculations of biodiversity in different portions of the school forest in relation to the quality of the habitat in those areas.

In each case, the instruction was designed to allow students to eventually address specific real-world problems or considerations. Student responses were not judged as right or wrong, but defendable or not defendable based on argumentation and discussion so as to allow them to function independently without their teacher. Students did not learn obscure facts as much as they learned underlying phenomena that helped them to explain real-world considerations such as why fertilizer was necessary for a field, how the type of crop affected the sustainability and carbon-neutrality of a biofuel, or how invasive species could decimate an ecosystem. Their education in my classroom often began as learning but continuously progressed until it was more about acquisition-based education through situations that were as real-world as a classroom environment could provide.

**Conclusion**

My high school French teacher once lamented that she couldn’t kidnap us and leave us alone in Paris. Looking back, I now realize two things: 1) that was a terrifying statement when taken out of context, and 2) she was absolutely correct in her realization that what we were learning in her classroom could never compare to how we could learn a language like French when immersed among native French speakers. Similarly, agricultural educators could never provide the level of education that could be achieved if our students could be immersed in an environment like a farm, forest, laboratory, clinic, or corporate headquarters. However, we can strive to create environments in our classrooms that reflect the real-world scenarios that occur only outside of high schools through strategies such as the problem solving approach.

Utilizing acquisition-based teaching methods such as the student-centered instruction, the problem-solving approach, inquiry-based education, experiential learning, and others can be challenging. Many teachers did not have similar experiences as students, making it hard to envision what this kind of curriculum might look and feel like in practice. It can often feel like students aren’t learning as much because they are covering fewer concepts (but gaining a much deeper comprehension of those concepts). Classroom management can be a challenge when students are encouraged to work in teams and converse with each other instead of just quietly taking notes or completing worksheets.

However, while these methods have their challenges, the benefits certainly seem to outweigh the drawbacks. If in doubt, remember back to your own student experiences and ask yourself which lessons were most enjoyable or most impactful. How many of us fondly remember taking multiple choice tests and writing endless notes? How many of us forgot all of the material on a long multiple choice exam by the time we got our grades back? On the other hand, how many of us really enjoyed taking part in labs that felt like real world situations? How many of us preferred to work in groups on projects in which we had some control and decision-making opportunities? How much more valuable did our education seem when it the connections to our future lives were unquestionably obvious?

In my experience as a teacher, the greatest feeling of success only occurred when I knew I was no longer needed, when my students could stand with me as an equal and I could have confidence in knowing that their success in life was as inevitable as I could make it. Teaching isn’t about telling students the ‘right answers’, whatever they may be. Teaching is a profession in which we make sure that students leave us with the ability to ask questions, determine answers, solve problems, and think critically long after they have stopped worrying about the grades that we would assign to them. To ensure that this can occur, we must enable our students to practice functioning without us and create a classroom environment that enables this to happen on a daily basis.