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THINKING CRITICALLY

Critical Thinking: A Life-Long Endeavor

By Jamie Cano

Everyone thinks, it is our nature to do so. But much of our thinking, left to itself, is biased, distorted, partial, uninformed, or down-right prejudiced. Yet the quality of our life and that of what we produce, make, or build depends precisely on the quality of our thought. Shoddy thinking is costly, both in money and in quality of life. Excellence in thought, however, must be systematically cultivated.

The ability to think critically is essential if individuals are to live, work, and function effectively in our current and changing society. Students must make choices, evaluations, and judgments every day regarding information to obtain, use, and believe and actions to take. As adults, our students will be living in a complex world and in a democracy where both individual and collective actions will require effective selection, processing, and use of information.

Critical thinking of any kind is never universal in any individual; everyone is subject to episodes of undisciplined or irrational thought. Its quality is therefore typically a matter of degree and dependent upon, among other things, the quality and depth of experience in a given domain of thinking or with respect to a particular class of questions. No one is a critical thinker through-and-through, but only to such-and-such a degree, with such-and-such insights and blind spots, and subject to such-and-such tendencies towards self-delusion. For this reason, the development of critical thinking skills and dispositions is a life-long endeavor.

Focusing directly on thinking skills and the development and use of thinking skills over time tends to produce more effective thinking than unplanned emphasis on skill development or short term emphasis. State education programs often times emphasize the development of thinking skills throughout the curriculum over time. Emphasis should be given to critical questioning, reading, writing, listening, and planning and carrying out activities in all curriculum areas of agricultural education.

There are many reasons to believe that the development of higher-order reasoning rests squarely on the availability of ample amounts of relevant discourse. The development of higher-order reasoning has not occurred on any regular basis in most agricultural education programs due to lack of teacher knowledge, lack of materials, and class sizes. Organizational arrangements which would dramatically reduce class size, at least for a proportion of the school day, would likely enhance the development of higher order thinking skills (Bennett, 1987).

The quality of discourse and the amount of student interaction are also important. There needs to be a shift in many agricultural education classes from a teacher-centered classroom to a student-centered classroom in which students can be involved in collecting and analyzing information, paired problem solving, cooperative learning settings, simulations, debates, and critical reporting sessions.

Providing experiences in real-life situations or situations that simulate real-life increases the probability that skills will be used. Providing modeling of the skills, ample opportunities for practice, and feedback on the effectiveness of the student's thinking are also important considerations. Selection of experiences should be based on the developmental levels of the students.

Critical thinking is, in short, self-directed, self-disciplined, self-monitored, and self-corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. Critical thinking entails effective communication and problem solving abilities and a commitment to overcome our native egocentrism and sociocentrism.

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Theme: Thinking Critically

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ENHANCING DIVERSITY

This issue will look at diversity in a global perspective. Why does agricultural education need to diversify its programs? Is the concept of urbanizing agricultural education programs now at the forefront of the profession?

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Can We Really Teach Students to Think Critically?

By Rick Rudd

In a recent conversation with a colleague, he asserted that teaching students to think in the context of a classroom is next to impossible. Our job as educators he suggested was to provide the knowledge for students so that they would have it in "reserve" when a decision needed to be made or a problem was presented to be solved. You may be able to guess that as theme editor for this issue of the Agricultural Education Magazine, I took issue with that position!

Good thinking skills will not develop on their own, they must be taught (Beyer, 1987). Sutton and de Oliveira (1995) asserted that although students complete basic courses, they have only a superficial understanding of what they have learned. In fact, few students are taught the skills needed to examine principles, values and facts. We can (and should) teach students to *think critically* and arrive at better problem solutions and better decisions. These "critical thinking outcomes" are influenced by knowledge and experience but they are also influenced by an individual's critical thinking skill and critical thinking disposition.

Teaching students to think critically about decisions and problems is a task that we should undertake as agricultural educators. Huitt (1998) said that critical thinking is one of the most important attributes for success in the 21st century. Paul (2002) proposed that "in a world of accelerating change, intensifying complexity and increasing interdependence, critical thinking is now a requirement for economic and social survival".

So, how can we teach students to think critically in and about agriculture and life? It begins with a clear understanding of critical thinking on our part. Rudd, Bake,r and Hoover (2000) defined critical thinking as, "A reasoned, purposive, and introspective approach to solving problems or addressing questions with incomplete evidence and information and for which an incontrovertible solution is unlikely." Chafee (1988) defined critical thinking as "our active, purposeful, and organized efforts to make sense of our world by carefully examining our thinking, and the thinking of others, in order to clarify and improve our understanding" (p.29).

> Good thinking skills will not develop on their own, they must be taught.
>
> *(Beyer, 1987)*

Norris and Ennis (1989) provided this simple definition of critical thinking, "Reasonable and reflective thinking that is focused upon deciding what to believe or do" (p. 18). Critical thinking is about reasoning, reflecting, introspection, purpose, and solutions.

Critical Thinking, Problem Solving, and Higher-Order Thinking

Often, critical thinking is confused with problem solving and higher-order thinking. Although some authors use similar terminology in describing components of critical thinking which are used to describe problem solving and higher-order thinking, the concepts are unique.

Hedges (1991) constructed a dichotomous breakdown of critical thinking and problem solving (p. 1). According to Hedges, problem solving is a linear process of evaluation, while critical thinking is an overlying set of abilities that allow the inquirer to properly facilitate each stage of the linear problem-solving process (See Table 1).

Some confuse critical thinking with cognitive processing, lower-order thinking and/or higher-order thinking. Although critical thinking does not necessarily entail hierarchical or linear processing such as cognitive processing, it does involve operation at a particular

Table 1
Hedges' Typology of the Relationship Between Critical Thinking and Problem Solving

Critical Thinking	Problem Solving
1. *The ability to identify and formulate problems, as well as the ability to solve them.*	1. *Recognizing a problem situation.*
2. *The ability to recognize and use inductive reasoning, as well as the ability to solve them.*	2. *Defining the problem.*
3. *The ability to draw reasonable conclusions from information found in various sources, whether written, spoken, tabular, or graphic, and to defend one's consclusions rationally.*	3. *The ability to comprehend, develop and use concepts and generalizations.*
4. *The ability to comprehend, develop, and use concepts and generalizations.*	4. *Testing hypotheses and gathering data.*
5. *The ability to distinguish between fact and opinion.*	5. *Revising hypotheses and testing revised or new hypotheses.*
	6. *Forming a conclusion.*

knowledge, comprehension, application, analysis, synthesis, or evaluation level. Critical thinking is a process that is influenced by cognition and the cognitive process.

Critical Thinking Skills and Dispositions

Peter Facione (1990) conducted a study to determine the common elements of critical thinking as held by experts in philosophy, psychology, sociology, and education. This study revealed two distinct components of critical thinking: critical thinking skills and critical thinking dispositions.

Six critical thinking skills were identified by the expert panel (see Table 2). These skills and sub-skills can be learned in formal and non-formal settings. Examples of instructional methods that can be utilized to teach the skills also appear in Table 2. Skills taught within a context (such as agriculture) are more likely to be remembered and applied by students in the future.

Critical thinking dispositions bring attitudes, values, and beliefs into the thinking process. Dispositions are not changed easily and are solidified over time. They are a very important component in the critical thinking process. Researchers in the Department of Agricultural Education and Communication at the University of Florida have identified three components of critical thinking disposition. They include:

♦ Engagement – Anticipating a situation to use good reasoning and being confident in one's ability to reason, solve problems and make decisions. Also can confidently communicate and explain the reasoning process one used to make a decision or solve a problem.

♦ Innovativeness – Consistently looking for new knowledge in their profession, situation, life and world. Also is intellectually curious using all resources to find the truth, even if conflicts with personal beliefs and opinions.

♦ Cognitive Maturity – Being aware of one's disposition and biases when making a decision and solving a

Table 2
Proposed Critical Thinking Cognitive Skills, Sub-Skills, and Instructional Skills

Interpretation	Sub-Skill	Instructional Component
Interpretation	Categorization Decoding Significance Clarifying Meaning	Factual Knowledge Discussion
Analysis	Examining Ideas Identifying Arguments Analyzing Arguments	Modeling
Evaluation	Assessing Claims Assessing Arguments	Case Study Analysis Role Playing
Inference	Querying Evidence Conjecturing Alternatives Drawing Conclusions	Guest Speakers Action Learning
Explanation	Stating Results Justifying Procedures Presenting Arguments	Presentation Debates
Self-Regulation	Self-Examination Self-Correction	Ethical and Social Analysis Reflective Examination Self-Evaluation

Facione (1990)

problem. Also is conscious that their opinions are shaped by their environment and experiences and their answer may not always be the right answer (Rickett, Irani, Rudd, & Gallo-Meagher, 2003).

Critical Thinking Outcomes

Figure 1 illustrates a model for high quality critical thinking outcomes that begins with a stimulus and concludes with a high – low quality thinking outcome. Teachers who are interested in teaching students to arrive at reasonable, high – quality critical thinking outcomes should pay particular attention to developing the students critical thinking skill, teaching the knowledge necessary to solve the problems faced, and molding critical thinking dispositions. In addition, teachers must be aware of student academic strengths and weaknesses, as well as other personal factors that can influence problem solving and decision making. Finally, the environment in which the teaching and learning occurs is critical to the success of thinking processes.

Can we teach students to think critically? Yes! Agriculture teachers and others interested in teaching students to think in and about their discipline can use critical thinking skills and dispositions to couch course content in such a way that will teach students the content and teach them the process of arriving at high quality critical thinking outcomes.

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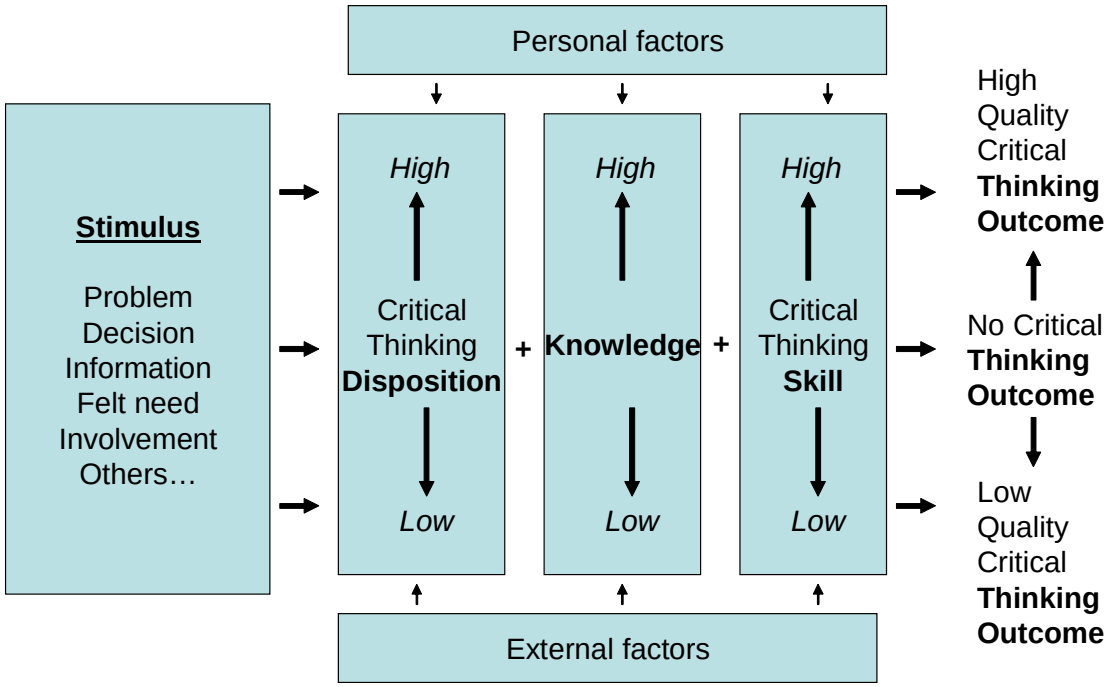
Model Of Quality Critical Thinking Outcomes



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How Do You Teach a Disposition to Think Critically?

By Curt Friedel

Have you ever noticed in the classroom that some of your students are really smart, but don't have that thing we generally call *common sense*? Or a student may be more *street smart* than *book smart?* Simply said, some students are great at using higher-order thinking skills to make decisions and solve problems, while others are not. Even if we teach critical thinking skills in the classroom, SAE and FFA, we find some students do not always use those learned skills. Why is this?

To answer this question, many variables play a role in describing the thinking behaviors of students; these include previous knowledge, values, motivations, ability and the environment. However, research has found that a student's disposition toward using critical thinking skills is also a variable that may promote or inhibit their ability to think critically (Norris, 1994). If this is true, a student taught critical thinking skills may not use those skills if he/she lacks the proper disposition. This poses two questions: 1) What is a critical thinking disposition? and 2) How can you teach a critical thinking disposition? This article will attempt to answer both.

What is a critical thinking disposition?

Many researchers have tried to determine the components of a critical thinking disposition and there is still much research to conduct in this area. However, there seems to be an agreement in the literature that a student's disposition towards using critical thinking skills is necessary for good reasoning. In problem solving and decision making, a critical thinking disposition is commonly referred to as a student's *felt need* to apply reason to the issue at hand. But what is a felt need? As agricultural instructors we commonly relate the concepts learned in the classroom to students' past experiences, SAE projects, and FFA Career Development Events to develop a felt need to learn. How is this different than developing a felt need to critically think?

It is important not to confuse a critical thinking disposition with a critical thinking skill. A thinking skill, as discussed in other articles in this magazine, can be performed at a specific level of expertise. A thinking disposition is composed of character traits supplying the proper attitude to use those skills. A skill can be taught in a semester, but a disposition must be developed over a longer period of time. Several authors have tried to define the components of critical thinking disposition. Paul and Elder (2001) believe that a critical thinking disposition includes eight essential traits. They include the following:

♦ Intellectual Humility – Not claiming to know more than you actually know.

♦ Intellectual Courage – Fairly examining beliefs that are against your own.

♦ Intellectual Empathy – Genuinely understanding the reasoning of another person.

♦ Intellectual Autonomy – Thinking for oneself with control over your beliefs, values and inferences.

September - October 2006

Theme: Developing Professionals

What does it mean to be a professional? Why should one belong to professional organizations? How does one mentor student teachers and first year teachers? What is the reponsibility of first year teachers related to their professional development?

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♦ Intellectual Integrity – Admitting your thinking is inconsistent with your actions.

♦ Intellectual Perseverance – Need to answer unsettled questions for better understanding and insight.

♦ Confidence in Reason – Faith that using reason will best serve humankind.

♦ Fairmindedness – Treating all viewpoints alike without regard to emotions (p. 13-14).

Collaborative research in the Department of Agricultural Education and Communication at the University of Florida found three components of a critical thinking disposition. They include the following:

♦ Engagement – Anticipating a situation to use good reasoning and being confident in one's ability to reason, solve problems and make decisions. Also can confidently communicate and explain the reasoning process one used to make a decision or solve a problem.

♦ Innovativeness – Consistently looking for new knowledge in their profession, situation, life and world. Also is intellectually curious using all resources to find the truth, even if conflicts with personal beliefs and opinions.

♦ Cognitive Maturity – Being aware of one's disposition and biases when making a decision and solving a problem. Also is conscious that their opinions are shaped by their environment and experiences and their answer may not always be the right answer (Ricketts, Irani, Rudd, & Gallo-Meagher, 2003).

The point of showing the two lists of disposition components is not to look for similarities and differences, but to give better explanation to describing a critical thinking disposition and to distinguish it from a critical thinking skill. A student may have a higher disposition for critical thinking allowing him/her to adequately use learned critical thinking skills. However, if a student has a lower critical thinking disposition he/she will tend not to use critical thinking skills. In other words, teaching critical thinking skills is pointless if students do not have a high critical thinking disposition! Can this be true? Certainly there is more to know.

How can you teach a critical thinking disposition?

That is a tough question! Remember critical thinking skills can be taught in a semester, but a critical thinking disposition takes a much longer time to develop. Fortunately, if your students stay in the agricultural program for a couple of years, you may have an opportunity to influence their critical thinking disposition. Little research has been conducted concerning how to teach for a higher critical thinking disposition, but Tishman and Andrade (1996) believe that a critical thinking disposition is best developed by immersing a student in a culture of critical thinking. To create this culture, Tishman and Andrade propose the following four fundamentals: models, explanations, interactions, and feedback.

The teacher must *model* and use models of good reasoning to provide students with examples to help them identify critical thinking in real-life situations. To do this, stay current with the news and keep a newspaper on your desk. The opinion section is a great place to start to analyze someone else's reasoning. Be willing to discuss agricultural issues, your opinion on those issues, and why you hold those opinions. Allow students to voice their view and then ask them why they hold that view. Question your own biases in class and allow students to question their own in order to keep emotions in check. Bring in a speaker to discuss their position on animal rights, or acceptance of biotechnology. Later, host another speaker with opposing views and discuss with students if either speaker's reasoning was better. Ask students if they can logically understand how a rational person can have an opposing point of view.

The teacher must give *explanation* to why critical thinking is important and overtly teach elements of critical thinking. It is not enough to use critical thinking in the classroom; a teacher must also define the terminology for the students. By teaching the student the difference between opinion, fact and theory, he/she can make distinctions for themselves and become more proficient as a critical thinker. Other need-to-know terms include bias, beliefs, values, hypothesis, evidence, argument, reason, rhetoric, and propaganda. Being knowledgeable of these terms and how they are related will also improve your critical thinking ability and serve as a better critical thinking model for your students.

FFA's LifeKnowledge© lessons *HS 24: Critical Thinking Skills* and *HS 25: Applying Critical Thinking Skills* may help you begin to incorporate elements of critical thinking into your curriculum. Furthermore, explain why it is important for everyone to use good reasoning. What would happen if leaders did not use critical thinking? What is the difference between poor judgment and good judgment? What are the benefits of a group having diversity of thought as opposed to thought coming from the same culture, values and beliefs? What are the disadvantages? Using questions like these, to

frame your lessons are sure to begin meaningful discussions to explain the elements of critical thinking.

The teacher must provide student *interaction* during the reasoning process. Giving students the opportunity to apply critical thinking skills together allows for more meaningful assessment of their peers' critical thinking disposition and their own disposition. This can be accomplished using a think-pair-share technique or various other group work activities. Place students into groups and provide each group with copies of a different article. Direct the student groups to find faults in the author's logic of their article and then have each group present the article to the rest of the class. You may also try organizing a debate between groups of students. Pick a topic and allow students a class period to work together in researching and formulating an argument against the position of the other group.

Once you have done this, have students switch sides and take the other groups position. This will challenge the students by forcing them to think about the issue from another perspective. Another idea is to have groups of students evaluate or develop a public policy. Let each group decide what policy they will develop or evaluate as it relates to the current unit being studied in the course. You may want to introduce this assignment at the start of the unit and have students present their findings at the end of the unit. This will assist student engagement during the presentation of the content and provide a great student review at the end of the unit.

The teacher must provide *feedback* to the students regarding their critical thinking disposition. Strengths and weaknesses of one's critical thinking ability can be assessed through teacher feedback, student peer feedback, and self feedback. If a student doesn't know if his/her reasoning is faulty, how are they going to improve? However, the teacher must be careful to provide supportive feedback and not be condemning. It is vital to create an atmosphere where students feel comfortable to make mistakes in reasoning and openly explain their thoughts. Start by posting a set of ground rules of discussion for all students to follow. As a teacher, purposely make an obvious mistake in your critical thinking and see if your students catch it. Then openly admit that you were wrong and that you will try to improve your critical thinking disposition in the future. This will help students realize that it is ok to make mistakes and that everyone can improve their ability to reason. Personally, I have found that the best tools for creating a supportive classroom environment are sincerity and honesty. Students know when you are sincere and honest and they will reciprocate.

Conclusion

There is strong evidence that a critical thinking disposition is necessary for a student to apply critical thinking skills to the topic at hand. Although critical thinking skills can be taught in a semester, a critical thinking disposition takes a longer period of time to develop. A student's critical thinking disposition can be influenced by the teacher's use of modeling, explanation, interaction and feedback concerning the elements of critical thinking dispositions and skills. An agricultural program incorporating these four fundamentals is certain to foster students' critical thinking dispositions and skills. All of this will help ensure that our future agricultural leaders will know how to effectively reason when it is necessary for them to solve complex problems and make decisions in our vastly changing world.

The teacher must be careful to provide supportive feedback and not be condemning.

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It's All Interpretation

By John Ricketts

All learning [in agricultural education] involves personal interpretation, since whatever we learn we must integrate into our own thinking and action (Paul, Binker, Martin, & Adamson, 1995).

I know we have some Diamond Rio fans who read this magazine, especially since many of us have had the opportunity to hear them at the National FFA Convention on several occasions. Regardless of whether or not you're fans, I am sure all of you are familiar with the lyrics:

"It's all interpretation,

To find the truth you gotta read between the lines,

Work out your own salvation,

That narrow path is hard to define,

Heaven's more than a place; it's a state of mind…"

Ok you can stop singing in your head now. I agree. A Diamond Rio song is a strange way to begin an article but the lyrics about finding "truth" by "reading between the lines" is a reasonable likeness of what it means to utilize interpretation as a good critical thinker.

What is Interpretation?

Interpretation is about developing and providing one's own conception of a particular topic/idea/issue in light of previous experiences, perspectives, or points of view. For instance, many of us agriculture teachers have different interpretations of the diversity problem in agricultural education based on our diverse set of prior experiences, perspectives, or points of view. Interpretation is different from facts, evidence, and situations, but the best critical thinkers certainly consider all of the information. In fact, good critical thinkers "recognize their interpretations, distinguish them from evidence, consider alternative interpretations, [and] reconsider their interpretations in the light of new evidence" (Paul et al., p. 369).

Breaking Interpretation into the subskills of *Categorization*, *Decoding Significance*, and *Clarifying Meaning* (Facione, 1990) provides further clarification about what it means to use Interpretation as a good critical thinker. *Categorization* is about identifying themes, distinctions, or categories so that information, experiences, or beliefs are meaningful. *Decoding significance* is about detecting and describing the most important, but sometimes hidden parts (content or function or motive or purpose or value or viewpoint) of information. Lastly, *clarifying meaning* is about paraphrasing, making things understandable, and removing the confusion associated with key content.

Let's interpret the following scenario. If you saw four cows walking in a straight line could you determine where they are going? What if you noticed that the four cows were black and white? Would that help you make any interpretations about where the four cows are going? Sure it would. You might use *categorization* to determine that the cows are Holstein. Through *decoding significance*, you might also determine that the cows are going to the milking parlor to be milked since Holsteins are dairy animals. You could *clarify the meaning* of these interpretations if you had more information (i.e. cows have large udders).

Learning and Interpretation

The dairy cow example is a very elementary example, but the total program of agricultural education (Classroom/lab, FFA, and SAE) provides the perfect atmosphere for good critical thinkers to engage in many rich active

Interpretation is about developing and providing one's own conception of a particular topic/idea/ issue in light of previous experiences, perspectives, or points of view.

learning and interpretation activities. Learning in agricultural education involves interpretation by students, because whatever our students learn must be integrated into their own thinking and actions. Learning must be given meaning by students, must be meaningful to students, and therefore involves interpretive acts by our students (Paul et al., 1995). Consequently, interpretive acts associated with land judging, agriscience labs, extemporaneous public speaking, and agriculture marketing CDEs, just to name a few, all qualify as significant vehicles of learning via the critical thinking skill of interpretation.

Students practice the skill of interpretation when they comprehend and express the meaning or significance of a wide variety of experiences (Facione, 1990) available to them through agricultural education. However, we educators must still be intentional about ensuring that our students are gaining this valuable critical thinking skill. Being intentional involves modeling the skill as teachers and using teaching tools that foster Interpretation.

Modeling Interpretation

Teachers are the starting point for improving critical thinking skills, especially the skill of Interpretation. Teachers who want their students to be able to find the truth by reading between the lines need to model interpretation skills themselves. "Thacker lists [several] recommended teacher behaviors, all of which will be familiar to good teachers, for fostering a climate conducive to the development of thinking skills:"

♦ Setting ground rules well in advance

♦ Providing well-planned activities

♦ Showing respect for each student

♦ Providing nonthreatening activities

♦ Being flexible

♦ Accepting individual differences

♦ Exhibiting a positive attitude

♦ Acknowledging every response

♦ Allowing students to be active participants

♦ Creating experiences that will esnure success at least part of the time for each student

♦ Using a wide variety of teaching modalities (Jerry Thacker, as quoted in Gough 1991, p. 5).

Teachers are the starting point for improving critical thinking skills, especially the skill of Interpretation.

We have all practiced each of the important teacher behaviors above, but we need to stay diligent in practicing them if we want our students to become good critical thinkers. Let's look at some teaching tools that will also help us be more intentional about making sure our students are adept at categorization, decoding significance, and clarifying meaning.

Teaching Interpretation

Silence

How often do you pose a question to a group of students and then answer your own question almost as soon as you ask it? It takes an average of 10 seconds for an adult to process a new or complex question and to organize a response. Imagine how long it might take for a teenager who can't wait for the 3:00 bell to ring to process your question and organize a response. Silence is a great tool because critical thinkers need time to interpret information. When we always answer questions for our students we are stifling the development of their interpretation skills.

Discussion

Research (Gokhale, 1995) tells us that collaborative learning tools such as Socratic Discussion or Fishbowling are effective instruments for helping students developing critical thinking skills such as Interpretation. Socratic discussion, developed by Socrates, is a method of conversational discussion that gives everyone a chance to contribute to the discussion, but more im-

portantly it gives everyone a chance to understand a focal point of information. The discussion usually revolves around a focal reading or statement (i.e. Avian Influenza is coming to America). Then there is usually a focus question (i.e. how could Avian Influenza affect the USA?). This question is posed to the entire group of students and the teacher, who is prepared with all of the necessary facts, information, and clarifying questions leads the discussion. Following discussion there should always be a debriefing seeking to identify students' perceptions of the discussion followed by a time of conclusion and summarization of the topic.

Fishbowling is another discussion method where a small group of students discuss a topic while sitting in the middle of a circle of a larger group of students. The larger group can only listen. Then members of the larger group move to the middle of the circle to discuss having listened intently to the previous discussion. Both methods challenge students to work on categorization, decoding significance, and clarifying meaning.

Critical Reading and Writing

Most of us read uncritically, meaning that we miss part of what the writer was trying to express while confusing other parts. Critical reading is a tool that more of us agriculture teachers should employ as a teaching tool. Critical reading is an active, intellectually engaged process in which the reader participates in an inner dialogue with the writer (Paul et al., 1995, p. 360). The critical reader [our students] looks for significance and attempts to clarify meaning as they read through selected text.

Writing is another key teaching tool for teaching critical thinking. In

Most of us read uncritically.

writing "it is essential that our students understand what our thesis is, how we can support it, how we can elaborate it to make it intelligible to others, what objections can be raised to it from other points of view, what the limitations are to our point of view and so forth" (p. 361). Good writing requires good thinking and good thinking is achieved through good writing. (Paul et al.). If we want students who can think, we need to assign writing assignments regularly, and then we need to evaluate the assignments based on content and grammar, but also on areas where they could improve their thinking.

Summary

Perhaps you are asking yourself, "What's the point?" The point is that all of the research points to this one fact. Improved critical thinking skills lead to improved academic performance. Intentionally focusing on improving students' critical thinking skills in Interpretation is a great place to start. Recall that Interpretation is about developing and providing one's own conception of a particular topic/idea/issue in light of previous experiences. As agriculture teachers, let's keep providing those valuable experiences that our program is so good at providing. Let's also use these experiences along with teaching behaviors and teaching tools that promote critical thinking and our students will be more competent critical thinkers in Interpretation as a result.

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Using Analysis in the Classroom

By Chris Morgan and Jon Ramsey

Have you ever received or found an object that you did not recognize? Maybe it was something old, a relic of sorts, and you wanted to determine the origin or use of this object. As you begin to examine the object, you decide to use a large magnifying glass so you can get a closer look. You begin by searching for some identifying marks, maybe a maker's name to help you understand more about this object. You examine the base, looking intently for some sort of symbol that will provide you with some truth about this object.

What you were doing to this mysterious object was analyzing it. You were examining it for clues that lead to the truth. You may have had some idea of what it could possibly be, but you needed to confirm or disaffirm your ideas. Critical thinking skills and subskills, such as analysis, provided a way for you to evaluate the object.

When we begin to think of analysis in terms of critical thinking there are many similarities to the analysis of the old relic. Critical thinking focuses on the evaluation of ideas and arguments. In the example above, we examined the object to determine its origin or use. In critical thinking we analyze arguments and examine ideas to determine their validity; that is, we attempt to determine if they are factual. By doing this we begin to understand what parts of an idea or argument are true, partially true, or false. Experts define analysis as "To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions or other forms of representation intended to express beliefs, judgments, experiences, reasons, information, or opinions" (Facione, 1990).

Analysis is part of Blooms taxonomy as well. Bloom listed the cognitive skill of analysis as the fourth level of thinking (Bloom & Krathwohl, 1956). Authors have described cognitive analysis as "seeing patterns," "organization of parts," "recognition of hidden meanings," and "identification of components" (Learning Skills Program, 2005).

The sub-skills of analysis are made up of two parts: Examining ideas and detecting arguments (Facione, 1990). It's as if someone proposes an idea and, before we accept it as truth, we critique and ponder the idea, determining how it measures up to what we already know and the theories we hold. Analysis has been described as "conscious evaluation" and being able to break down arguments into parts and determine the relationship between the parts (Harris, 2001). When practicing analysis, a person is more likely to connect observations with their theoretical knowledge base (Facione, Giancarlo, Facione, & Gainen, 1995).

How can we teach students to analyze and use analysis properly? Prompting students to ask questions about ideas and arguments is a good place to start. Some sample questions to use are: How is this known? What does it mean? Are reasons given? What is implied? Is this a balanced presentation? Is something missing? Are there underlying motives? Is there bias? Are there inferences we can make? How does this measure up to other things I know about this subject? (Fowler, 2004; Harris, 2001). By encouraging students to ask these types of questions we are teaching them to go beyond face value when examining ideas. They learn to probe and seek out facts upon which the idea is founded.

The Department of Agricultural Education, Communications & 4-H Youth Development at Oklahoma State University is working hard to develop critical thinking skills in future generations of agricultural education instructors. AGED 4113, Laboratory Instruction in Agricultural Education, focuses on laboratory safety instruction, methods of teaching, and application of technical agriculture skills to the secondary program. This course is delivered at the beginning of the student teaching block, at a time when the students' may or may not see the value of the information presented to them.

Critical thinking skills like analysis help students identify where this information "fits" and allows them to relate new information to something they already know (Rudd, 2005). In AGED 4113 students begin the student teaching block with a variety of preexisting experiences and expectations. Throughout the course, topics are presented that either reinforce those experiences or create some cognitive dissonance that requires students to sort and identify for future reference.

The interpretation of the teaching block experience is facilitated in the form of a concept matrix. Students record their experiences provided in AGED 4113 in a concept matrix, which allows them to reflect on the topic as it relates to application in an agricultural education program. The final interpretation culminates in a 3-5 page paper

that allows the student teachers to interpret and analyze what they have learned, discover why the information is important and relate the experience to an agricultural education program.

Students use the skill of analysis to examine their pre-existing ideas about pedagogy, classroom discipline, lesson planning, etc. and compare these ideas to the their teaching block experiences. Through this process many students who began the teaching block not seeing the need for this intensive "pre-student teaching" experience begin to understand how this experience has improved their teaching skills and has better prepared them for their student teaching experience.

Teacher educators have long been familiar with Blooms taxonomy and the importance of moving students closer to higher order thinking. Agricultural education teacher preparation provides a rich contextual opportunity for students to understand the technical concepts inherent in agriculture through the development of critical thinking skills.

Students of all ages, whether in high school, college, or adult learners, can benefit from practicing the skill of analysis. Encouraging students to ask questions such as "what's the point?", "what are the assumptions?" and "what evidence or information supports the position?" helps them to understand the relevance or irrelevance of information. This questioning also helps students to detect fallacies, not only in the information and arguments presented to them, but also of their own ideas and arguments. The conceptual matrix presented here is one method that allows students to examine ideas, and analyze arguments so they can better understand how this information "fits" together and how this information is relevant to them. Creating experiences

How can we teach students to analyze and use analysis properly?

which allow students to compare preconceived ideas with factual information helps them to take ownership of and better understand why they believe what they believe.

Regardless of the age, we want students to be critical thinkers. It seems that many times our students are receivers of information without properly interpreting and analyzing what is presented. We ask them to receive, memorize, and then recite information, but what we really want is for students to be thinkers. They need to know how to process information so they can make intelligent decisions and be successful in life. To do this they need to think critically. The skill of analysis will help students analyze arguments and examine ideas, bringing students one-step closer to becoming a critical thinker.

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Four Steps to Teaching Evaluation Skills

By Lori Moore

Almost every agriculture teacher, at some time during their career, has been asked the question, "What do you teach?" Many of us reply with the title of the courses we teach or focus on the subject matter. Yet, what we know to be true but sometimes have trouble communicating to those outside agricultural education is that, through the content in each of our classes, we teach transferable skills that help students become better problem-solvers and better thinkers. One such transferable skill is the critical thinking skill of evaluation.

Evaluation is one of those terms that everyone knows what it means yet has trouble defining the concept. A group of critical thinking experts have described evaluation as the ability "to assess the credibility of statements or other representations which are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions or other forms of representation" (Facione, 1990). These same experts included assessing claims and assessing arguments as sub-skills of evaluation. But what exactly does all of this mean and, perhaps more importantly, how can we teach students the skill of evaluation?

When I started thinking about teaching evaluation as a critical thinking skill, the first thing that came to mind was ways we teach students to assess the value of information and the credibility of sources. Anecdotal evidence suggests that students today believe the internet has replaced the library. One teacher I know stated, "Students think that if it is on the internet, it is as good as if it were in the bible." So I started thinking about ways to teach students the skill of evaluation using the internet. I thought about teaching a lesson on genetically modified foods and how teachers might incorporate activities designed to teach students how evaluate internet sites by comparing and contrasting information.

Through such a lesson, it would be possible to teach students how to assess the credibility of various sites and claims related to the production and consumption of genetically modified foods. This type of lesson could be very effective at teaching evaluation. But, after more thought, I realized that some of the most popular activities within agricultural education and the FFA are also some of the best activities for helping students develop evaluation skills. Whether we realized it or not, agriculture teachers have long been teaching students evaluation skills when preparing students to compete in many of the evaluation-based Career Development Events (CDEs), such as the livestock evaluation CDE.

When trying to develop students' evaluation skills, it does not really matter if you are trying to teach critical thinking in an on-line world or how to place a class of market swine. What matters is the development of the thinking process required for students to make reasoned judgments and support them. No matter the content used and the context in which it is taught, I believe there are four steps involved in teaching the skill of evaluation.

Step 1: Provide Foundation Knowledge

Before students can evaluate something, they must first speak the language. As teachers, it is our job to help students acquire the necessary foundation knowledge. In the case of evaluating livestock, students must first learn such things as the parts of each species, general terms appropriate for describing animals, specific terms appropriate for describing market animals, specific terms appropriate for describing breeding animals, and the performance measures used in the evaluation of livestock. For example, students should learn that finish is the appropriate term for describing the fat cover of market animals while condition is the appropriate term for describing the fat cover of breeding animals. Learning the foundation knowledge is an important first step in developing evaluation skills.

Step 2: Provide Evaluation Criteria

After learning to speak the language, students must know the criteria that will be used in the evaluation. In other words, they have to know what to look for. In the case of livestock evaluation, the criteria for evaluating market animals is different that the criteria for evaluating breeding animals. According to Gillespie (2004), there are nine factors students should look at

How can we teach students the skill of evaluation?

when judging classes of market animals (type; muscling; finish; carcass merit; yield; quality; balance; style; and smoothness) and five factors when judging breeding animals (condition; size; feet, legs, and bone; breed character; and sex character). Students should learn what each factor means when learning the foundation knowledge in Step 1, but should learn what to look for with respect to each factor during this second step. For example, in Step 1, students should learn that muscling refers to the natural fleshing of the animal and in Step 2 that the width of the round, depth of the round, and width between the legs are things to look for when assessing the muscling of animals when looking at them from the rear (Gillespie, 2004). Students need to learn what to look for when evaluating a class of feeder cattle as opposed to a class of slaughter cattle. They need to learn how to look at a class of eight keep/cull ewes and narrow it down to the four most desirable animals. In essence, teachers need to help students identify what factors to look for when evaluating each type of class they will find in the livestock CDE. By doing this, students know the criteria they will be using when conducting the actual evaluation.

Step 3: Apply the Criteria

Once they know the evaluation criteria, students are ready to learn how to conduct the evaluation. In the case of livestock evaluation, students need to learn how to critically evaluate a set of animals. Every teacher probably has their own specific method that they teach their students, but for the most part, students are taught to identify the strengths and weaknesses of each animal on an individual basis and then compare and contrast the differences between animals. Once these characterizations have been made, students are often taught to group the animals into an obvious top animal, an obvious bottom animal, and a middle pair of similar animals or into a two pair class with a top pair and a bottom pair. These techniques provide students with a framework for making judgments about the animals in each class and identifying the reasons behind those judgments. Essentially, students have conducted the evaluation by applying the criteria learned in Step 2.

Step 4: Communicate Findings of the Evaluation

After applying the criteria and conducting the evaluation, students need to communicate the findings of the evaluation. In livestock judging, students usually communicate their findings through oral reasons. By preparing their reasons, students must once again go through the thought process they used to make their placing. In delivering their reasons, students make claims about each animal and justify their placing. In essence, students are trying to demonstrate to others that they have the skills to conduct sound evaluations.

Conclusion

Education reform has called for the integration of critical thinking skills. In other words, schools should be teaching students how to think, not just what to think. Agriculture teachers have long been teaching the skill of evaluation. What we need to remember, and perhaps emphasize more, is that teaching livestock evaluation is just as much about teaching the skill of evaluation as it is about judging livestock.

Not all of our students will remain in the field of agriculture, but the chances of them one day buying a car or a house is pretty good. The evaluation skills they learned when judging livestock are transferable to these, and many other situations, but only if students recognize exactly what it is they learned. Students should know that judging livestock, or even assessing the credibility and accuracy of information on the internet in a lesson on genetically modified foods, is really an exercise in thinking. In terms of teaching the skill of evaluation, the final responsibility of the teacher is to emphasize the transferability of the skills learned in the process by which students arrived at their decisions.

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Inference: An Alternative to the *Guess-What's-On-My-Mind* Game

By Travis D. Park

As a newly minted teacher, son of an agriculture teacher, and former FFA officer, I was certainly ready for the challenges of teaching secondary agricultural science and business at Tri-County High School. Well, that was the first day. When day two arrived, the honeymoon was over and students ceased to be awed by my newness, personality, and FFA credentials. They wanted relevant, challenging, and interesting instruction in and about the agricultural sciences. So, we lectured, handed out worksheets, and played the *guess-what's-on-my-mind* game; all for little avail in helping students learn.

Somewhere in the first couple of years of teaching, I realized that students are capable of much more critical thinking than I had given them credit for. What's more, they actually *wanted* to think critically about agriculture, its issues and problems. My students were capable of finding evidence to support positions, examining alternative solutions, and arriving at feasible conclusions related to problems in agriculture. They were capable of drawing inferences about agricultural sciences, their SAE, and FFA chapter activities.

How do agricultural science teachers help their students think critically and inference? What kinds of evidence do we challenge students to gather and analyze? How do we lead them to create and consider alternative solutions to problems and issues? What help do we provide them in drawing conclusions and testing suitable hypotheses? These questions all relate to a fundamental aspect of critical thinking: *inference*.

Inference is where the proverbial rubber meets the road with critical thinking. During inference, we secure appropriate evidence for the problem, conjecture alternative hypotheses and solutions, and draw conclusions and opinions regarding the issue or problem (Facione, 1990). Often, especially in agriscience, we even apply those conclusions to real issues and problems in agriculture classrooms, SAE, and FFA experiences. How can we challenge our agriscience students to consider appropriate evidence, explore possible alternatives, and arrive at feasible conclusions?

Querying Evidence

Querying evidence involves judging what kinds and pieces of information are relevant to the problem at hand (Facione, 1990). Students consider evidence when answering many agriscience questions. Yet, querying evidence is perhaps one of the more difficult aspects of critical thinking for students. After all, in today's information age, many pieces of information exist which may or may not constitute credible evidence. Many pieces of information and data appear to be relevant to the problem, but not all are important. Determining what evidence is relevant and credible is key to critical thinking.

Agricultural education teachers use text approximately 20% of the time in their courses (Park & Osborne, 2006). As students read, they should attempt to construct meaning from the text, which means that they are querying evidence to support a position or gather information to propose a solution related to agriscience problems. Teachers may assist in this venture to query evidence from text through the use of *anticipation guides*. Anticipation guides are presented to students prior to reading and ask them to respond in some way (agree/disagree, true/false, yes/no, etc.) to statements related to the reading. After students have responded to the statements, they then read the passage to find evidence to support their response. In doing so, they are querying the evidence in the text. Sometimes they find that their initial response was incorrect based upon the evidence in the text. Thus, with new evidence, they may develop a new response or conclusion to a particular statement. They then cite this new response and the appropriate evidence from the text to support their conclusion. Right there, on their paper, students can see their learning.

Students may often query evidence when performing calculations within agriscience. For example, each spring in my horticulture class, we determined the selling price for our greenhouse products. What pieces of evidence are necessary to determine pricing? While this calculation may seem straightforward, I found that students struggled with the task, and perhaps rightly so. It is a rather complex task. Logically, one must determine the cost of production for each product, which involves geometric and arithmetic calculations. However, simply figuring the cost of production does not lead to a simple selling price. Other evidence and information are necessary, such as pricing for similar products in the local area, anticipated sales promotions, and loss of plants that remain unsold, among others. Challenging students to consider these other

pieces of evidence for determining selling price is crucial to the learning process. Teachers cannot forget these simple agricultural problems that provide a rich learning opportunity for students. While I could have easily calculated the pricing or referred to the previous year's sales information, doing so would have also circumvented a profitable learning opportunity for my horticulture students.

Students also query evidence when determining and selecting an appropriate SAE. What resources are available? What need can be filled by a young, energetic student with initiative? Teachers have a prime learning tool available for helping students query evidence in starting a SAE—the *American FFA Degree Star Battery*. Students, even those early in their SAE, can use the star battery to describe any special advantages or disadvantages—in other words, evidence—that they anticipate will have a major impact on their SAE. When considering the level of achievement related to their SAE, older students must also cite relevant evidence to support their achievement. Further, in calculating efficiencies later in the star battery, students find evidence that supports their increased efficiency in production and placement.

While some teachers may balk at completing pencil-and-paper FFA applications such as the National Chapter Award application, these also provide an opportunity for students to query evidence. (*Writing has a fine way of stimulating thinking!*) When completing the chapter award application, my FFA officers had to determine our three best activities/programs in member, chapter, and community development. Because the application calls for a statement of goals, planning, and evaluation of the activity, students must set goals and then find evidence that supports their conclusion that the activity is one of the chapter's best. In fact, the *National Chapter Awards Applications Tips* specifically encourages chapters to query the evidence for each activity by showing how the goals were achieved, illustrating the benefit of the activity, showing the number of members and others involved in the activity, and explaining what other organizations were involved (National FFA Organization, 2006). In essence, these measures are evidence of successful chapter activities. By considering the evidence of successful activities, chapter leaders are also conjecturing alternatives among the range of possible *best* events.

Conjecturing Alternatives

When students brainstorm multiple solutions to problems with their SAE, experimental classroom or laboratory project, or FFA chapter activities, they are, in essence, conjecturing alternatives. Conjecturing alternatives involves developing hypotheses, creating alternative plans for achieving goals, and/or projecting a range of possible consequences for decisions, actions, and beliefs (Facione, 1990). When we conjecture alternatives, we imagine the possibilities.

Embedded within the LifeKnowledge© lessons are e-moments, one of which is the *go-with-the-flow moment*. This flow chart activity is an effective means of engaging students in develop a sequence of events with possible consequences and outcomes. It can be used for many applications in our agriscience classrooms. When using a flow chart graphic organizer, students propose a sequence of events that should lead to possible outcomes, such as reversing global warming, finding a solution to engine trouble so that it starts and runs, and conducting an experiment that controls for extraneous factors and tells us which feed is the most efficient at promoting growth in mice.

Again, real problems in agriculture provide opportunities to teach students about conjecturing alternatives. For example, why are all of the marigolds in the greenhouse facing south? This question arose during my horticulture classes nearly every spring. Once students determined that the position of the sun in the spring sky was the culprit, then they could devise alternative hypotheses for combating the south-facing marigold problem. In this way, they proposed and tested their hypotheses for an authentic learning experience.

Students also conjecture alternatives within their SAE. For example, what is the difference if I rely upon mom or dad to provide resources for my SAE (i.e.: give me half of the florist business) or if I create my own SAE from my own resources outside of those which mom and dad can provide? What happens if I start a SAE and the market falls apart? What happens if my SAE is wildly successful? These questions about a student's SAE lead the student to develop alternative hypotheses and plans for achieving their SAE goals.

When FFA advisors give their FFA members more freedom in selecting, developing, and managing chapter activities, they often challenge those members to conjecture alternatives for chapter improvement. For example, each year as our officers and committees revised the chapter program of activities, the FFA members realized that they wanted to add more activities and propose more changes than our chapter calendar of events and budget would allow. Thus, in order for the chapter to add a new activity, the chapter and officers had to decide what activity to drop from the program

of activities. In working through this decision, leaders in the chapter had to develop plans for the new activity and project both the ramifications of dropping the existing activity and the opportunities for improvement derived from the new activity. Then, they made a decision about both events, in essence drawing conclusions and charting the chapter's course for the future.

Drawing Conclusions

Drawing conclusions asks that students develop conclusions that stand up to tests of logic and reason, and that they determine which conclusions are more strongly supported by the evidence so as to have a greater probability of success (Facione, 1990). These conclusions are the precursors to action in many instances. Querying the evidence, conjecturing alternatives, and then arriving at viable conclusions are the hallmarks of developing critical thinking and living a conscious life. Agricultural education provides a rich context for considering alternative conclusions to a variety of problems and issues.

When reading texts of various types in agriscience, teachers may scaffold learning about how to draw conclusions by using *discussion webs*. With a discussion web, the agriscience teacher selects a reading passage that elicits a relatively strong response from students, such as global warming, genetic engineering, or organic food production. Students read the passage. Collectively they determine the key question in the article. Then, in groups of three or four, they identify three to five reasons for answering "yes" (pro) to the question and a three to five reasons for answering "no" (con). Then, as a class, students discuss the passage using the evidence that they gleaned from reading. The learning event concludes as one or both of the following happen: 1) students individually take a conclusive stand on the issue, or 2) the teacher guides the students to develop a class conclusion to the issue or problem.

The very nature of SAE and maintaining appropriate records calls for students to develop logical conclusions to real applications of their agricultural science learning. An effective use of SAE would be for students to update their records regularly and write a year-end analysis of the progression toward accomplishing the goals of the SAE. Further, students should also anticipate changes in their SAE and extrapolate conclusions to different scenarios. For example, a student with a lawn care SAE may have developed a large clientele, so much so that s/he needs to either purchase larger, newer equipment or hire another employee. The student should gather financial and resource evidence, consider the alternatives, and then develop a conclusion that has the highest probability of success. If the student is nearing high school graduation, perhaps another viable conclusion could be selling the enterprise.

The FFA chapter and its activities provide another avenue for students to practice developing practical conclusions. The whole competitive nature of CDE may help students develop conclusions, especially when they do not win first place. For example, FFA advisors can ensure that all students read the feedback from judges. Upon reading the feedback, advisors can challenge students to also analyze their preparation for the CDE. Based upon these pieces of information, the advisor can work with students to develop conclusions about their practice, preparation, and performance in the CDE. Out of these conclusions, students should also develop improvement plans for reengaging in the CDE. These improvement plans represent a form of conclusion by themselves.

Conclusion

Similar to a newly minted agriculture teacher, we may occasionally conduct our classroom, SAE, and FFA programs based upon what *we know*, rather than what we want *students to learn*. By taking advantage of real problems in agriculture and implementing a few active learning strategies, teachers can assist students in developing the critical thinking skills, especially inference, that will help ensure lifelong learning. It will also help teachers avoid playing the *guess-what's-on-my-mind* game. Students are capable of and want to query evidence, analyze alternatives, and draw conclusions about real agricultural, personal, and leadership problems.

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Teaching the Critical Thinking Skill of Explanation

By Tracy Irani

As children, we've all had the experience of being asked to explain ourselves. "Tell me why you hit your brother!" "Explain Newton's third law of motion." "Tell me how you did this."

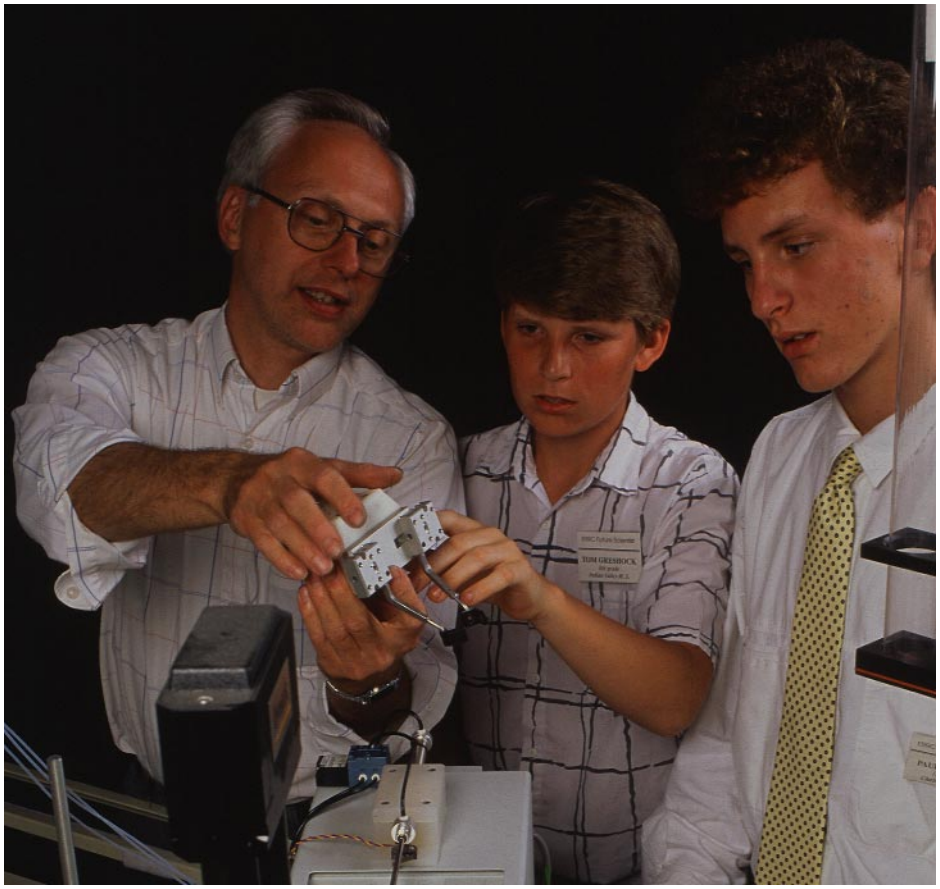
But, although explanation is a skill that may be fairly easy to observe, it is also one of the most difficult to measure. In the classroom, in particular, we see examples of the skill of explanation every day. As instructors, we first seek to explain concepts in our discipline to our students. We then ask them to explain how and why they arrived at a particular answer, based on the questions we have posed to them. But measuring the quality or level of explanation itself is not easy. Explanatory power or skill can be affected by a variety of influences, including knowledge, efficacy, expressiveness, personality, etc. These influences can make it harder for a teacher to evaluate a student's level of explanation objectively, and even more of a challenge to try to build students' skills in explanation.

Explanation is a term that is used in a variety of ways in everyday speech, both in and outside the classroom. We *explain* how to make or do something, how we solved a problem or arrived at an answer, and/or what were the results of a test or process (Mayes, 2006). Explanation goes beyond mere description; the key aspect is an emphasis on *why* things happen. In fact, it is common to think of explanation as an attempt to identify the cause of something. According to Hempel, explanation is "an argument that the phenomena to be explained…..was to be expected"; Salmon argued that adequate explanation for a phenomenon or event can't be achieved unless the cause has been determined, while Achinstein felt that explanation was connected to the "pursuit of understanding" (Mayes, 2006, para 9).

Explanation and Critical Thinking

Looking at explanation from the standpoint of critical thinking may provide a way to separate the skill from what surrounds it. From a teaching and learning perspective, explanation holds a special place as one of six core critical thinking skills, as defined by the Delphi study on critical thinking (Facione, 1990). According to Facione, "good critical thinkers can explain what they think and how they arrived at that judgment" (Facione, 1998, p. 5). The Delphi study expert panel defined explanation as being able "to state the results of one's reasoning; to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments" (Facione, 1998, p. 6).

In addition to the skill, the Delphi experts identified a set of three subskills underlying explanation. These include stating results, as in stating one's research findings or writing down one's current thinking about a complex matter; justifying procedures,



There is a strong link between critical thinking and reading comprehension.

which could entail presenting all considerations used in forming an opinion about something; and presenting arguments, as in writing an advocacy paper arguing for a particular position or policy based on evidence and inference.

Using Explanation in the Classroom

Critical thinking, and especially the core skill of explanation, is directly related to communication and expression. After all, the way you express your thoughts is through communication. This process has been formalized in the rhetorical tradition of the academic debating team, with its focus on argumentation, evidentiary logic and reasoning capability. Facione himself argues that there is a strong link between critical thinking and reading comprehension. It's no surprise therefore, that teaching students how to enhance the skill of explanation should involve communication processes. A holistic approach to critical thinking (Heaslip, 2005) should involve the concepts of critical listening, thinking, writing, reading and speaking.

For the *Critical Thinking in the Sciences* project, a USDA funded grant project focusing on teaching for critical thinking in the specific context of biotechnology, the instructional model identified classroom presentations and debates as specific curriculum components that could be utilized to stimulate explanation. The focus of this project was on the restructuring of a college level course in biotechnology to show how to teach for critical thinking in a science context. One of the major assignments of the restructured course involved having students create a new biotechnology derived plant based food product, to research its potential attributes, and then to design and present a business case for the product, including a self designed label. This assignment is a good example of how the subskills components of explanation can be factored into student learning. Students presented the results of their research as to what would make a viable new plant biotech product, justifying its development through presenting attributes in terms of the benefits it would convey, and through the self-designed label, were able to give reasons for their claims and potentially refute any objections through labeling disclaimers.

Teaching to Improve Your Students' Skill in Explanation

Explanation is an important skill for everyone, no matter what field students decide to pursue. Becoming good at explanation requires practice, as do all skills. But, given our human need to communicate, express ourselves and above all argue for our point of view, our students are probably more predisposed to engage in this critical thinking skill than almost any other. The classroom provides many great opportunities to engage students in presentation, debate, contests, representations and depictions of phenomena and events under study. These activities are all associated with good teaching pedagogy, and students usually feel they learn from the hands-on practice explanation oriented assignments provide. Explanation may be a critical thinking skill that's hard to measure empirically, but it can be a skill that's a great joy to teach, and employ in the classroom. Think about the many ways you can use explanation to help students learn and to think critically about what they are taught in your classroom.

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Helping Students Regulate Through Reflection

By Nicole Stedman

Insanity: doing the same thing over and over again and expecting different results.

~Albert Einstein

So, what does this quote have to do with Critical Thinking? It illustrates the rationale of instructing students in the critical thinking skill of self-regulation. So many times, we want something to change, but lack the necessary know-how to make it so.

As teachers, this often materializes in students wanting better grades and performance, but not willing to put in the time or energy to successfully create the change. The frustration often occurs after repeatedly grading a paper with the same errors, regardless of the instruction provided. So, maybe the question becomes, how can we guide students through the skill of self-regulation, so they become better critical thinkers?

Self-regulation refers to one's ability to evaluate judgments with the intention of questioning, confirming, validating, or correcting the reasoning or results. In other words, it is how well we are capable of justifying or correcting our reasoning. Self-regulation does not function on its own; it is supported by two sub skills, self-examination and self-correction.

These two complementary sub skills require students to reflect upon their reasoning and then correct the reasoning based upon any deficiencies identified. As educators, we want our students to face new experiences with an open-mind and to be critical of their biases and view points. But, if the proper guidance is not provided to students during this time then outcomes may fall short.

When discussing the use of reflection as a teaching methodology, students are usually told to *reflect*, which could be interpreted as a number of behaviors. In most cases, the outcome desired is the recording of one's personal thoughts and opinions about a topic or an experience. This affective dimension of reflection is one piece.

Reflection, defined as, "consideration of some subject matter, idea, or purpose" is an obscure process that we believe students should be able to do. However, much like critical thinking, if we have never been taught this skill then the reflections may be shallow and one-dimensional. One goal of critical thinking is proficiency in self-regulation and so is reflection.

In order to encourage students to think deeper about a topic or subject matter an outline for how to reflect and what to reflect upon is helpful. One way to do this is to support students in the three domains of learning, Cognitive, Affective and Psychomotor. These are also commonly referred to as, knowledge, attitude and skills. The cognitive domain focuses on the development of intellection. With that, there are six categories, these we are familiar with as Bloom's Taxonomy (Bloom, 1956), and are knowledge, comprehension, application, analysis, synthesis, and evaluation. The second domain addresses the emotional development of students and can be categorized into five parts.

The affective domain has five categories developed in 1973, by Krathwohl, Bloom and Bertram and were meant to focus on how students begin to internalize experiences. The

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most simplistic form is to receive phenomena, then to respond to phenomena, on to valuing, organizing, and then the internalization of values. The intent of this domain of learning is students begin to recognize any feelings or attitudes they may have about the experience. In this case, as we discussed with self-examination, biases may be uncovered and addressed.

The third domain, psychomotor, emphasizes the physical or behavioral and motor-skill area. Simpson (1972) identified seven categories of psychomotor development. These ranged from perception, set, guided response, mechanism, complex overt response, adaptation, to origination. The intent, as with the other two domain categories, is that the student moves from a very basic level of performance, or understanding, into a higher level or more complex level of performance or understanding over time.

Utilizing these three domains ensures regardless of the impact the experience has made on the student, they will have had to think through the experience. For example, in a class of 30 students, it may be difficult to determine the effect of the experience on a student; did they gain more knowledge?, were their emotions or attitudes impacted?, or, did they learn a new skill or behavior? The reflections document what they student felt he/she got from the experience and provides a basis for further development.

Providing students with instruction on reflection provides them with a sense completion. In experiential learning, reflection-in-action (Cervero, 1988), refers to the students ability to allow thinking to reshape their actions, or what they are doing. In Self-Regulation, this is a perfect example of how reflection can assist students in examination of their current thoughts or behaviors.

The difficult part of this strategy in teaching is developing experiences that encourage students to think critically and to support thoughtful reflection of those experiences. Educational objectives can provide a starting point for creating critical thinking outcomes of students. It is important to establish critical thinking as a measurable outcome of the educational experience, because students will have a better idea of the challenge in assignments.

The challenge of the assignments often is not the reflection and examination, but the correction. Self-correction is a skill students need assistance developing. With that, if students are left with the reflection, but without the opportunity to correct the behavior or reasoning then the process is incomplete. Experiential learning complements the development of self-correction because it allows students to actively experiment (Kolb, 1984) with behaviors, or in the case of critical thinking, thoughts, judgments and reasoning.

Learning to Reflect

In a leadership education program, students were exposed to a number of experiences to develop their understanding of leadership. In one experience, students were invited to dine with an international community. Below are the examples of the questions the teachers asked to encourage thoughtful reflection. Each set focuses on the three domains of learning:

Affective - In your conversations with others at the potluck dinner, how did your perceptions of diverse cultures change throughout the evening?
Psychomotor - What behavioral norms (perhaps mannerisms), including your own, did you observe across the cultures during this event?
Cognitive - Contrast similarities and differences between yourself and other students present at this event. How does this new knowledge fit with your current knowledge? What has changed?

Being provided guiding questions takes the guess work out of reflection. It offers focus allowing the teacher to be purposive in directing outcomes of a learning experience. The goal of this experience was to expose students to an international community to develop their understanding of cultural diversity and to break down any barriers that may have existed.

Self-Correcting as a Goal

Again, students in the leadership education program were presented with a task of defining leadership. Definitions were pictorially presented and shared with the class. As one may predict, students did not have many experiences, in which to base their definition. After being presented with a number of lessons, discussions and the opportunity for reflection, students were asked to revisit the pictorials.

During this time, definitions of leadership became more complex and included many more descriptions than the original pictorials. Students were then provided the opportunity to tear-up the original pictorials, representing their moving beyond their first thoughts and definitions of leadership.

Although, this was not a complex task to carry out, students were surprised at their new vision of leadership.

Once students have completed the reflection process, it is important to have them document their points of perceived deficiency. During this step, the student may define the goals of self-correction. The self-correction process should provide ample opportunity for students to discuss and share their reflections and receive feedback. At this time, students can verbalize the corrected reasoning or practice the new behavior.

Reflection can be a wonderful teaching tool to develop the skill of self-regulation. As discussed in this article, it is not an easy task and ample consideration should be made in guiding students through the process of developing their sub skills of self-examination and self-correction. However, self-regulation does not operate in a vacuum and the other skills of critical thinking should be equally developed by students in order to produce true critical thinkers.

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Bring *It* to Class

By Julia Rotman-Smith & Donna Moore

Students won't find *it* in a textbook, they can't ask a friend what *it* is, and the teacher will not give *it* to them. *It* is the proper response to a question that requires critical thinking - the "right answer". Why do so many students struggle when they are asked to provide their own reflective response to an open ended question? Why is it so difficult for teachers to encourage students to *think* and formulate their own ideas about a topic? How do teachers create less passive learners and instead, guide students to develop abilities in which they actively engage in critical thinking practices in the classroom.

There may be several factors that contribute to a student's inability to interpret and analyze material, think critically, and respond to reflective questions. These factors may range from family issues to "lethargic indifference" or simply a lack of previous instruction. As teachers we cannot create the perfect thinker. However, teaching the skills of critical thinking can be incredibly empowering for both the teacher and students if both are able to overcome the perceived barriers. Once a teacher understands the concepts and process of critical thinking, it is important to create an intellectually safe environment for students in which they can express their thoughts and thought processes without fear of ridicule. Integrating the skill of critical thinking into the curriculum may seem like a daunting task, but taking on the challenge in small steps and accepting that there will be bumps in the road when a lesson doesn't quite go as planned will make the process a little easier to tackle.

A Naked Brain

Developing of intellectual safety for students evolves over time. For example, Julia's classes are in three-hour blocks so she likes to have a break in the middle of the session where she often brings in snacks to share. An interesting "phenomenon" occurs every year when new students join her class; most of them will not eat the snack even if it is a *good* snack like cookies or chips. As the year progresses, the students evolve from self-conscious eaters to a "swarm of locusts", cleaning her out of every type of food in the classroom. Why the change? It is a matter of their perceptions of safety in the learning environment. Students don't want to be the first ones to take the snack for fear of standing out. What if they take a snack and no one else does? How will their peers perceive them? If students are nervous about eating a simple snack in front of others, then how do we expect them to voice their personal reflections about their own thought processes unless we create an intellectually safe classroom environment?

Asking students to think about and respond to an assignment using critical thinking can be a very intimidating experience for the students and a challenging process for the teacher. How might a teacher be able to reduce the level of intimidation that her students experience as they attempt to provide responses to questions that require some degree of critical thinking? Developing an intellectually safe classroom environment can contribute as much to a student's willingness to engage in critical thinking as their understanding of the actual process itself. As teachers in agricultural education, we take classroom safety very seriously when it comes to our laboratory layout, tool maintenance, and safety instruction, but how often do we think about the intellectual safety that we provide for our students?

While teachers may not specifically think about the intellectual safety of their students, typical planning practices and pedagogy generally provides an environment that encourages student participation. What then is intellectual safety? It is an environment in which the teacher is, "open and caring, demonstrates respect, and embraces the uniqueness of students and their perspectives" (Schrader, 2004, p. 98) in a classroom where all students are encouraged to participate in discussions and activities under the teachers direction and guidance. Since critical thinking encourages students to share how or what they think, intellectual safety is necessary to ensure students feel there is little risk of negative comments from their peers and they are contributing to the educational experiences in their classroom (Schrader, 2004).

Critical Thinking in Practice

A stack of books and articles about critical thinking, a safe classroom environment, and good intentions; the only piece missing – integration. Taking time to realign and integrate a new teaching habit into the curriculum to develop critical thinking abilities in students, while sustaining an agriculture teaching day that already includes multiple class preparations, projects, and the latest FFA chapter activity may be overwhelming. Some suggestions to transition from the ideas on paper to the living and breathing classroom in-

clude:

♦ Be realistic. Learning and teaching critical thinking is a considerable charge that must develop into a habit over time. Are students going to be complete critical thinkers in 12 weeks? Probably not. However, they will hopefully begin to gain an understanding of the processes of critical thinking and become more active (versus passive) thinkers.

♦ Start small. Select one course in which the concepts of critical thinking are compatible with the curriculum and the students, perhaps an agricultural leadership class. Choose an area such as one specific element or concept of critical thinking and focus on teaching that versus teaching the entire process at once.

♦ Chat with colleagues. More than likely other teachers are teaching pieces of critical thinking in their curriculum, (hint: they may not refer to it as "critical thinking"). English teachers often cover clarity, accuracy, precision, completeness, and relevance fairly well. While not all agricultural students may be taking the same classes or be in the same grade, understanding what is already being taught throughout the school may help narrow down an otherwise enormous area to cover.

♦ Choose a topic taught frequently. Critical thinking is a habit that must be reiterated over time. Recreating lots of different lessons is not always realistic for teachers under a constant time crunch, instead select several easily adapted lessons that assist students in analyzing and assessing their own thinking; something that is not taught during one stand alone lesson.

One example of a lesson that may be taught frequently is a review and synopsis of a current agriculture magazine article in which the students are instructed to respond to guiding questions that integrate critical thinking concepts. Choose an article that presents an issue (hint: initially pick one that students probably know something about and have an opinion such as animal rights). Before reading the article, have students respond to questions that bring out their preconceived perceptions about the topic such as: what are your thoughts on this topic, and what connections do you have to this topic? Students might find the use of a graphic organizer (discussion web) a helpful way in which they can connect their prior experience or knowledge to the topic. After the students complete the article have them factually summarize it.

Many students will add their own opinions to a *factual* article summary. This is an opportunity for teachers to point out that people often perceive their own opinions as fact. At the conclusion of the assignment, have students evaluate whether or not their initial assumptions impacted their reading and if the facts in the article changed their initial assumptions. Ask student to provide evidence for their answers. A yes or no answer is not sufficient. Rephrased or guiding questions may be needed as a follow up to the assignment

Other additional activities for more advanced thinkers could include creating a "T" chart of the pros and cons stated in the article. Or have students reflect on questions and statements such as: Is this article taking a side? What evidence in the article defends this answer? Who are the "players" and/or "stakeholders" in the article? Is the article written from the perspective of one of these stakeholders? What is the evidence of this perception? What are some perspectives that are not addressed? Identify the information in the article that is reliable and that which is unreliable. What connections can be made to other articles or information discussed in class? Students should be encouraged to clearly discuss their responses to the questions, perhaps first in small groups as a means of providing a safe classroom environment.

Why is it so difficult for teachers to encourage students to think *and formulate their own ideas about a topic?*

A small group activity that incorporates critical thinking could be created based on a series of articles regarding a particular issue. Each student within a group would be expected to address the issue presented in the articles with the aforementioned questions. Students would prepare a round table discussion in which they must develop a thesis statement regarding the issue and lead a portion of the discussion (a teacher may assign a side, or have the students dispute it neutrally). During the roundtable discussion each student would ask questions of a peer committee and be asked questions as well. It can be incredibly beneficial to have students argue the side that they are initially against.

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