Student Conceptions of the Nature of Science
Implications for Agricultural Education

Hannah Scherer, Agricultural and Extension Education
Courtney Vengrin, Agricultural and Extension Education
Aaron Bond, Institute for Distance and Distributed Learning

This work was funded by an IDDL Distance Learning Research Fellowship
Science is an exciting, complex, and human endeavor.

Key points of this talk

- The *nature of science* is relevant to agriscience and teacher preparation courses
- Direct instruction paired with experience and reflection can improve student understanding of the nature of science
- Agriscience instructors should address the nature of science along with content in their courses
Ideas about the nature of science are *always* conveyed in science teaching (McComas et al., 1998)

Scientific Method (1 serving)

1. Ask a question.
2. Formulate a hypothesis.
3. Perform experiment.
4. Collect data.
5. Draw conclusions.

Bake until thoroughly cooked.
Garnish with additional observations.

Image credit: http://undsci.berkeley.edu/article/0_0_0/howscienceworks_01
Science is a way of knowing

- distinction between observation and inference
- meaning and role of scientific theories and laws
- role of imagination and creativity in generating scientific knowledge
- observations are guided by theoretical perspectives
- scientific knowledge is socially and culturally embedded
- there is not one "scientific method" that will lead to absolute knowledge
- scientific knowledge is tentative yet durable

(Lederman, 2007)
Instructional context lends itself to a diverse group of graduate students.

- Ag teachers
- 4-H Agents
- On campus
- Online
- Off campus
- Thesis MS/PhD
- Non-thesis MS

STEM Integration in Agricultural Education
Research-based design strategies were used in course planning

- Direct instruction (McComas et al., 1998)
  - Readings
  - Application assignments

- Engage in scientific inquiry (Schwartz et al., 2004)
  - Agriscience project

- Reflection (Abd-El-Khalick, 2001)
  - Discussion forum
  - Reflection assignments
Student ideas about the nature of science were investigated

- Pre- and post- test based on Views of the Nature of Science, Form C (Abd-El-Khalick, 2001)
- Intrinsic case study (Berg, 1998)
- Qualitative analysis of open-ended responses

- Open coding
- Codes grouped into families
- Codes classified as naïve, intermediate, or informed
Student ideas about the nature of science were investigated

- distinction between observation and inference
- meaning and role of scientific theories and laws
- role of imagination and creativity in generating scientific knowledge
- observations are guided by theoretical perspectives
- scientific knowledge is socially and culturally embedded
- there is not one "scientific method" that will lead to absolute knowledge
- scientific knowledge is tentative yet durable
Student ideas about the nature of science were investigated

- distinction between observation and inference
- meaning and role of scientific theories and laws
- role of imagination and creativity in generating scientific knowledge
- observations are guided by theoretical perspectives
- scientific knowledge is socially and culturally embedded
- there is not one "scientific method" that will lead to absolute knowledge
- scientific knowledge is tentative yet durable
Aspects of nature of science received different attention

- **Methods of scientific inquiry**
  - Reading assignment
  - Reflection in discussion forum
  - Application assignment – observation

- **Creativity and imagination**
  - Personal reflection following individual agriscience research project
More informed views about the methods of scientific inquiry

**Does the generation of scientific knowledge require experiments?**

<table>
<thead>
<tr>
<th>Student</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C</td>
<td>Naïve</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student E</td>
<td>Naïve</td>
<td>Intermediate</td>
<td>More informed</td>
</tr>
<tr>
<td>Student F</td>
<td>Naïve</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student G</td>
<td>Naïve</td>
<td>Naïve</td>
<td>No change</td>
</tr>
<tr>
<td>Student H</td>
<td>Naïve</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student J</td>
<td>Naïve</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student K</td>
<td>Naïve</td>
<td>Naïve</td>
<td>No change</td>
</tr>
<tr>
<td>Student L</td>
<td>Naïve</td>
<td>Intermediate</td>
<td>More informed</td>
</tr>
<tr>
<td>Student M</td>
<td>Intermediate</td>
<td>Informed</td>
<td>More informed</td>
</tr>
</tbody>
</table>
More informed views about the methods of scientific inquiry

Student H: naïve to informed

To develop scientific knowledge one would need to conduct experiments. (Pretest, 2:53)

Experiments are not always required to develop scientific knowledge. There are some opportunities which can allow observations to be used…(Posttest, 3:35)
Student L: naïve to intermediate

I think that the development of scientific knowledge requires experiments or else the information would be a theory (an un-verified, non-repeatable answer to a question). (Pretest, 2:50)

Science in general should consist of information that is obtained in a repeatable/reliable way. That is what makes it scientific and not just a hunch. We would not want to hear that the best way to plant a crop is to hand plant each seed individually 6 inches apart without first testing out other methods of planting or other distances of planting to determine the best growth and harvest. (Posttest, 3:30)
Increased appreciation for the role of creativity and imagination in science

Do scientists use creativity and imagination?

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C</td>
<td>Intermediate</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student E</td>
<td>Naïve</td>
<td>Intermediate</td>
<td>More informed</td>
</tr>
<tr>
<td>Student F</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>No change</td>
</tr>
<tr>
<td>Student G</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Slightly more informed</td>
</tr>
<tr>
<td>Student H</td>
<td>Naïve</td>
<td>Intermediate</td>
<td>More informed</td>
</tr>
<tr>
<td>Student J</td>
<td>Intermediate</td>
<td>Informed</td>
<td>More informed</td>
</tr>
<tr>
<td>Student K</td>
<td>Intermediate</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Student L</td>
<td>Naïve</td>
<td>Intermediate</td>
<td>More informed</td>
</tr>
<tr>
<td>Student M</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>No change</td>
</tr>
</tbody>
</table>
Increased appreciation for the role of creativity and imagination in science

Student H: naïve to intermediate

I feel experiments are more based on black and white factual knowledge so there is little room for creativity (Pretest, 2:147)

The study of science is a creative effort and various scientists are likely not to think the same about certain hypothesis. This just shows how using the same data, scientists can reach totally different conclusions (Posttest, 3:79)

I think the imagination and creativity is used during the planning and design (Posttest, 3:96)
Increased appreciation for the role of creativity and imagination in science

Student C: Intermediate to Informed

The *planning and design stages* use the most imagination and creativity. (Pretest, 2:137)

Science can be interpreted in many different ways and it is up to the person to use the evidence that they have to interpret what is taking place and happening. (Posttest, 3:76)

They use creativity and imagination in coming up with the experiment and how to test for what they are trying to find. *They then use creativity to expand on the data they collect.* (Posttest, 3:93)
Students views of the nature of science changed

- Most students involved in the study started out with a naïve view of some aspects
- All students involved in the study developed a more informed view of some aspects
- Aspects that were explicitly addressed showed greater change than those that were not
- Varied change in other aspects
Recommendations for practice

What do we know and how do we know it? (Matthews, 1994)

- Agriscience instructors at all levels should consider how they are presenting the field.
- Teacher educators should address the nature of science explicitly in methods courses.