Guest
Editorial

Inquiry, Process Skills, and Thinking in Science

By Mike Padilla

Inquiry is central to science education today. But understanding its many nuances is still an issue according to research (Flick and Lederman 2004). And understanding is the first step to implementation. Here are some of the questions teachers ask frequently:

- What is inquiry?
- Does it differ from process skills, and if so, how?
- How do I know whether my students are inquiring?
- Is inquiry something students learn, is it a way for teachers to teach, or is it both?
- Do students have to be involved in hands-on activity to do inquiry or are there ways to involve students in inquiry while using textbooks and print materials?

These are significant questions—ones that every teacher ought to be asking. So let's take them one at a time.

Inquiry and Process Skills

The National Science Education Standards define inquiry as "the diverse ways in which scientists study the natural world and propose explanations based upon evidence…" (NRC 1996, p. 23). Notice the word *evidence*. This is the most crucial part of defining inquiry. Inquiry is about logic, it's about reasoning from data, and it's about applying scientific techniques and skills to real-world problems. I will say more about this later, but for now you can think of inquiry as the ways scientists think about and try to solve problems using logic.

Beginning in the 1960s, there was an attempt to break inquiry down into a set of discrete skills called *process skills*. Scientists observed, described, inferred, measured, and predicted. They identified variables, controlled variables, designed experiments, and hypothesized. The notion was that students could practice individual skills, and as they mastered these, they would begin to put them together to solve problems. Educators even designed a full elementary school curriculum that focused on just teaching process skills called Science—A Process Approach (see Internet Resource).

Essential Features

The process skills approach continued to be popular through the late 1980s, but it was often criticized for being atomistic and piecemeal. Although students could perform the individual skills, they could not solve problems, and they were not able to think like scientists. This led to the more holistic "inquiry approach" popularized by the National Science Education Standards. Inquiry is a central—some would argue the central—concept of the Standards. Realizing that more definition needed to be brought to the concept of inquiry, The National Research Council (2000) identified several "essential features" that describe what the learner does in inquiry. Instead of a series of skills, the features portray important broad components of inquiry, and these have become the most widely accepted conception of the process in which the learner:

- Engages with a scientific question,
- Participates in design of procedures,
- Gives priority to evidence,
- Formulates explanations,
- Connects explanations to scientific knowledge, and
- Communicates and justifies explanations.

Notice that all of these essential features might be part of a science investigation. I personally like this definition because it allows students to focus on learning discrete parts of the process like reasoning from evidence, for example, but still keep the purpose of inquiry—problem solving—in mind.

Are Students Inquiring?

This is the million-dollar question. One way to think about it is to ask who is doing the work. If it is the teacher, then students are only observers to the process. If the students are the ones thinking, however, then it is likely inquiry is happening. Try using the following questions when your students are doing science as a guide for judging the quality of their inquiry.

Who asks the question? That is, who asks the question that focuses the investigation (e.g., "How does soil type affect erosion rate?" or "What effect does exercise have on heart rate?" or "What variables affect flower freshness?")? Is it the student, the teacher, or the textbook? At least some of the time investigations should be driven by student questions.

Who designs the procedures? I'm speaking of procedures in an investigation, but sometimes students need to determine how observations or measurements are made. In order to gain experience with the logic underlying science, students need continuous practice with designing ways to gather information.

Who decides what data to collect? This is similar to designing procedures, but the focus is on the data itself. What data is important? Who determines that?

Who formulates explanations based on the data? Does the teacher or the text materials give the answers? Or, do questions posed during activities make students analyze and draw conclusions based on their data? The bottom line—do the questions make students think about the data they collect?

Who communicates and justifies the results? Do activities push students not only to communicate but also to justify their answers? Are activities thoughtfully designed and interesting so that students want to share their results and argue about conclusions?

Goal and Method

Inquiry is both something students learn and a method for teaching science. So far, we have considered only what students learn. But great science teachers use inquiry methods to teach. The inquiry teacher poses questions, stimulates discussion, and involves students with important scientific problems. Inquiry teachers use wait time, questions, silence, and other techniques to initiate and extend student thinking. Inquiry teaching is an approach that engages student curiosity and wonder, that inspires students to observe and reason, and that helps them to sharpen their critical-thinking and communication abilities. Without a skilled teacher guiding student learning, however, inquiry does not often take place.

Inquiry, Hands-on Learning, and Books

All this begs the last question—do students have to be involved in a hands-on investigation to inquire? Not really. The key, often forgotten, aspect of inquiry is that it is an intellectual endeavor. Too many students have a knack for being physically but not intellectually engaged in science. So hands-on science may help many students to inquire, but skillful use of print materials can accomplish the same goal. It is what the teacher and students do with the materials—books or lab equipment—that makes the difference.

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References

Flick, L.B., and N.G. Lederman. 2004. *Scientific inquiry and the nature of science: Implications for teaching, learning, and teacher education*. The Netherlands: Kluwer Academic Publishers.

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, DC. National Academies Press.

NRC. 2000. *Inquiry and the national science education standards*. Washington, DC. National Academies Press.

Internet Resource

Science—A Process Approach
www.coe.ufl.edu/esh/Projects/sapa.htm