INQUIRY 101

Thinking like a scientist

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SCIENCE IS A PROCESS CALLED INQUIRY

From the beginning of human history, natural phenomena have puzzled people and caused them to ask questions. Scientific inquiry is a process for answering these questions through investigation. Scientific inquiry is not a rigid set of procedures, but rather a broad approach to investigation that begins with questions: "Why? What's going on? How is this explained?" and leads an investigator to reasoned, evidence-based answers to those questions.

Also called "The Scientific Method" or "The Process of Science," inquiry is a logical and rational order of steps by which scientists come to conclusions about the world around them. Through a careful sequence of observations, questions, hypotheses, data collection, and logical reasoning, the process of inquiry serves as a helpful framework that helps to ensure a scientist can be confident in the answers he or she finds. Used in science education, it also helps to ensure that young people are engaged and interested in the research process, and teaches them how science is done.

After observing monarch larvae in a field of milkweed, youth naturally become curious and ask questions about what they see.

INQUIRY TEACHES SCIENCE SKILLS

The process of inquiry can be both quite simple (ask questions, methodically pursue answers) and overwhelmingly complex (a 10-step process with piles of data). When people learn through inquiry, they are actively engaged in the construction of ideas and explanations (National Research Council, 2000). Instead of *learning about* science, they *learn by doing* science. When students take on the role of scientist, they come to understand the very nature of scientific inquiry. They begin to acquire the thinking skills important in everyday life, and may even set on a course toward pursuing careers in science (National Research Council, 2000).

By participating in inquiry-based experiences, learners make observations of the world around them which leads them to ask questions about what they see. They conceptualize possible explanations, or hypotheses, for their questions, and gather evidence that might lead them to favor one explanation over another. Ideally, they design experiments or conduct other kinds of study to answer their questions, and to share their findings with their peers. Inquiry is often cyclical, with reflections on the experience sparking new questions for study.

A STEPWISE PROCESS

Though there are many components and steps, inquiry boils down to the process of asking questions based on observations and methodically pursuing answers (See Figure 1).

- **Observe & Wonder:** Inquiry begins when a person focuses attention on the world around them and uses their senses to experience what's there. They may compare what they see to what they already know or to other things they see. They may record notes or illustrations about their observations in a journal.

- **Question:** Observations naturally trigger curiosity. At this stage, observers become scientists. When they pose questions, they may challenge assumptions, synthesize observations, or infer that a phenomenon involves more than meets the eye. Though scientists may ask thousands of questions, they must narrow down their specific query to pursue answers.

- **Develop Hypotheses:** Scientists will use logical reasoning to theorize about what answers they might find, and whether and why they think that some of these answers might be more likely than others. Often, scientists will identify variables they think will influence the possible answers.

- **Plan & Test:** In this stage, scientists organize a systematic method to collect data that will verify or refute their hypotheses. They may use tools such as thermometers, microscopes, chemical tests, binoculars, or they may just use their own eyes and ears to collect information. They must remain as objective and consistent as possible through the data collection process to ensure their evidence is sound, and not biased in some way.

- **Analyze & Interpret:** Once the data are gathered, scientists summarize their data to report statistics or evidence about what they've found. This kind of analysis can include both very simple summaries or complex analyses that help determine the statistical significance of the data. Then, scientists will apply their best logical reasoning to give the information meaning.

- **Conclude & Report:** When considering all the data, scientists determine which hypothesis is best supported by the evidence. They often will use graphs or tables to explain to others what they found and what they think their findings mean.

- **Reflect & Rethink:** The diagram's dotted arrows illustrate that throughout this process, scientists continuously reflect on their assumptions, consider alternatives, identify problems with their process, seek input, troubleshoot, and ask more questions. At any point, they may rethink their investigation plan and take a new direction with new questions.

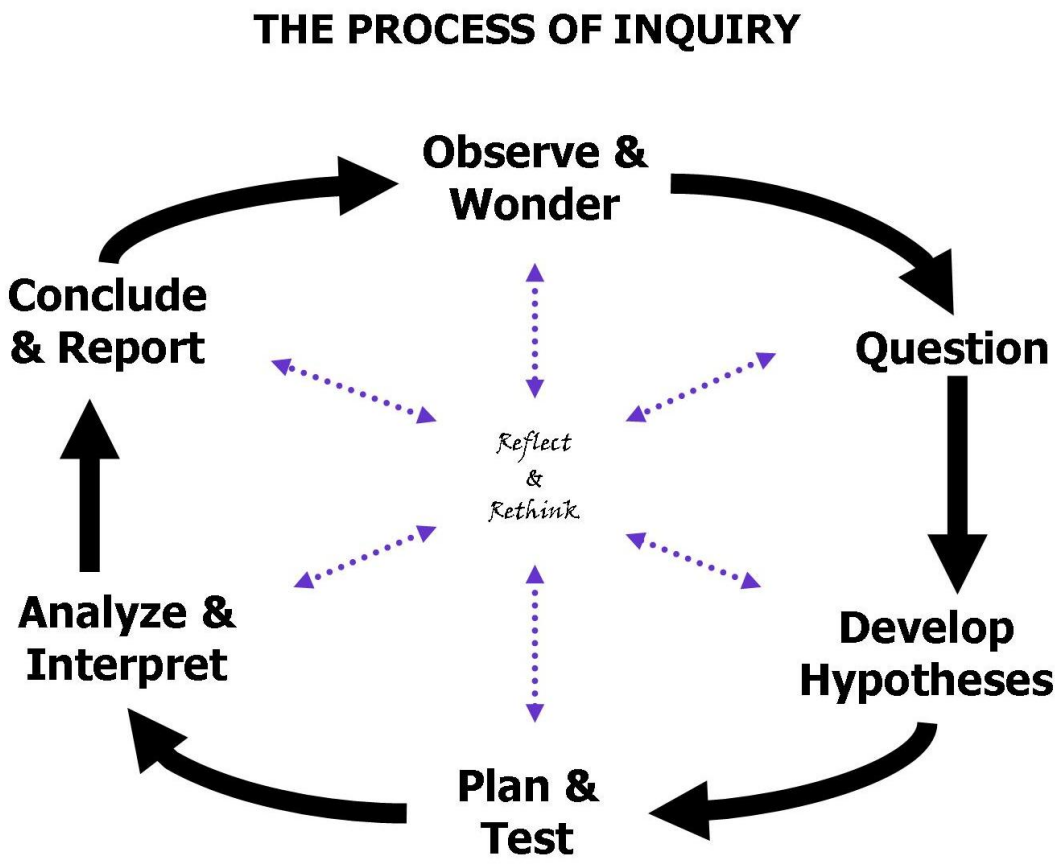

FIGURE 1. Scientific discoveries are made through the process of inquiry, though scientists often use the word "research" or "the scientific method" to describe what they do. Inquiry involves detailed examination of phenomena with the goal of discovering and interpreting new knowledge, whether the knowledge is new to human-kind, to a small group of people, or even just to the person doing the research.

FACILITATOR SKILLS THAT FOSTER INQUIRY

Inquiry is learner-driven, not teacher driven, so the instructor must take a back seat to his or her participants' curiosity. The instructor simply facilitates the learning process, so a lesson plan for an inquiry-learning activity might look more like a "facilitation plan" in which the instructor plans ahead for the many different ways an activity may turn out ("Step-by-step facilitation-plan creation," 2004). Such a plan helps retain the focus on the essential learning points and habits of mind the students should take away from the experience while still allowing the learner to drive the process.

Facilitating inquiry experiences requires flexibility, patience, tolerance of ambiguity, and an emphasis on student skill building. When learner-driven inquiry takes place, the instructor becomes a learner, too. And not just in the content area, but by gaining a deeper understanding of his/her students' thinking processes as well as the process of inquiry itself.

INQUIRY AND THE K-12 STANDARDS

The National Science Education Standards recognize three essential aspects to science learning: learning essential scientific concepts and principles, learning skills necessary to do science, and learning about the process of science (National Research Council, 2000). The process of inquiry, then, is both a teaching method and a learning goal. Though specific standards increase in complexity from Kindergarten through Grade 12, all age levels must ask questions, plan and implement investigations, and communicate results.

Each step in the process of inquiry is crucial for developing a clear grasp of science, but any one lesson or activity might not embody all the steps. Depending on the learning setting, it may not be possible or appropriate to carry out the entire learner-driven inquiry process. In some cases, it may be useful for the instructor to guide the process by providing a provocative question or a pre-determined set of data in the interests of dedicating more learning time to other steps in the inquiry process.

SUMMARY

True inquiry learning is driven, as much as possible, by a learner's questions rather than by what the instructor wants to teach. At its core, it draws on and feeds a learner's natural curiosity. Through inquiry-based experiences, learners develop essential skills: those that help them learn how to learn.

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ADDITIONAL RESOURCES

Center for Inquiry-Based Learning, Duke University, http://tasc.pratt.duke.edu/index.php

Inquiry Page, University of Illinois, Urbana-Champaign, http://inquiry.illinois.edu/index.php

Institute for Inquiry, Exploratorium, San Francisco, CA, http://www.exploratorium.edu/ifi/

Cornell Lab of Ornithology, http://www.birds.cornell.edu/birdsleuth/inquiry-resources

REFERENCES

Bell, P., Lewenstein, B., Shouse, A., & Feder, M.A. (2009). Learning science in informal environments: People, places, and pursuits. National Research Council. Washington, DC: The National Academy Press.

National Research Council. (2000). Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Washington, DC: National Academy Press.

Ryken, A., Otto, P., Pritchard, K., & Owens, K. (2007). Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes. Olympia, WA: Pacific Education Institute.

Step-by-step facilitation-plan creation. (2004). Educational Broadcasting Corporation. Retrieved February 21, 2011, from http://www.thirteen.org/edonline/concept2class/inquiry/implement_sub2.html

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