Learning to Observe *and* Infer

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"I have always thought that observation is the key to science but national and state standards say to emphasize inference and explanation. But shouldn't observation come first?"

How do scientists use observation and inference?

When exploring phenomena, scientists draw from many resources to gather information about what is happening and develop explanations. Sometimes they gather evidence directly using their senses; other times, direct observation is not possible. For example, atoms are much too small to be seen, even with the most powerful microscopes. Yet Rutherford proposed a model of atomic structure based on his observation that alpha particles deflected at different angles when they tried to pass through a thin layer of gold foil. His direct observations alone could not fully explain what was occurring in this experiment (Abd-El-Khalick 2002). Rutherford also *inferred* from his prior knowledge about charges and deflection to explain that there must be something massive and tiny, deep within each atom, interfering with the passing of the alpha particles—now known as the nucleus. In science, this process of logical reasoning is referred to as *inference* and allows scientists to use their observations to understand a phenomenon, even when they cannot directly observe it.

In what ways are observation and inference important in elementary classroom science?

Students need to develop these inquiry skills at an early age, so that, like scientists, they can use observation and inference to construct explanations for phenomena (Harlen 2001). When learning science, students cannot rely on observation alone. In elementary science students can observe many phenomena directly (e.g., an object floating or sinking) but not all. For example, when studying electrical circuits, students cannot see electrical current. Rather, they make inferences about the flow of current from their observations of the brightness of the bulb. As

students add bulbs to a circuit in series, they observe the bulbs get dimmer but remain equally bright. From this they may infer that the current has lessened although each of the bulbs receives the same amount of current. Combining what they observed (lights equally dim) and inferred (current lessens but each bulb receives the same amount), students can generate an explanation for how resistance affects the flow of current in a circuit.

What difficulties do students encounter in understanding how scientists use observation and inference?

Research shows young learners often believe scientists use only observation when developing explanations, as they do not understand the importance of inference to scientific work. In a study of 23 fourth-grade students' views of science, researchers asked how scientists use observation and inference to learn about dinosaurs (Akerson and Abd-El-Khalick 2005). The researchers found most students believed scientists used evidence such as bones and fossils to explain what dinosaurs looked like. However, when asked to describe how scientists determine the color of dinosaurs, students gave a variety of responses or no response at all. Findings from this study demonstrate elementary students' difficulty in recognizing the role inference plays in helping scientists to understand natural phenomenon.

Similarly, when Akerson and Volrich (2006) asked first graders how scientists knew what dinosaurs looked like, many students believed scientists had actually seen whole dinosaurs, not that scientists inferred what dinosaurs looked like based on fossil evidence. After teaching

students how to observe and infer by modeling those processes in her lessons and being explicit about the role of observation and inference in science, Volrich found her students improved their understanding of the two processes and the importance of each to scientific work.

For example, postinstruction, 12 of the 14 students discussed how scientists observed and compared bones to infer what dinosaurs looked like and how they lived. These students developed a better understanding of how scientists use both observations and inferences to explain science phenomena. These studies demonstrate that young children have the ability to learn the difference between observation and inference and their role in science, but teachers must be explicit about the difference between the two and their role in the development of scientific knowledge.

How can I develop my elementary students' observation and inference skills?

Researchers describe the need for students to have multiple opportunities and social interaction to learn about the differences between observation and inference and their role in developing scientific explanations (Harlen 2001; Simpson 2000). For example, Herrenkohl and Guerra's (1998) examination of fourth-grade students' science learning found an increase in student learning when a) students had opportunities to discuss in small groups and as a class what they observed and inferred; b) they saw the teacher modeling these scientific practices (i.e., observing and inferring); and c) these practices became a part of the normative practice of their science class regardless of the content. In addition, Metz (2000) found that elementary students' science learning needs to be scaffolded around a metacognitive approach, where students are asked to think about what they know (i.e., what they can directly observe) and what they do not directly know (i.e., what they need to infer).

Drawing from this research base, teachers can build a classroom environment in which students build their understanding, like scientists, through observing and inferring. The following instructional strategies are recommended:

- Giving students multiple opportunities to practice observing and discussing similarities and differences they find in their observations;
- Asking students challenging questions throughout their explorations to focus their attention on situations where it is possible and not possible to gather data using observations;
- Encouraging students to look for patterns and make generalizations from their data (i.e., inferences); and
- Establishing a positive learning environment where students feel comfortable challenging one another's claims about observations and inferences and how they were used to generate explanations.

Helping children develop their skills of observation and inference in science while emphasizing the importance of each skill will also help them develop a better understanding of how scientists generate knowledge about the world.

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