Understanding the True Meaning of Nature of Science

Teaching suggestions to help you highlight nature of science

By David T. Crowther, Norman G. Lederman, and Judith S. Lederman

Along with the awesome responsibility to teach science content and inquiry comes a responsibility to nurture an understanding of the nature of science. Just what is nature of science? As simple as this statement sounds, the term in and of itself is not readily agreed upon in scientific communities. For K–12 and science education communities, nature of science is not so much defined by a concise statement, but rather defined more by its components:

- That science is a way of knowing, and there are values and beliefs inherent to the development of scientific knowledge (Lederman 1998);
- That the philosophy, history, sociology, and psychology of science affect science teaching and learning (McComas, Clough, and Almazroa 1998);
- That science is a human endeavor and that people of all ages, races, sexes, and nationalities engage in this enterprise (Weinburgh 2003); and
- That science is based upon evidence—not logic or faith (Weinburgh 2003).

A list of elements important to understanding nature of science would also include the following statements from the National Science Teachers Association position statement (NSTA 2000) (see Internet Resources):

- No single universal step-by-step scientific method captures the full complexity of doing science;
- Creativity is a vital, yet personal, ingredient in the production of scientific knowledge;
- With new evidence and interpretation, old ideas are replaced or supplemented by newer ones; and
- While science and technology do impact each other, basic scientific research is not directly concerned with practical outcomes, but rather with gaining an understanding of the natural world for its own sake.

When these parts of the whole are considered individually, a clearer picture can be gained of what nature of science should promote or not promote in science teaching. However, teaching about nature of science sometimes gets lost as it is embedded in regular science instruction. Nature of science in science instruction should be formal and as much as an aspect of subject matter as pH, stages of the life cycles, or the components of the water cycle. That means that we should provide explicit instruction on nature of science. How do we accomplish that? It’s not as difficult as you might think.

This article describes ways to explicitly teach nature of science that are easily incorporated into your lesson plans.

Some Things Change . . .

Scientists develop their ideas based on evidence and they change their ideas when new evidence becomes available or the old evidence is viewed in a different way. You can help students understand more about nature of science by designing lessons around science topics or concepts that have changed over time. Such lessons show students that scientific knowledge in and of itself is not static and that with new information, scientific theories can change. In the lesson, the instruction must be explicit on “how” knowledge has changed and why.

For example, sixth-grade students might get this idea from a lesson or discussion about the solar system and how very recently scientists have just decided that there
might be a tenth planet.

In earlier grades, reinforce the nature of science by talking about the change in views concerning the lineage of dinosaurs. Scientists used to believe that dinosaurs were most closely related to reptiles, but they now believe they are more closely related to birds.

While some ideas change, it's also important for students to understand that some laws in science have stood the test of time. For example, when teaching scientific laws—how they describe nature and how things act under certain conditions—discussing Sir Isaac Newton's three laws of motion brings in a fine example of how a law has survived the test of time.

Newton first published these laws in 1687 and they are still supported to date. Newton was well known for his devotion to showing that some scientific principles are of universal application. In addition to his laws of motion standing the test of time and scrutiny, so also did his definitions of the nature of mass, weight, force, inertia, and acceleration—all still viable since the late 1600s.

**Many Methods of Science**

A common mistake in understanding nature of science is to focus on the scientific method. There are many methods to doing science, not just one “Scientific Method.” We can teach that questions lead to investigation and experiments that then lead to conclusions—but still stress there are many different pathways that scientists take.

Different disciplines conduct investigations in different ways. For example, astronomers make systematic observations of the objects they see in the sky. However, they cannot control the behaviors of celestial bodies and so most of their research is descriptive in nature. Similarly, environmental scientists study relationships among inorganic and organic components of the environment, but they, too, cannot do a classical experiment because they cannot control the environment. On the other hand, chemists can easily control levels of various compounds in their laboratories and assess the effects of changing the amount of one of the compounds in a system.

In summary, it is incorrect to assume that all scientific investigations follow the same set and sequence of steps. With respect to nature of science, one of the reasons why knowledge is subject to change is that these different types of investigations provide different information and evidence concerning the natural world.

**The Human Factor**

Finally, there is the human element of science. This is perhaps the most elemental yet most often overlooked aspect of nature of science. The development of scientific knowledge involves human creativity and human subjectivity. Scientists are constantly making observations and then drawing inferences based on these observations involving both creativity and subjectivity. This is unavoidable and it is another reason why scien-
Connecting to the Standards

This article addresses the following National Science Education Standards (NRC 1996):

**Content Standards**

*Standard G: History and Nature of Science*

**Grades K–4**
- Science as a human endeavor

**Grades 5–8**
- Science as a human endeavor
- Nature of science
- History of science

Scientific knowledge is subject to change. Scientists interpret the same data in different ways because they are different individuals with different backgrounds. The same is true of your students.

Elementary students must first be taught the difference between observations and inferences. One way to do this is to have another adult walk into your classroom and then leave. After the person leaves, ask your children to make a list of the observations about the person and share them with the class. Divide their answers into two lists: one labeled “Observations” and the other “Inferences.”

Height, age, and the colors and types of clothing the person was wearing are observation, but being friendly, smart, or in a hurry are inferences. Discuss the differences between the items in these two lists and why they are different.

A common classroom activity that illustrates subjectivity is a version of the “Telephone” game. Set up two rows of 10 desks deep. Each student will be directly behind the next. This is not a race, but the activity is timed. The teacher will give the first desk in each row a drawing. (Note that using a drawing of an animal that is too common will not work, so use an animal shape that is somewhat complicated). The lead person will have 15 seconds to redraw the drawing.

Next, the teacher takes away the original, and the “new” drawing is passed back to the next set of desks. This is repeated until all 10 students in the row have completed the task for the given time.

Then, show the original drawing with the end product from each group. Look at the series of pictures for the major changes (e.g., when the animal picture no longer contains eyes or when the legs went from long and skinny to short and fat, etc.). This shows how information can be interpreted by others and then passed along as different from the original information.

As we teach these aspects of nature of science, elementary students will be better able to connect what they are doing in their science classrooms to the work of scientists. This explicit approach to teaching nature of science also enables teachers to help students better understand the changing claims that scientists make everyday in television and in the newspapers.

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**Resources**


**Internet**
