DEMYSTIFYING NATURE of SCIENCE

Two activities help young children understand nature of science.

By Judith Lederman, Selina Bartels, Norman Lederman, and Dionysius Gnanakkan

With the emergence of the Next Generation Science Standards (NGSS; NGSS Lead States 2013), it is apparent that teaching and learning about nature of science (NOS) continues to be an important goal of science education for all K–12 students. The understandings of NOS are included in the both the science and engineering practices and crosscutting concepts of NGSS as:

- Science is a way of knowing
- Science is a human endeavor
- Science addresses questions about the natural and material world
- Science models, laws, mechanisms, and theories explain natural phenomena
- Scientific knowledge is based on a variety of methods
- Scientific knowledge is based on empirical evidence
- Scientific knowledge is open to revision in light of new evidence
- Scientific knowledge assumes an order and consistency in natural systems
With this emphasis on NOS, early childhood teachers are asking how to design instruction to teach NOS within the context of these new standards. During a recent research project, we had the opportunity to teach NOS to 70 first-grade students in an urban midwestern city. For this study, our instruction focused on the learning of three aspects of NOS from the NGSS: Scientific knowledge is based on empirical evidence; science is a way of knowing; and scientific knowledge is open to revision in light of new evidence. However, it is important to note that other aspects of NOS, including “Science is a human endeavor,” were also addressed. The lessons were integrated into the science curriculum and augmented with literature connections. Interwoven throughout these inquiry lessons were reading, writing, and drawing activities. These multidisciplinary lessons allowed us to address topics found in both the Common Core State Standards for English Language Arts (CCSS-ELA) (NGAC and CCSSO 2010) and the NGSS (NGSS Lead States 2013).

To begin to develop an understanding of the aspects of NOS, we introduced the idea that scientific knowledge is based on humans making observations and inferences. Observations are descriptive statements about natural phenomena commonly obtained by young children through their senses. Inferences are statements about phenomena inaccessible to the senses (Lederman and Lederman 2004). Often, students confuse observations with facts and inferences with guesses. Teaching students at an early age explicitly about observations and inferences and that science is a human endeavor can prevent these common misconceptions from forming. In this article, we share examples of the lessons and activities we used in the study.

Mystery Tube Activities

This lesson opens by asking students to make observations of the classroom around them. We ask the students to share their observations (e.g., “Leaves are green and there are chairs”). Then the word observation is defined, introduced by the probing question, “What do we use to make observations?” Students begin to understand that they use their senses (sight, hearing, smell, taste, and touch) to make observations. Then we play a game to see how well the students can observe. We ask a student to volunteer and the other students make observations about the volunteer. Then we ask the student to leave the room and change one thing about their appearance. When the student returns, the remaining students make observations about the changes in that student. After a few rounds of the observation game, we bring out something else for students to observe. This is where the mystery tube is unveiled.

When and How To Teach NOS

In the past, many teachers wondered if it was even developmentally appropriate to introduce NOS to children this young. On the contrary, recent research is now showing that it is not only possible but also that in many cases young students are actually more open to these views of science than older students who may hold more absolute views and misconceptions about science. Young children’s natural curiosity and wonder about everything, coupled with their joyful questioning, provide their teachers with a perfect jumping-off point for inquiry-based science instruction and create an opportunity to explicitly teach about NOS.

Teaching about NOS, as with any other content, is most effective when explicit and reflective instruction is used. Explicit instruction simply means that specific objectives to teach NOS are planned for and taught. During and at the end of lessons, teachers guide students to reflect on what they just did and make connections between their inquiry-based science activities and the work of scientists. Explicit and reflective teaching emphasizes student awareness of the NOS aspects the teacher is targeting within the lesson (Khishe and Abd-El-Khalick 2002). Explicit instruction makes NOS visible in the classroom, as opposed to the notion that students will come to understand science solely by participating in science activities. For example, during science investigations, teachers often have students collect and use data to form evidence-based conclusions. This is something students do repeatedly in their school careers. However, students may never understand that all scientific knowledge is empirically based if this is not explicitly taught to them. Scientific knowledge is based on observations from senses and data collected from the natural world rather than intuition or opinion. It is also important to note that the teaching of NOS should occur during the course of the school year and be considered a theme as opposed to an isolated unit.
“The Tube” (Lederman 1997) is often used to teach about scientific modeling in the older grades, but we have found it equally as effective in primary grades. It can be made from any type of cylinder (often a paper towel roll). See Figure 1 for a diagram of the tube. We made our tube from an oatmeal cylinder covered in bright paper. The strings were made of thick cord, and we used a plastic ring to connect the strings.

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We first asked the students what they thought would happen when we pulled the various strings. They responded, “The other string will pull in,” indicating which string they were referring to, and they explained why they believed this. When a student pulled the top...
string on the left, the right string moved in. Then we asked another student to pull the right string and the left string moved in. We finally asked them what they thought the inside of the tube might look like. Some suggested it was one big string. But other students said, “No, there are four strings!” Others said there were only two. We then asked, “Do you know this? Did you actually see this or do you just think this?” Students said they didn’t know this for sure because they can’t see inside the tube but think that it is. We explained that thinking something based on an observation is called an inference. Inferences are a combination of what we observe and what we already know or have experienced. We then asked the students to pull one of the lower strings. When the lower string caused the top string to move in, the whole class was surprised! We then asked, “What did you observe?” and “What do you infer from this now?” As we continued pulling different strings, we asked students if their responses were observations or inferences, and followed up with why they thought so. Next, the students were told to draw a picture of what they thought was inside the tube (see Figure 2), saying that these drawings were also inferences. Students then shared their drawings with each other. We pointed out that although they all made the same observations, their inferred explanations (their drawings) were different. We explicitly discussed with the children that often people have different experiences and knowledge, so even though they observe the same things, they may make different inferences. We talked about this also being true for scientists when they do their work. One child drew a picture of tiny people in his tube pulling the strings (see Figure 3). We asked the children, “Is this possible?” and “Have you ever seen people that small?” Once the children agreed that this could not happen, we followed with a discussion of how science knowledge has to be based on data and what is possible in the real world.

After sharing, we asked the children how they could know if their models would work the same way as the original tube. They decided that they would have to make them! Students were provided with prepunched tubes from toilet paper rolls and precut lengths of string to build 3-D versions of their drawings. Students shared their models and demonstrated how they worked. It is important to note that there are a number of model designs that result in tubes that operate in the same way as the original. In our class, students came up with various ways of making the tube work as our tube did. We asked the students, “If your tube works like ours, does this mean that it is the same as ours inside?” After much discussion, they said this would not necessarily be true. We told them that often scientists make observations and inferences based on those observations but can never be absolutely sure and understand their inferences may change in light of new information.

As a follow-up to the tube activity, we read aloud Dr. Xargle’s Book of Earthlets by Jeanne Willis (1988) to the students. This book is a humorous story about a space alien describing human babies and their interactions with their parents. After reading a section, we stopped and asked students if the descriptions are observations or inferences and why. This served as a way to informally assess student’s understanding of observation and inference.

**Fish Activities**

Finally, we read Fish Is Fish by Leo Lionni (1970) to the students. This book is about how a fish infers his frog friend’s stories of the different living things he encountered on land. Much like the Earthlets book, this text serves as a platform for students and teachers to discuss observations and inferences and how they lead to conclusions. We asked students to close their eyes and visualize a fish. Then we told them to open their eyes and draw a picture of the fish they imagined (Figure 4, p. 44). Stu-
dents were then divided up into groups of three and each group was given a cup of water containing a live goldfish. Again students were asked to draw pictures of their observations, then compare and contrast their two fish images. We modeled ways to write sentences to show two similarities and two differences between the students’ drawings. Students were also asked to compare their observation drawings with other students in their group who looked at the same fish and discuss the similarities and differences of their inferred drawings. A discussion of how scientists observing the same things may have different inferences followed.

A final text was used to bring home this unit on observations and inferences entitled Seven Blind Mice by Ed Young (1992). This book is an old fable about seven blind mice that venture out separately to investigate an unfamiliar object in a nearby pond. Each mouse makes observations and inferences about the new object based on the segment of the object they touch. Finally, the last mouse runs over the entire object and concludes that the unknown object is really a compilation of the separate observations of the other six mice. As we read the book, students were called on to explain what the mice were observing and inferring. We had the students reflect on the investigations they have been doing in science, and again we had a discussion about how it is necessary for scientists to talk to each other, share their observations and inferences, and perhaps as a result of these communications, rethink their inferred conclusions.

Wrapping Up

At the conclusion of these lessons, we used the Young Children’s Views About Science (YCVS) assessment protocol (Lederman 2010) to measure the students’ understandings about science and NOS. Because the YCVS is an oral protocol, it is capable of eliciting views of science from students who are not yet able to fully express themselves in writing. A copy of this assessment protocol and a scoring guide can be found online (see Internet Resource). The YCVS consists of six multipart questions. It assesses students’ understandings of what
Demystifying Nature of Science

Judith Lederman (ledermanj@iit.edu) is an associate professor of science education and director of teacher education at Illinois Institute of Technology in Chicago, Illinois. Selina Bartels is a PhD research assistant at Illinois Institute of Technology. Norman Lederman is a professor of science education at Illinois Institute of Technology. Dionysius Gnanakkan is a PhD research assistant at Illinois Institute of Technology.

The only way to truly achieve the vision of the NGSS and develop scientifically literate citizens is to begin science instruction as early as possible. The results of our study offer compelling evidence that young students are very capable of learning nature of science. However, it is the responsibility of their science teachers to ensure that NOS is explicitly included in their students’ science instruction. It is reasonable to assume that whenever students are learning discrete science content, they should also be learning what this thing called science is as well!

References


Internet Resource