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The phrase "nature of science" (NOS) is often used in referring to issues such as what science is, how it works, the assumptions underlying the doing of science, how scientists operate as a social group and how society itself both influences and reacts to scientific endeavors. These and many other thoughts regarding the NOS are informed by contributions from several disciplines including, but not limited to, the history, philosophy, sociology, and psychology of science.

Why Accurately Teach about the Nature of Science?

A number of studies document students' misconceptions regarding scientists, how science works, and the nature of scientific knowledge (Clough, 1995; Rowell & Cawthron, 1982; Rubba, Horner & Smith, 1981; Ryan & Aikenhead, 1992, Williams, 2008). The significant misunderstandings that students hold regarding the NOS are particularly damaging to general scientific literacy because they affect students' attitudes toward science and science classes, and this clearly impacts student learning and the selection of further science classes. For example, Sheila Tobias (1990) interviewed a number of successful science students and reported that they became disenchanted with science classes and chose different majors, in part, because science courses ignored the historical, philosophical, and sociological foundations of science.

Moreover, understanding the NOS is intricately tied to deeply understanding science content. For instance, conceptually understanding biological evolution requires "students to become familiar with the metaphysical assumptions and methodological process that Darwin laid out. (Rudolph and Stewart, 1998, p. 1085). Consider also the following student's frustration that illustrates how misunderstandings regarding the NOS may affect interest in and understanding of science content.

> *What is this game that scientists play? They tell me that if I give something a push it will just keep on going forever or until something pushes it back to me. Anybody can see that isn't true. If you don't keep pushing, things stop. Then they say it would be true if the world were without friction, but it isn't, and if there weren't any friction how could I push it in the first place? It seems like they just change the rules all the time. (Rowe and Holland, p. 87)*

Deeply understanding many science concepts is linked to understanding the fundamental assumptions and methodological practices that underlie that knowledge. Teachers who want their students to truly understand science content must accurately and explicitly teach the NOS. When taught accurately and effectively, NOS instruction also has the following positive outcomes:

- students better understand science's strengths and limitations
- many social decisions that involve scientific knowledge may be made in a more informed manner
- science content instruction improves
- students' interest in science and science classes generally increases

Students may initially be puzzled by and balk at explicit attempts to accurately portray the NOS. A study by Meyling (1997) indicated that students who had not experienced explicit nature of science instruction showed little initial interest in such topics. However, of those students who actually experienced explicit instruction regarding how scientific knowledge comes to be accepted, two-thirds showed further interest in such learning.

Ironically, all science teachers *do* teach the NOS! We can't escape conveying an image of the NOS to our students. Cookbook laboratory activities, textbooks that report the end products of science without accurately addressing how the knowledge was developed, and the language appearing in instructional materials and used by teachers to describe science, scientists and scientific knowledge are just some of the ways students pick up misconceptions about the NOS. The issue is not whether science teachers will teach about the NOS, only whether that image conveyed to students is accurate.

Accurately and Effectively Teaching the Nature of Science

Overcoming students' significant and deeply held misconceptions regarding the NOS requires that teachers explicitly plan for accurate NOS instruction and that they mentally engage their students in wrestling with issues such as (Clough, 2007):

1. In what sense is scientific knowledge tentative? In what sense is it durable?
2. To what extent is scientific knowledge empirically based (based on and/or derived from observations of the natural world)? In what sense is it not always empirically based?
3. To what extent are scientists and scientific knowledge subjective? To what extent can they be objective? In what sense is scientific knowledge the product of human inference, imagination, and creativity? In what sense is this not the case?
4. To what extent is scientific knowledge socially and culturally embedded? In what sense does it transcend society and culture?
5. In what sense is scientific knowledge invented? In what sense is it discovered?
6. How does the notion of a scientific method distort

how science actually works? How does it accurately portray aspects of how science works?
7. In what sense are scientific laws and theories different types of knowledge? In what sense are they related?
8. How are observations and inferences different? In what sense can they not be differentiated?
9. How does private science differ from public science? In what ways are they similar?
10. How is science different from technology? How do they influence one another?

Of course, before tackling these issues, science teachers must first have some understanding of them and how to effectively engage students in discussing the NOS. The following are just a few readily accessible sources useful for coming to understand key NOS issues and effective NOS instruction:

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- Centre for Science Stories (2008). http://science-stories.org/
- Clough, M.P. & Olson, J.K. (2004). The Nature of Science: Always Part of the Science Story, *The Science Teacher*, 71(9), 28-31.
- Colburn, A. (2004). Focusing Labs on the Nature of Science, *The Science Teacher,* 71(9), 32-35.
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- National Academy of Science (1998). Teaching about Evolution and the Nature of Science. Available on-line at http://www.nap.edu/openbook.php?record_id=5787
- American Association for the Advancement of Science (AAAS) (1989). The Nature of Science. Chapter 1 in *Project 2061: Science for all Americans*. Washington, DC: AAAS. Available on-line at http://www.project2061.org/publications/sfaa/online/chap1.htm
- National Science Teachers Association (NSTA) Position Statement on the Nature of Science, Adopted by the NSTA Board of Directors. *NSTA Reports!* 11(6):15. Available on-line at http://www.nsta.org/about/positions/natureofscience.aspx

The authors in this special *ISTJ* issue have kindly shared their expertise on how they accurately and explicitly integrate the NOS throughout the school year. They make clear that such instruction enhances science content instruction and is intricately tied to promoting other equally important goals for science education. Their work deserves to be read closely, and I know they would enjoy hearing from readers wishing to learn more about accurate and effective NOS instruction.

A Farewell

This issue concludes my three-year term as *ISTJ* Editor. I am very proud to have played a key role in reviving *ISTJ* when I was elected ISTS President in 2004. I am pleased that the final issue of *ISTJ* under my editorship is this special issue devoted to teaching and learning the nature of science (NOS). I know from my seven years teaching secondary school science that students can and will develop accurate and enduring views of the NOS if it is taught in a developmentally appropriate and engaging manner. I work now to help teachers effectively teach science in a way that also accurately portrays the NOS. I am honored that the four authors in this special NOS issue are former students of mine.

For more than a decade now, I have had the great pleasure of working with prospective and experienced teachers to improve science teaching. As part of that effort, I teach courses and provide professional development that address the NOS and how to effectively teach it to children. I once wrote to a student that what sustains me in teaching is the pleasure of interacting with individuals who are working so hard for others. When I see what others are doing, and the positive effect it has on individuals, I know that I am not alone, and that my own efforts are not in vain. Thank you for the opportunity to serve as Editor of *ISTJ*.

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