Teaching Against the Mystique of Science: Literature Based Approaches in Elementary Teacher Education

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School science experiences shape learners' attitudes and beliefs about science. Yet, school experiences often consist of reading from a text, memorizing scientific facts, or conducting "verification" type laboratories, and thus may fail to accurately portray the nature of science. Lemke (1990) refers to this as the "mystique of science" in which teachers, often without realizing it, reinforce a set of harmful myths that impersonalize science and alienate learners. Our own reading of preservice teachers' science autobiographies (Koch, 1990) confirms that the images of science they hold are often inaccurate and oversimplified versions of this rich human and social endeavor. Indeed, when asked to "Draw A Scientist" (Chambers, 1983) our preservice elementary teachers overwhelmingly represent scientists as the stereotypical white male in a lab coat, similar to students and teachers in national studies (Barman, 1997; Moseley & Norris, 1999). Thus, they are likely to perpetuate such images through their own instruction, which can have profound consequences. As Lemke (1990) argues,

> It is dangerous to society to have students leave school believing that science is a perfect means to absolute, objective truths, discovered by people of superhuman intelligence. Apart form the danger that scientific "findings" could be used to justify wrong social polices, an impersonal, inhuman view of science alienates many students from the subject. If we are to encourage students of all kinds to take in interest in science, and use it for their own purposes, we need to show it as it really is (p175).

However, many future teachers have had few firsthand experiences with scientific inquiry and little or no contact with professional scientists. Science is an intimidating and impersonal activity to them—which poses a challenge to developing, and indeed teaching, ideas about the nature of science. Because "the actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned" (NRC, 1996, p.28) it is critical that science teacher educators provide opportunities that challenge their perceptions and extend their understanding of the nature of science.

Lemke (1990) recommends teachers "emphasize the human side of science: real activities by real human beings, both today and in specific periods of history. Personal characteristics of scientists, with which students can identify, should be emphasized rather than making scientists seem superhuman or alien" (p175-6). We follow this recommendation in our methods courses by utilizing explicit-and-reflective teaching strategies (Akerson, Abd-El-Khalick, & Lederman, 2000) that involve preservice teachers in 1) exploring their views of science and the source of these views, 2) confronting their misconceptions and stereotypes, and 3) considering the implications for their future teaching. A key aspect of our approach is the use of children's literature to convey science as a human and social endeavor and to model appropriate teaching strategies for the elementary science classroom. In the sections that follow, we outline specific components of our instruction.

Eliciting initial views of science and scientists

During first day of class, we employ the Draw-A-Scientist Test (DAST) developed by Chambers (1983). Heeding recommendations of Symington and Spurling (1990) who noted that elementary students may draw recognizable stereotypes if they do not understand the purpose of the drawing, we prompt preservice teachers by asking them to: "Draw a picture of a scientist doing science which tells what you know about scientists and their work." As students finish their individual pictures, we invite them to share and discuss in small groups by asking questions focused on eliciting not only their views of scientists but of science (e.g., What does your picture show about what scientists do and what science is about? What does it not show about what you know about scientists and their work?). To assist their reflection, we have students do a gallery walk (e.g., Fasse & Kolodner, 2000; Kolodner, 2004) focused on comparing similarities and differences across drawings (What did you notice? What was similar? How do your drawings differ?). The whole class is convened to share and respond to various observations. As students notice typical traits (e.g., lab coats, male, messy hair, test tubes) this leads to discussion about whether there are specific attributes common to those who do science. By focusing on the environment in which the scientist was drawn, students may express ideas about where science occurs, what scientists study, what tools are used, or how scientists go about their work.

Our preservice teachers' ideas and drawings are stereotypical and similar to those of elementary students (Barman, 1997; Driver, Leach, Millar, & Scott, 1996). Primed by this initial discussion, they then read about "Students Views of Scientists and Science" (Barman, 1997). In the subsequent class session, preservice teachers consider commonalities between students' and their own drawings and ideas, possible origins of these views, and why this all matters for elementary science teaching. A key insight for many teachers at this point is the way in which their own teachers shaped their perceptions of science—this brings out the importance of the accuracy of their own views to effectively teaching science. Within the first week of class, students also write a science autobiography (Koch, 1990) in which they simultaneously describe personal experiences with science and make sense of what science is. A critical aspect of this assignment is the reflective analysis and evaluation of how and why their experiences influence their current understanding and attitudes toward science.

Confronting misconceptions and stereotypes- Using children's literature

During the semester-long course, students learn multiple elementary science teaching and learning methods (e.g., guided to open inquiries, using trade books, keeping a science notebook) by synthesizing classroom experiences, readings, assignments, and discussions. We explicitly relate the science teaching methods to the nature of science by asking students to connect their inquiries to scientists and their work. Students may realize scientific inquiry can occur beyond the walls of a laboratory as they test everyday consumer products and observe mealworms in terrariums they keep in their dorm room. By sharing data and sense-making together, some recognize the value in collaborative problem solving in science teaching and learning. However, without familiarity of historical and contemporary scientists and their work, students may not readily relate their own science learning to the human aspects of the scientific enterprise. Hogan (2000) highlights this phenomena by differentiating between students' understanding of and perspectives on the nature of their own science knowledge-building practices and the scientific knowledge they form and encounter (proximal knowledge of the nature of science) and students'

knowledge of the protocols, practices and products of the professional scientific community (distal knowledge of the nature of science).

Our own teaching experience illustrates the way in which preservice teachers' science education has focused on "school science" to the exclusion of learning about the professional science community. Within their autobiographies and class discussions, our students candidly express having had no or limited knowledge of what scientists do on a daily basis, what an actual scientific notebook looks like, how and why scientists collaborate with others, and why someone might be interested in pursuing science as a career. Thus, by introducing children's books as part of their learning experience, teacher educators can help preservice teachers broaden their views about science as a human endeavor and bridge the gap between their proximal and distal knowledge of the nature of science.

As Ford emphasizes, "the use of tradebooks in the instruction of science has been advocated for decades as a means of including more relevant, more focused, and more interesting scientific information within science curricula" (2006, p. 214). This is especially important, as Rudolph notes because "the curriculum is the one place that society has set aside specifically for the purpose of systematically conveying to the public just what science is" (2002, p.67) as well as who can participate in science. When we have asked students to name a female scientist, though a few mention Marie Curie, students are hard pressed to come up with even a handful of other women. In contrast, students abounded with names of prominent historic men who made their livelihood in science. Thus, a primary consideration is portraying the diverse men and women who participate in the scientific endeavor.

To select appropriate tradebooks, we draw upon the National Science Teachers Association (NSTA) *Outstanding Science Trade Books*, an annually published annotated bibliography compiled by NSTA in cooperation with the Children's Book Council. We carefully read and screen books to determine their potential to teach about the nature of science. Some criteria developed by Mayer (1995) prove to be useful as we pre-select biographical-type books appropriate for elementary-level students: Does the book contain misrepresentations? Are characters portrayed with gender equity? Does the story promote a positive attitude toward science and technology? While many of our selections are biographical, we also consider recommendations from Melber (2003) to include nonfiction books written from the perspective of practicing scientists to provide a "real life glimpse of the process of scientific discovery" (p. 24). Collectively, the books we select acquaint preservice teachers with historical and contemporary scientists representative of different social and ethnic backgrounds, genders, renown, and/or scientific disciplines (see Appendix A).

We have used several strategies to introduce the books: a series of read-alouds (Farland, 2006); reading within small groups of students through literature circles (Straits & Nichols, 2006); and independent reading (Lovedahl & Bricker, 2006). As students explore literature-based accounts of scientists' work, we pose questions to guide their thinking.

- When and where did the scientist live?
- How did the scientist become interested in doing science?
- What was the scientist interested in studying?
- How did the scientist go about his/her investigation?

- What tools did the scientist use to help them do science?
- How is what the scientist did like the things you do in science class? How is it different?

Questions can be discussed among small groups of students reading together, through "book talks" shared with the whole class, or in written reports by individual students. These enable preservice teachers to consider key ideas about 'Science as a Human Endeavor' within the elementary and middle level science standards (NRC, 1996). Whole class discussion leads to explicit referral to the national standards. In addition, the final question requires them to juxtapose their science learning experiences to the lives and work of past and present scientists.

Confronting misconceptions and stereotypes – Meeting with a scientist

Throughout the course, students read about, discuss, and conduct science investigations as well as consider how they would hope to portray science to elementary students. Armed with experiences and new understandings about science as a human endeavor, preservice teachers then prepare to visit a scientist on our university campus to compare what they do in the science classroom to the work of "real, live" scientists. Similar strategies have been suggested by Koch (1993) for preservice teacher education, but also in elementary education by a number of authors (Bodzin & Gehringer, 2001; DiBiase, 1998; Kesselheim, Graves, Sprague, & Young, 1998; King & Bruce, 2003) as a means to addressing learners' stereotypes of science.

The informal visit with university scientists is an opportunity for preservice teachers to ask questions based upon their understandings and wonderings about the nature of scientists' work and its relevance to elementary science teaching and learning. As preparation, students individually create a TWL chart (Akerson & Young, 2004) to write down what they think they already know about science and scientists as well as what wondering are wondering ("T" column for "What I think" and "W" column for "What I wonder about"). Students then partner with each other to brainstorm possible topics for discussion and questions to ask the scientist. Following their interview, students revisit their TWL chart to fill in the "L" column with "What I Learned".

Students are provided with questions to facilitate reflection upon the conversation and implications for their future teaching but are also encouraged to report other connections and revelations. We have had students share and respond to each other on an electronic discussion board on the class website as well as convene as a whole class to debrief the ideas about science they developed and what implications this has for their future elementary science teaching.

- How did your visit with a scientist challenge or confirm what you thought before the visit?
- What new ideas did you come away with afterwards?
- How and what could your students learn by interacting with a scientist or scientists?

In addition, students use a Venn diagram to compare and contrast their inquiries in the methods course to what they have learned about scientists and the nature of scientific work. This graphic organizer as well as student thank-you letters to scientists, in-class and on-line discussions all serve as informal assessments as well as a means to help forge explicit links between preservice teachers' proximal and distal knowledge of the nature of science.

Considering implications for future teaching

The ultimate goal of our efforts is to help our students understand the implications of the nature of science for their own practice.

> Science teachers have a special responsibility to study the nature of science as a discipline, how it works, how it is described by sociologists, historians, and philosophers from different points of view…. Science education cannot just be about learning science: Its foundation must be learning about the nature of science as a human activity (Lemke, 1990, p.175).

We argue that science teacher educators have a similar responsibility within their methods courses, to enable preservice teachers to develop the necessary understandings of the nature of science and science as a human endeavor, as well as the means to assist their own students in doing the same.

Our assessment of students' work in our course demonstrates changes in their ideas about the nature of science, particularly in regard to *who does science.* Reading about and meeting with actual scientists served to break many of the stereotypes they held.

> *My drawing of what I thought a scientist looked like at the beginning of the semester shows I had some serious misconceptions about what scientists can look like. My view of scientists was very narrow and rather stereotypical. I drew a white male wearing a white lab coat and working with chemicals. True, this man can be a scientist, but he is only one type of scientist. Scientists can be from both genders and of any nationality. Scientists may work in a lab with chemicals, but they can also work outside with animals, in hospitals, or even be students in a classroom! I have realized that everyone can be a scientist, even me!*

By reflecting on their own ideas about science at the beginning of the semester through the Science Autobiography and Draw-A-Scientist test, and throughout subsequent course activities, prospective teachers became aware of the changes in their ideas. This revelation about their own learning often served as an inspiration for opening their future elementary students' eyes to the nature of science.

> *I held misconceptions and from a class assignment I was able to change these misconceptions and understand real scientists better. I want to do help my students grow in this same manner by addressing their misconceptions.*

Additionally, based on our assessment of student work, we believe the learning experiences in the course provided students with insightful links between their proximal and distal knowledge of the nature of science, and the similarities between the science conducted by professional scientists and their own students.

> *Teachers should make clear connections to how students are acting like scientists. Any time students record observations and data in their science notebooks, the students are demonstrating another key aspect of the nature of science—science demands evidence.*

These kinds of comments are representative of our students as a whole, and offer us encouragement that these prospective teachers will make similar efforts to our own to teach against the mystique of science.

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Appendix A: Suggested Titles for Use in Elementary Science Teacher Education

Accorsi, W. *Rachel Carson.*

Alexander, C. *Rachel Carson: Writer and scientist.*

Aliki. *A weed is a flower: The life of George Washington Carver.*

Bishop, N. *Digging for bird-dinosaurs: An expedition to Madagascar.*

Bredeson, C. *Astronauts*.

Burby, L. N. *Rachel Carson: Writer and environmentalist.*

Carter, A. & Saller, C. *George Washington Carver.*

Driscoll, L. *George Washington Carver: The peanut wizard.*

Fridell, R. *The search for poison-dart frogs.*

Jackson, G. N. *Benjamin Banneker: Scientist.*

Kramer, S. *Hidden worlds: Looking through a scientist's microscope.*

Linder, G. *Marie Curie: A photo-illustrated biography*.

Mallory, K. *Swimming with hammerhead sharks.*

Martin, J. B. *Snowflake Bentley*.

Matthews, T. L. Light shining through the mist: A photobiography of Dian Fossey.

Montgomery, S. *The tarantula scientist.*

Montgomery, S. *The snake scientist.*

Patent, D. H. *A polar bear biologist at work.*

Powzyk, J. A. *In search of lemurs: My days and nights in a Madagascar rain forest.*

Rau, D. M. *Marie Curie*.

Ray, D. K. *The flower hunter: William Bartram, American's first naturalist.*

Ring, S. *Animal watch*.

Sis, P. *Starry messenger: Galileo Galilei.*

Sis, P. *The tree of life: Charles Darwin.*

Webb, S. *Looking for Seabirds: Journal from an Alaskan Voyage.*

Williams, J. *Saving endangered animals with a scientist.*