Authentic Experience in Scientific Inquiry for Pre-Service Teachers

(excerpt from 2007 UW Oshkosh proposal to the Teacher Quality Initiative of the University of Wisconsin System)

Statement of Need/Problem. Science instruction in the nation's schools is currently guided by standards and benchmarks that give weight to scientific content, the nature of science, and inquiry (AAAS 1993, NRC 1996, NSTA 2003). Scientific content standards are based on a student's understanding of concepts and facts in major scientific disciplines. Standards addressing the nature of science (history, philosophy, and social relevance) and scientific inquiry have been recognized as fundamental to scientific literacy, improving our ability to be skeptical in the face of unscientific claims (AAAS 1993, NRC 1996, Sagan 1996). Teacher licensure in Wisconsin under PI-34 (WDPI 2006) reflects these goals by requiring completion of a program that incorporates Wisconsin model academic standards for science (WDPI 2005).

Meeting the standards for the nature of science and for inquiry has been more difficult than for content standards with respect to improving student and teacher understanding (NSTA 2003). In a review of science education studies, Lederman (1998) noted that there is little conclusive evidence that understanding of the nature of science or inquiry can be demonstrated from implicit instruction (e.g. "doing" science, or taking a course in science history separate from science content). While acknowledging that implicit instruction is a start, he called for more explicit instruction that would allow students to reflect on the science they are doing, and the context in which their science is conducted (e.g. via discussions). This reflection phase echoes the final step in the "3P's" science teaching method of Problem-Posing, Problem-Solving and Peer Persuasion (Peterson & Jungck 1988). A more detailed cycle used for elementary school science inquiry is the "5E's" of Engage, Explore, Explain, Elaborate, and Evaluate (Bybee 1997; Ansberry & Morgan 2005), where the last three steps fall into reflection stage. Regardless of how the reflection phase is defined, it is the mostly likely step to be rushed, truncated or neglected because it comes last and can be sacrificed to time management – a problem in K-12 and college. Studies show that teachers who focus on the nature of science as an instructional objective within a science curriculum offered their students more explicit instruction (Lederman et al. 2001).

The importance of inquiry in the teacher preparation curriculum is highlighted in the National Science Education Standards Professional Development Standard A (NRC 1996):

> *"Prospective and practicing teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding".*

A difficulty arises when we explore the potential for teachers to meet this standard by taking science courses. The NRC noted that the undergraduate science courses taken by pre-service teachers may be failing to provide such in-depth experiences (NRC 1996):

> "*For all teachers, undergraduate science courses are a major factor in defining what science content is learned. Those courses also provide models for how science should be taught. For K-4 teachers and 5-8 teachers with general certification, undergraduate introductory science courses often are the only science courses taken. Because of the crucial role of such courses, reform in the content and teaching of undergraduate science is imperative*."

The lack of progress in achieving this goal over the past decade reflects the major difficulties in reforming introductory college science courses to suit the needs of pre-service teachers. First, these courses are unlikely to be reformed solely to meet pre-service teacher's

needs, as they often serve many constituent groups, such as: general education requirements (non-major students), prerequisites for science majors, and preparation for professional school exams (e.g. medicine). Second, the developers of teacher preparation curricula are rarely in a position to dictate the content, goals, or evaluation of the instructors for these courses, which are usually in multiple other departments and colleges. Third, college science departments traditionally invest much more staff and supply resources in upper division courses for declared major students, and there may be resistance to changing this model in order to expand science inquiry opportunities in introductory courses. Finally, and perhaps most important, due to competing needs and lack of time, most introductory science courses will do a poor job of demonstrating the use of inquiry and teaching, and are unlikely to demonstrate a wide array of approaches found in science. If inquiry-based laboratories are conducted, they are often limited to following the "scientific method" (hypothetical, deductive) with experimentation – rarely introducing the pre-service teacher to other approaches (e.g. observational/historical inference, induction, mathematical modeling, etc.).

Therefore, teacher preparation programs would be better served by a more direct approach to providing experience in scientific inquiry. Besides science courses, secondary teacher preparation programs include one or more courses on science teaching methods. This might be an opportunity to redress shortfalls of introductory science courses (e.g. students may be able to pass the latter based solely on conceptual or factual knowledge, without gaining an adequate or complete understanding of scientific inquiry). Teaching methods courses provide future teachers with the background and skills to "*make effective decisions about learning objectives, teaching strategies, assessment tasks, and curriculum materials*" (NRC 1996). With such a broad agenda, it is difficult to provide the pre-service teacher with experience in scientific inquiry. In recent studies, Windschitl (2003, 2004) found the application of inquiry in the classroom appears to be more strongly predicted by whether teachers have had "significant undergraduate or professional experiences with authentic science research" than by inquiry experiences in science methods courses.

Thus it is possible that future teachers might never carry out a scientific investigation as part of a science content course taught by scientists, and inquiry in science teaching methods courses taught by education faculty are insufficient preparation. Windschitl (2003, 2004) concludes that independent science investigations should be part of pre-service teacher education, and that these experiences should be "scaffolded" to allow the students to reflect on the nature of inquiry.

At a local level, we have conducted several surveys of in-service teachers in CESA-6 and CESA-8 school districts to determine their interests and preferences for teacher professional development in the sciences. In CESA 6, the most popular request (78% of respondents) was to increase their understanding of inquiry-based instruction; for CESA 8, this was the second-ranked request (68% of respondents). These surveys also showed that in-service teachers strongly preferred that professional development opportunities be short in duration (less than one week), suggesting that it will be difficult to engage in-service teachers in lengthy immersion experiences in authentic scientific research. Thus, we considered how a scientific research experience could best be accomplished as part of pre-service teacher training.

This proposal describes a partnership between faculty from the UW Oshkosh College of Education and Human Services (COEHS) and the College of Letters and Sciences (COLS). COEHS project leaders include two science educators and an educational psychologist. COLS project leaders include two scientists with strong interests (and responsibilities) in professional development of K-12 science teachers: the directors of the Science Outreach Office and the Aquatic Research Laboratory. These UW Oshkosh staff have a history of collaborating on projects funded by the US Department of Education, UW System, and UW Oshkosh.

Literature Cited

AAAS (American Association for the Advancement of Science). (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Ansberry, K.R. and E. Morgan. (2005) *Picture-Perfect Science Lessons: Using Children's Books to Guide Inquiry*. Arlington, VA: National Science Teachers Association Press, 304 pp.

Bybee, R.W. (1997) *Achieving Scientific Literacy: From Purposes to Practices*. Portsmouth, NH: Heinemann.

Lederman, N.G. (1998) The State of Science Education: Subject matter without context. *Electronic Journal of Science Education*, v. 3 (unr.edu/homepage/jcannon/ejse/lederman.html)

Lederman, N.G., R.S. Schwartz, F. Abd-El-Khalick, and R.L. Bell (2001). Preservice teachers' understanding and teaching of the nature of science: An intervention study. *Canadian Journal of Science, Mathematics, and Technology Education*, *1*(2), 135-160.

NRC (National Research Council). (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

NSTA (National Science Teachers Association) (2003). *Standards for Science Teacher Preparation*. www.nsta.org/main/pdfs/NSTAstandards2003.pdf, accessed June 22, 2006.

Peterson, N.S. and J.R. Jungck. (1988). Problem-posing, problem-solving, and persuasion in biology education. *Academic Computing*, Winter/Spring, pp 48-50.

Sagan, C. (1996). *The Demon-Haunted World. Science as a Candle in the Dark*. New York NY: Ballantine Books.

WDPI (Wisconsin Dept. of Public Instruction). 2005. Wisconsin's Model Academic Standards for Science. (http://dpi.wi.gov/standards/sciintro.html) viewed on Jan. 15, 2007.

WDPI (Wisconsin Dept. of Public Instruction). 2006. PI 34 - Wisconsin Quality Educator Initiative. (http://dpi.wi.gov/tepdl/watsnew.html) viewed on Jan. 15, 2007.

Windschitl, M. (2003) Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education* 87:112-143.

Windschitl, M. (2004) Folk theories of "inquiry:" How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching* 41:481-512.