

[RE] ENVISIONING UPPER ELEMENTARY SCIENCE TEACHER EDUCATION EXPERIENCES

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Vexation

The importance of subject matter knowledge for teaching is not a new idea in education. Shulman (1987, 1986), however, focused attention on the powerful blend of content and pedagogy as being the unique domain of teachers when he coined the construct of pedagogical content knowledge (PCK). Shulman and his colleagues (Grossman, 1990; Wilson, Shulman & Richert, 1988) acknowledged that teaching for understanding is a complex cognitive activity that requires the transformation of knowledge from diverse areas, including subject matter knowledge, pedagogical knowledge, and knowledge of context. PCK refers to a teachers' unique knowledge of how to create learning opportunities that make particular content more comprehensible to others. While the construct of PCK appears to have waned in recent years, the *International Journal of Science Education* published a special issue on developments and challenges in researching PCK in August 2008. In this issue, Abell argues for the continued usefulness of PCK as a heuristic for a number of applications, such as the development of teacher preparation programs.

The perennial issue at the elementary level is that teachers are prepared as generalists and typically have limited knowledge of science subject matter. To make matters worse, the scope and sequence of elementary science curricula include life, earth and physical science content at each grade level. When secondary science teachers are required to teach outside of their areas of specialization there are often concerns about quality and effectiveness. Yet elementary teachers with the most limited science subject matter knowledge are expected to teach a wide range of content effectively.

Recently released research and policy documents outline ambitious new guidelines for proficiency in science for K-8 learners (NRC, 2007), further raising the bar for elementary teachers. In particular, these documents emphasize the role of scientific discourse and practices in science learning. Prospective elementary teachers consistently report that they have not engaged with science or science learning in this way. Yet we expect them to teach in ways that more authentically represent the practices of the scientific community.

It has been suggested that teacher educators will never be able to assist preservice elementary teachers in constructing all of the subject matter knowledge for teaching that they will need to begin their careers (Magnusson, Krajcik & Borko, 1999). A more reasonable target for teacher preparation, however, is to aid preservice teachers in developing initial frameworks for supporting the ongoing development of their pedagogical content knowledge (PCK), or "PCK readiness" (Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005; Smithey, in preparation). My vexation, then, is how to support the development of well-started beginners who will continue to progress in productive ways with respect to science teaching throughout their careers. What are possible and appropriate expectations/outcomes for elementary teachers at various stages of their careers, and what approaches have the most potential for achieving these short and long-term outcomes?

Background & Context

Throughout my career I have attempted to understand the nature, mediating factors, and development of prospective and early career elementary teachers' specialized knowledge and practices for supporting children's meaningful science learning and scientific inquiry. I have the best of all possible worlds in terms of context because I work with education students and practicing teachers simultaneously within a professional development school (PDS) partnership. School leadership and practicing teachers in this setting espouse an inquiry orientation. That is, they are actively engaged in systematically examining their practice, and they are supportive of reform-based approaches to teaching.

The students with whom I work are no different than the prospective elementary teachers reported in the literature. They are mostly female, ~20 years of age, largely middle class, and have limited science subject matter knowledge. They participate in an undergraduate teacher education program in which three science courses and one science methods course are required. What makes them unusual is that they commit to a year-long, field-based internship in the PDS in which they abandon the Penn State calendar and adopt that of the local school district. Education students in this program are known as interns, and the practicing teachers who host them are called mentors.

For the past eight years or so, my interests have focused specifically on teaching school science as argument (Zemba-Saul, accepted). I have collaborated with mentor teachers in the PDS and examined what argument construction looks like in elementary classrooms, with particular emphasis on how the teacher supports children's discourse associated with constructing scientific explanations from evidence. I use a design-based research approach to ensure an intentional interplay between research and practice. More specifically, research findings have informed the ongoing development of my science methods course, instructional strategies, conceptual tools, and resources, such as video-based teaching cases.

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The progress mentor teacher collaborators and I have been able to make is both exciting and encouraging. Through the complementary relationship between research and practice, I have learned where I can make progress with PDS interns and have gained insight into the mechanisms that mediate change. For example, by coupling particular science learning experiences and video-based cases of classroom science teaching, interns rather quickly begin to recognize the centrality of explanations in science and the role that evidence plays in constructing them (Zembal-Saul, 2005). This shift from engaging in mere activities to conducting investigations in which data are collected and analyzed for the purpose of constructing arguments and explanations is often accompanied by increased emphasis on the importance of science subject matter. Additionally, the shift to giving priority to evidence and explanation is paralleled by new views of the teacher's role in monitoring student learning. For example, instead of walking from table to table asking how groups are doing (the guide on the side), the teacher's role becomes that of asking students to discuss the patterns that emerge in their data and construct the claims that are supported by evidence. The initial science teaching of interns reveals tight connections between their developing knowledge and their practices (Zembal-Saul, 2007). Instructional approaches, such as mapping the arguments being constructed by students in terms of questions, claims and evidence, are evident in interns' teaching.

Still, when issues with science teaching are encountered, the culprit is almost always related to limitations in knowledge of subject matter, of scientific practices, and of the nature of science. While we have been able to make tremendous strides during the internship year with regard to developing PCK for science discourse and practices, these limiting factors remain. On my worst days, my vexation becomes, what in the hell am I doing?! I have the ideal context, dedicated collaborators, generous support and the best we can do still falls short of the mark. Is this a problem without a solution – at least under the current configuration of the education system, including higher education?

Venture

Recently (Spring 2008), the Pennsylvania Department of Education mandated new certification guidelines for upper elementary and middle school teachers. Our established K-6 program for elementary teachers must redefine itself around preK-4 and 4-8, while the secondary program (grades 7-12) remains untouched. This has created much angst for my colleagues and I; however, it does present an interesting opportunity to reconsider how upper elementary teachers are prepared. Given the overlap with middle grades, areas of specialization for the 4-8 program have been proposed, including one in science. Rather than the minimum requirement of three science courses for elementary education majors, the new guidelines provide for 30 credit hours of specialization. Unless we target a specific science discipline, preservice teachers completing such a program are likely to remain generalists of sorts – science generalists. Nevertheless, a glass half full perspective allows one to imagine the possibilities, which are potentially improved in terms of the kinds of opportunities that we can craft for preservice elementary teachers.

My intent is to use the construct of PCK as a heuristic for program development and the goal of PCK-readiness as a realistic target. This suggests that we need to consider the following kinds of learning experiences as we construct the 4-8 science program.

- Develop science content courses that aim to develop deep conceptual understanding of big ideas in science, model effective science teaching, and engage preservice teachers in the discourse and practices of science. **We have co-developed three such courses with STEM faculty and have received new funding to develop three more.*
- Capitalize on the PDS context to develop coherent field experiences that initially help future teachers recognize important aspects of reform-oriented science teaching in action, and later evolve into supportive settings to engage in teacher inquiry (action research) on science teaching.
- Create a 2-part science methods/pedagogy sequence that addresses new perspectives for proficiency in K-8 science and integrates contemporary research on children's science learning.
- Use argumentation as a strand throughout program experiences to foreground aspects of the nature of science and scientific discourse and practices.
- Sequence program experiences in such a way as to maximize the impact on teacher development.
- Craft a design-based, longitudinal research agenda that allows for the continual improvement of the program.

Many questions remain. My hope, however, is to come away with a better understanding of how to take the best of what we know from research and practice in science education and teacher education to craft a more robust experience for preservice elementary teachers than is possible in a typical undergraduate teacher education program.