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EDITORIAL

Talking the Talk and Walking the Walk

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As we travel to various places around the world, there continues to be discussion about what are considered essential components of a science teacher education. Naturally, there is much discussion about the nature and quality of some of the most well-known experiences/elements, such as early field experiences, methods courses, student teaching, microteaching, etc. The research literature on these aspects, as well as others, has been comprehensively discussed in the Report of the AERA Panel on Research and Teacher Education, "Studying Teacher Education" (Cochran-Smith & Zeichner, 2006). Additionally, however, there continues to be discussion surrounding the importance of authentic scientific research experiences for preservice science teachers. If future science teachers are expected to have college degrees in their specific science teaching areas, one could assume that such experiences would be included with one's science subject matter courses. However, knowing what we know about the didactic nature of postsecondary science instruction, this may be a weak assumption. And, of course, the situation is totally different for those preparing to be elementary teachers. In the US, such experiences for teachers are more commonly associated with externally funded projects (as opposed to a mandatory part of a preservice program), but in other parts of the world, (for example, The University of Helsinki) such experiences are more commonly institutionalized into preservice programs.

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What is the Value of Authentic Research Experiences for Preservice Teachers?

Science education reform documents throughout the world strongly support inquiry-oriented instruction and students' ability to do scientific inquiry. Naturally, it is assumed, that if teachers are expected to teach students to do scientific inquiry/practices (science practices stems from the new US *Next Generation Science Standards*, NGSS, 2013, but for ease, **inquiry** will be used subsequently) they should have had some experience doing inquiry themselves. After all, it is difficult to teach something with which you have had little experience. This is a fairly logical and intuitive assumption with which few would disagree. In addition, the worldwide focus on scientific literacy also proposes that students know about inquiry, that is knowledge about how inquiry (e.g., the idea that there is no single scientific method) and have an understanding of nature of science (characteristics of scientific knowledge that are directly derived from how the knowledge is developed). These desired student understandings have most recently been expressed (more or less) in the NGSS (2013).

The National Science Foundation also has perennially recognized the value of research experiences for teachers through its well known Research Experiences for Teachers (RET) program. But, again, this is an example of research experiences that are supported by external funding as opposed to being institutionalized in a teacher preparation program. There are programs where a research experience is required, but these are not common. And, in fact, the RET program is really targeted for inservice teachers. The scientific community has valued such experiences for its neophyte scientists in its fairly successful (Campanile Faurot, Doe, Jacobs, Lederman, & Brey, 2013; Campanile Faurot, Lederman, Jacobs, & Brey, 2014; Seymour, Hunter, Laursen, & Deantoni, 2004) Research Experiences for Undergraduates (REU) programs. These programs are slightly different in focus from such experiences for teachers because they attempt to enculturate science majors into the community of scientists. Field experiences for pre-service teachers are the analogous experience for preservice teachers, but they are not science research experiences.

Do These Experiences Accomplish Their Goals?

Generally speaking, preservice teachers having research experiences benefit in terms of classroom practice, attitude toward science, and ability to do inquiry (Brown & Melear, 2006; Windschitl, 2002), however, the results do not always translate into classroom practice (Brown & Melear, 2007). More impressive is that there is some evidence that the gains in teachers' knowledge, skills, and confidence also translate into achievement gains in their students (Silverstein, Dubner, Miller, Glied, & Loike, 2009). The connection between research experiences for teachers and teachers' skills in doing inquiry seems to be direct and expected. Whether these skills translate into classroom practice is a bit more complicated and would need to involve some instructional support (Windschitl, 2002).

But, what about research experiences and their impact on teachers' knowledge of scientific inquiry and nature of science? Unfortunately, there is quite a bit of empirical evidence showing that simply participating in an active science laboratory, or doing scientific investigations, does not necessarily result in functional understandings of nature of science and scientific inquiry (Lederman, 2007). This is most commonly the result of the teachers not receiving any explicit and reflective instruction on nature of science and scientific inquiry. The same has been found with high school students working in scientists' laboratories (Bell, Blair, Crawford, & Lederman, 2003). In both cases the scientists within whose laboratory the teachers or students are working do not necessarily have the time, knowledge, or inclination to engage in conversations about nature of science and/or inquiry. The focus of these experiences tends to be focused solely on doing the investigation. This is quite analogous to the problems that often occur in REU laboratory experiences. In particular, the laboratory scientist does not necessarily have the time to engage in instructional/mentoring discussions with the undergraduate students about the research project and the dynamics of a functioning science research laboratory. The lead scientists are also commonly concerned about the impact of a relative novice on their research projects (Dolan & Johnson, 2009, 2010; Reddick, Griffin, Cherwitz, Crda-Prak, & Bunch, 2012; Thiry & Laursen, 2011).

In summary, suffice it to say, that although there can be some problems with requiring teachers to have authentic research experiences during their preservice preparation (and probably as part of their inservice professional development), most science teacher educators would agree that such experiences are a valuable experience. Perhaps, we should investigate whether these experiences need to be in an actual science laboratory or would it be just as beneficial in a more carefully monitored science research class in which it could be insured that specific attention is given to nature of science and scientific inquiry.

What About Engineering?

With the current advocacy for attention to the integration of the STEM disciplines within science instruction, engineering and its relationship to science has attracted the attention of many. Indeed, the NGSS (2013) have explicitly stated standards for engineering practices. It would seem that the same logic used for advocating the inclusion of authentic science research experiences for teachers should also apply to engineering experiences. After all, if a teacher is expected to facilitate students' understandings of engineering practices, shouldn't they have had experiences in performing engineering practices? At this point, we think most teacher education programs are still struggling with how to include engineering in any way (e.g., knowledge of engineering) within their preservice programs. If we want to *talk the talk and walk the walk* with respect to inquiry, shouldn't the same be true for engineering? In some ways, we are fortunate to be at Illinois Institute of Technology (IIT), a university that is primarily an engineering institution. All students at IIT are required to take an Inter-professional (IPRO) projects course as part of their undergraduate, regardless of major. These courses form groups of students from the

various university majors to work together on completing what is most commonly an engineering project. The goal is to have students experience the interdisciplinary teams that engineers work on in the "real" world. Naturally, this is not always useful for students majoring in non-engineering fields, but IIT still has an engineering mentality for all. In short, it could be argued that such experiences are teaching students about engineering practices. We said we may be lucky at IIT because we have courses focusing on engineering practices already institutionalized. We dare say that most science teacher educators do not have the same "luxury." These IPRO courses are not a panacea, which is why we placed luxury in quotes. But, we are carefully considering whether such experiences should be included in our preservice teacher education programs.

But the big questions that remain is whether science teacher education programs should require formal science research experiences and should they also include formal engineering research experiences? The logic for each directly follows the policies and reform advocacies worldwide that stress STEM (in one way or another) and, therefore, also stress students' knowledge about inquiry and about engineering. In many ways, the situation is the same as we have all experienced throughout our careers in teaching and teacher education. That is, although we have well-meaning and carefully thought out goals for what students should know and be able to do in order to be productive citizens, we continually fall short in providing the appropriate preservice education and inservice professional development to afford teachers the opportunity to help their students achieve. We do not have any quick fixes or definitive solutions, but the questions we raise are serious and compelling. As science teacher educators, **if we want to talk the talk, we need to walk the walk!** (regardless of the pathway).

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