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More Regard for Teaching and Can We Learn from Math Education

Success

One of the strengths of educational research in general—and science education certainly played a major role in this—is the re-recognition of the importance of the teacher in schools/learning. Although not a new idea (Durkheim (1902) and many others have suggested as much) the explication of how teachers are important is relatively new, and has proven productive. Over the past 30 years or so, the reform in science education has moved beyond analyses of teaching and learning in terms of notions of "correct/incorrect" and "effective/ineffective" to a more nuanced effort to uncover the structures in student and teacher thinking about the teaching and learning of science. And when taken with other productive domains of science education scholarship, such as misconceptions research, and multicultural science education; coupled with multiple research perspectives/methods, our understanding of teaching and learning has dramatically increased—to the point where I find it a terribly daunting task to make sense of it. Add on top of that, the attention given to inquiry, nature of science, history of science, standards and so on makes my head spin.

As I look across the body of work in science education reform, I am drawn to attempting a comparison with mathematics education. As a high school teacher of both math and science, I believed that the connections and relationships between the two were both powerful and illuminating. When I looked at graduate schools, I chose because of my institution's strength in both mathematics and science education, hoping to capitalize on the interaction of both domains. As I quickly learned with surprise (due to my naiveté), mathematics and science education as research enterprises tend to operate quite independently.

But I can't shake the notion that there might well be something important to learn from a comparison between science and mathematics education. Linked intimately in common perception, and across many contexts, they are broadly considered essential components for education in our country. But mathematics, due to its central place in the elementary curriculum, has been forced to run a few steps ahead in terms of their development of national standards, in their development of curriculum, and in their investigation of teacher learning and professional development. So, it might be interesting to consider how the field of mathematics education is a model for the construction and enactment of standards. How do standards in mathematics differ from the standards developed in science? How might we build off of the methodological and conceptual work of folks such as Deborah Ball? And would we even want to?

It might be fun to think about science education from a mathematics education perspective by making liberal use of a paper written by mathematics educator Jack Smith (1996) entitled, "Effficacy and Teaching Mathematics by Telling: A Challenge for Reform." I will frame some discussion questions around an adaptation of the ideas found in this paper to examine the question that seems to undergird many efforts in science education: "Traditional Instructional Practices in Science: A Challenge for Reform."

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Vexation

Adapting Smith to science education equivalents, the challenges to teaching reform-based science lies in the following 4 standard features of traditional practice. First, school science is largely a fixed set of facts, concepts, theories and techniques. Second, given the first, the central task of teaching is to provide clear, step-by-step instruction, respond to student questions, provide adequate opportunities to practice and to offer corrective support. Third, students learn by careful listening to the teacher, doing practice problems and homework, and following directions. Due to the emphasis on memorization, success for the student is largely dependent on effort or innate ability. And fourth, answers to all science problems are known and found in textbooks. The teacher serves as an "intermediate authority" for students on matters of scientific truth. If students' have questions, the teacher should know or will look it up and get back to students the next day. Smith recognizes that these four "pillars" are not independent, but that they are features that constitute a consistent and robust source of efficacy for teachers. In these terms then, the trouble with reform is that each traditional pillar is undermined by reformist notions of teaching and learning. Knowledge in science isn't fixed; teachers don't tell, they create learning opportunities; students' construct their own understandings; and textbooks are tools, not final authorities. Smith argues that successful reform will require that such traditional pillars of efficacy can be replaced with equally satisfying, reform-based pillars.

Smith argues that there are likely four sites of efficacy in mathematics reform that the research community and teachers might profitably engage. I write their parallels in science as: (1) choosing learning tasks that engage significant scientific content (where content is broadly construed), (2) predicting and responding to student reasoning, (3) generating and directing scientific discourse, and (4) the "judicious" use of traditional practices.

I am curious to hear what people think about each of these. First of all, to what extent do these four characterize the trajectory that mathematics education has taken? Has the research in mathematics provided empirical support for them? And then, how do these four sites of teacher efficacy serve to depict what science education research is attempting to articulate? Recalling the centrality of teachers in successful reform, how does (or could) empirical work of the science education community help provide bases for science teacher efficacy? Do these four sites form an adequate basis for reform-based teaching practices? In what ways has science education research engaged them? In what ways do science teachers have opportunity to base their teaching efficacy on the four pillars of reform-based teaching as opposed to the four pillars of traditional science instruction.

And in thinking back to the broad trajectory of mathematics education research/practice… Is this a trajectory that science education could follow? I mean, it's possible that the fields are different enough that it's not possible to follow mathematics' lead? And then, what might we learn from a comparison to mathematics education? Perhaps such a discussion will inform our collective vision about what's possible for science education research and it's ability to inform and improve practice.

Durkheim, E. (1977). *The evolution of educational thought* (P. Collins, Trans.). London, Boston: Routledge & Kegan Paul.

Smith III, J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education*, *27*(4), 387-402.