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Conceptual Change: It's Not Just for Teaching Science

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Mark Twain is often given credit for saying, "It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so." Science teachers likely resonate with this quote because we know our students come to class confidently holding many ideas about the natural world that "just ain't so." More than a decade ago Driver (1997) noted that:

> Some of the more complicated learning we have to do in life, and a lot of science is like this, involves not adding new information to what we already know, but changing the way we think about the information we already have. It means developing new ways of seeing things.

For students to develop new ways of seeing things, science teachers must first create experiences that cause students to question their intuitive ideas and then provide a more plausible idea that will, over time, move students to a deep understanding of accepted scientific knowledge.

Teaching for conceptual change is challenging for teachers, but also for our students. As Driver (1997) stated:

> We know that changing the way you think about things can often be not just difficult, but emotionally taxing because it means giving something up. It means letting go of some knowledge that you have used in the past. It means letting go of something while you are still unsure about what it is you are grasping after in terms of a new way of seeing things.

This conceptual and emotional difficulty in letting go of long held ideas is also seen among scientists during periods of significant change in their field (Kuhn, 1962) and is also ubiquitous in most professions when accepted ways of thinking and acting are challenged.

For these same reasons, science teachers often resist changing their time-honored practices. Presenting information via lecture, overheads (and now presentation slides), textbook readings, worksheets, and cookbook activities has been the standard for science teaching for as long as most of us can remember. Even though overwhelming evidence makes clear such practices are largely ineffective for most students (Minner, et. al., 2010), we resist the long-standing calls (Dewey, 1909; Schwab, 1962; AAAS, 1989 & 1993; NRC, 1996; NSTA, 2004) to change our pedagogical practices and teach science through inquiry. Much like our students who experience cognitive dissonance between old and new ideas, rethinking learning, teaching, and the teacher's role in the classroom means we must reconsider what we find familiar, comfortable, and perhaps even intuitively obvious about teaching. Views about teaching are constructed and sharpened through years of experience, both as students and then as teachers. The very act of questioning such long-held notions of teaching and learning can be unsettling.

Even when we genuinely want to change our pedagogical practices, because our past experiences are so often dissonant with inquiry-based teaching, we struggle to actually implement such practices – tripping over questions, giving in to student resistance, or genuinely not knowing how to scaffold students from their mistaken or initial ideas to accepted science thinking. In essence, efforts to improve practice may initially be no more effective than previous practices. Again, in the words of Driver (1997):

> Teaching is a very complicated job. Teachers need to carry a lot of information in their minds at once — there are many planes at which they are thinking. Overall general lesson strategies, what they want to happen at particular times. The minute-to-minute eye that they're keeping on different children in terms of their behavior and whether they are on task. Now if you ask teachers to change their strategies from tried and tested strategies they've developed over the years, it de-skills them to begin with. All this complicated behavior that they've developed a way of managing, they start having to rethink it again. It's like riding a bicycle, if you start thinking about what you're doing, that's when you fall off.

The editors of the *Iowa Science Teachers Journal* know effective teaching is very difficult and emotionally taxing. All current editors have taught secondary school science, and we confronted many difficulties and institutional constraints in teaching science through inquiry. But the improvement in students' understanding of science content and the nature of science, and their improved attitudes toward science were worth the difficulties and uncertainties we often faced. That is why we strive to ensure that all articles appearing in *ISTJ* support teachers in their efforts to teach science through inquiry. We work with authors to ensure each article effectively conveys:

- How students are engaged in wrestling with questions about the natural world.
- Strategies teachers use to promote deep thinking about those questions.
- How students are encouraged to make sense of data and share their results.
- The questions teachers ask, the wait-time they use, and how they respond to correct and incorrect student ideas to promote extensive small and large group discussions that scaffold students to accurate science understanding.

These pedagogical practices are essential for mentally engaging students deeply in science content, promoting critical thinking, and developing a far more robust understanding of science concepts and the nature of science. Furthermore, this approach can be used to help students to see science as more than a set of facts to be memorized, thus improving attitudes toward science.

Editorials in the next two issues of *ISTJ* will address some of the difficulties associated with understanding and implementing inquiry-based science teaching practices, and how to persevere when the going gets tough. Conceptual change *is* cognitively demanding and emotionally taxing. Understanding science concepts often requires students to abandon tightly held ideas about the natural world. Understanding effective science teaching may demand that we abandon our tightly held ideas about teaching and learning. Many of these long-held views *just ain't so*, and these misconceptions *are* hurting students and the teaching profession.

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