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When Dissatisfaction is a Good Thing

Michael P. Clough
Iowa Academy of Science

Jerrid Kruse
Iowa Academy of Science

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Dr. Michael P. Clough and Dr. Jerrid Kruse

Our previous editorial (Clough and Kruse, 2010) in the *Iowa Science Teacher Journal* used conceptual change theory (Posner, 1982; Pintrich *et al.*, 1993; Abd-El-Khalick & Akerson, 2004; Clough, 2006) to highlight the similarities between students learning science content and educators learning to teach well. An important part of conceptual change is first acknowledging and then confronting current ways of thinking. That is, before learners (whether children or adults) will consider altering their thinking, they must first develop some sense of dissatisfaction with their currently held ideas. That can be difficult because the ideas people hold do appear to work — that is why they are satisfied with their current thinking.

For example, many middle school students maintain that “heavy” objects sink and “light” objects float. When asked to explain why they think that, many examples are provided of heavy objects sinking. And, of course, many heavy objects *do* sink! That's why misconceptions are so resilient; they often do have a grain of truth to them. Thus, even though students may memorize the formula for density, or *appear* to conceptually understand density, probing often shows deeply held misconceptions regarding why things sink and float. The ability of learners to hold incongruent perspectives side-by-side for use in different contexts with no awareness of a contradiction is well established (Resnick 1987; Galili & Bar 1992; Mortimer 1995; Tyson *et al*. 1997). What this means is that learners will unlikely abandon their misconceptions without first coming to accept that those ideas don't work as well as they previously thought.

Clear and compelling evidence and reasoning must be directed at confronting strongly held misconceptions to create the dissatisfaction that will result in learners considering alternative ideas. Consider for instance when students are shown several very heavy objects that float and several very light objects that sink. Any teacher who has done this and then asked students to reflect on how what they've observed fits with their thinking that “heavy things sink” can attest to the cognitive dissonance seen on students' faces. Moreover, continuing student reflection with a question such as “What is the demarcating line between heavy and light?” helps students see cracks in their previous explanation regarding sinking and floating. These sorts of direct experiences and cognitive challenges initiate the dissatisfaction prerequisite to the eventual abandonment of students' intuitively appealing and strongly held ideas regarding floating and sinking. While traditional instruction may quickly have students reciting the correct formula for density with fidelity, if they have not become dissatisfied with their “heavy” logic, students will easily slip into previous problematic ways of thinking.

Politicians, business people, scientists, and even educators also possess strongly held intuitive ideas about teaching and learning. Many of these ideas have rarely been examined, but they are strongly held because they appear to make sense. For instance, many people subscribe to the idea that “as long as the expert tells the story clearly and that the person who is learning is listening and paying attention then they will automatically build up the understanding that the expert has (Driver, 1997).” Reflecting this view, presenting information via lectures, presentation slides, textbook readings, the internet, and cookbook activities just makes sense. These common science teaching practices *appear* to work because they do have an element of truth about them — in the same way that some heavy things do sink. Moreover, these intuitively obvious ideas about teaching and learning are held by students, parents, policymakers, and even many teachers and administrators. Thus, intuitive views of teaching and learning, the fact that such views have some truth to them, and their widespread appeal coalesce to make difficult creating dissatisfaction with common teaching practices. But as we noted in our last editorial, “Long-held views about learning and teaching science *just ain't so*, and these misconceptions *are* hurting students and the teaching profession.”

Given the ubiquitous view that teaching is presenting information and learning is recalling that information, and the high stakes testing that reflect and promote that view, why should science teachers question and become dissatisfied with the status quo? We maintain that teachers truly do care about children of all ages and that teaching is a sacred activity (Clough, 2008). This genuine caring for our students and their learning, and acknowledging our responsibility as teachers (in the most noble sense of that word) is what initiates the questioning and dissatisfaction with traditional teaching practices. The connection between genuine interest in our students' welfare and dissatisfaction with traditional teaching practices is nicely illustrated in the words of Minstrell (1997):

> When I started as a teacher, my students, my administrators thought that I was doing a very admirable job. And as long as I asked questions I had trained the students to do, they did fine. But if I snuck up on them just slightly and went for some depth of understanding, then they were in trouble. And that bothered me.

Being bothered by students' superficial recall of fundamental science ideas, their difficulties applying in novel situations what has been previously taught, their misunderstandings of the nature of science, and falling well short of the goals in figure 1 *should* bother us and initiate a sense of dissatisfaction with long held views about teaching and learning.

But obviously something about time-honored science teaching practices makes sense and appears to work. In addition to the intuitive idea that understanding results from having something carefully explained,

FIGURE 1
Goals for Students

- Demonstrate deep and robust understanding of fundamental science concepts.
- Use critical thinking skills.
- Convey and apply an accurate understanding of the nature of science.
- Identify and solve problems effectively.
- Use communication and cooperative skills effectively.
- Actively participate in working towards solutions to local, national, and global problems.
- Be creative and curious.
- Set goals, make decisions, and self-evaluate.
- Convey a positive attitude about science.
- Access, retrieve, and use existing scientific knowledge in the process of investigating phenomena.
- Convey self-confidence and a positive self-image.
- Demonstrate an awareness of the importance of science in many careers.

many students do pass our classroom and high-stakes assessments, and some students do successfully enter science and science-related careers. That evidence, like the evidence students cite supporting their views that heavy things sink, appears sufficient to support time-honored teaching practices. However, just as we have students look beyond their superficial confirming evidence for why things sink and float, we must look more broadly at the research regarding students' understanding of science content, the nature of science, and other goals in figure 1.

Perhaps the greatest indictment against traditional instruction is the persistence of students' misconceptions regarding fundamental science ideas despite having been repeatedly told correct science explanations (Lord, 2005; Minds of Our Own, 1997; Private Universe Project, 1995). Indeed, research into the general public's science literacy demonstrates that time-honored science teaching practices do little to improve understanding of science content and the nature of science (Miller, 1983, 1987; NAEP, 1979; Ziman, 1991). Although citizens continually express interest in science, they are largely not well informed about science issues (National Science Board, 1986, 1998, 2000, & 2002). The 1998 National Science Board reports that adults universally could not explain science ideas when asked open-ended questions. Students' superficial grasp of science ideas is illustrated in their inability transfer what has been taught to new contexts (Georghiades, 2000). Even the best students too often struggle to accurately explain and apply what they are told. For instance, graduates from some of our country's finest universities provide naïve intuitive responses to questions regarding science content repeatedly taught in their K-college schooling, and other graduates struggle to light a light bulb with a battery and wire (Minds of Our Own, 1997; Private Universe Project, 1995).

While science content is accurately *taught* via traditional teaching practices, it is too often not *learned* by students. Accurate responses on end-of-chapter tests and other recall assessments mask the underlying conceptual misunderstandings that students possess. Those misunderstandings and the inability to apply scientific knowledge in novel circumstances persist despite traditional teaching practices. Furthermore, traditional science teaching practices create and reinforce inaccurate views of the nature of science (Clough, 1995; Durant *et al*. 1989; Millar and Wynne 1988; Miller 1983, 1987; National Science Board 2002; Rowell & Cawthron, 1982; Rubba, Horner & Smith, 1981; Ryan and Aikenhead, 1992) and make science-related careers appear unappealing.

We do not mean to paint an overly bleak picture of the state of science education. Pockets of undeniably excellent science teaching do exist and science teachers do care about their students. Everything we write here reflects our deep respect for teachers, the teaching profession, and the complexity of truly effective science teaching. However, we must acknowledge the overwhelming evidence that something is amiss with traditional teaching practices, and become dissatisfied with how science teaching is commonly done.

Moreover, defending archaic teaching practices will further intensify the attacks by those who wish to see computers and on-line instruction replace face-to-face teaching. Simply presenting information to students, having them read textbooks, complete worksheets, follow highly directive activities, and repeat back information are not effectively promoting the goals in figure 1. On-line instruction will be just as ineffective as this kind of face-to-face instruction, but it will be less expensive!

We are genuinely concerned that the sacred nature of teaching is being lost as policymakers reduce the goals of schooling to simply passing high stakes exams. Truly effective science teaching practices cannot be replaced by machines. Children deserve the presence of a caring teacher, one who interacts with them and engages them in a way a computer cannot. Intuitive and time-honored science instructional practices can be easily replicated and replaced by machines, and that alone should make us pause, create a great sense of dissatisfaction about traditional teaching practices, and move us all toward what research has made clear for decades is crucial for a meaningful and effective science teaching and learning.

Choosing to be dissatisfied with long-held teaching practices and the journey toward effective science teaching are cognitively and emotionally challenging — as is all meaningful conceptual change. But the results are worth the effort. Our next two *ISTJ* editorials will address that journey, and the obstacles that can interfere with the most ardent desire to promote highly effective science teaching practices that restore the sacred nature of teaching.

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