Why We Can't Talk to One Another About Science Education Reform

Even though science teachers and other stakeholders all want students to be instructed in the most effective way possible, discussions about what that way might be are seldom productive. The problem, as Mr. Windschitl sees it, is that the participants automatically revert to the "scripts" of two warring factions. He suggests a way to move the conversation forward.

BY MARK WINDSCHITL

RECENTLY I recalled an incident from some 20 years ago when a fellow middle school science teacher nearly put my eye out. This wasn't an angry encounter. Rather, a group of us had come together in a classroom after school to discuss an article in a professional journal that advocated cooperative learning for students. We had barely begun the conversation when someone made the mistake of mentioning "kids constructing their own knowledge." Immediately I heard a shuffling sound and turned my head just in time to avoid being hit by an enflamed colleague swinging a meterstick back and forth with both hands, like a fireman at a three-story blaze, shouting, "And then — look out! We'll just have to hose off all their crazy ideas and teach them real science!"

This bit of excitement turned out to be just a taste of the controversies to come as our science department engaged in passionate discussions during the school year over reform issues like student-centered teaching and inquiry learning — discussions that were typically disappointing and often divisive. I wondered, "Whenever we consider changing the status quo in classrooms, what is it about the way we talk to one another that makes discourse so unproductive?"

In the years since, I have listened intently during dozens of school board sessions, textbook-adoption meetings, and science department retreats where par-

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ticipants have used closely held beliefs, values, and images to stake out positions on issues of instruction and curriculum. What I have found in these conversations is that, despite a number of shared goals for student learning that participants bring to the table and despite the shared understanding that there are as many ways to teach as there are teachers, the dialogue about science education quickly and inevitably reaches a stalemate in a contest between two irreconcilable scripts. For lack of more colorful terms I will refer to them as "traditional talk" and "reform talk." It is this rhetorical bottleneck that I want to explore here, using a recent experience with such a conversation as an illustration. First, however, some background is necessary.

Roughly speaking, traditional talk focuses on student acquisition of scientific facts, concepts, principles, and skills. It argues that the classroom works most efficiently when teachers give clear explanations of scientific ideas and guide students through carefully controlled laboratory experiences. Reform talk, on the other hand, emphasizes that teachers must challenge and build upon students' existing ideas, as well as offer authoritative explanations of scientific phenomena. Reform talk further argues that students are often capable of making sense of scientific ideas on their own or in concert with other students and that learners can best understand the processes of science by conducting their own investigations.

At this point, I have probably insulted readers who consider themselves reformers or traditionalists and left the rest wondering where I get off inventing simple-minded caricatures of such complex positions. Please bear in mind, however, that I am not referring to actual teaching practices. I am referring instead to *two streams of talk that get activated* when people with different beliefs, values, and backgrounds come together to discuss the possibility of departing from business as usual in their school's science classrooms.

Of course, when people discuss such issues (e.g., how standards will be implemented in their school or whether to use curriculum kits), they feel as compelled to belittle the views of those different from themselves as they do to explain why their visions of teaching should dictate new directions (or preserve the old). Traditional talk, then, often casts reform classrooms as experimental, child-indulgent free-for-alls, while reform voices criticize traditionalist approaches as rigid, authoritarian, and outmoded.

What is remarkable about these conversations, apart from the predictability with which participants play out such scripts, is the historical regularity of similar arguments. The reform view of education in the late 1950s, for example, was tied to a "life adjustment" curricular ideology that had its roots in the progressive education movement. It was a type of functional schooling in which academic subject matter was deemphasized in favor of courses designed to meet the immediate social, personal, and vocational needs of the student. Academics and scientists charged that life adjustment focused on methods of instruction rather than content and promoted emotional adjustment at the expense of learning.[1]

The traditionalist critique was articulated most earnestly by Illinois historian Arthur Bestor in his classic polemic, *Educational Wastelands*, in which he claimed that reform teaching served "only as a narcotic to kill the pain of thinking."[2] Reformers of the era, in turn, believed science learning should begin with what students were curious about rather than be imposed through, as one educator put it, "the willing acceptance of Olympian pronouncements on the authority of that terrible trinity — text, teachers, and tests."[3] Similar antagonisms were expressed in the early 1980s and are being replayed again today. For contemporary science educators, these bitter arguments now involve inquiry-based curricula, "constructivist" approaches to teaching, and the impact of standards on instruction.

I propose that if those of us in the science education community want to do more than resurrect, once again, those artificial roles and threadbare patterns of dialogue, we must begin by *shedding some light on the arguments themselves*. I offer a recent experience of my own to begin this task. About a year ago, I wrote a story for a Seattle newspaper on standards-based teaching in science classrooms. My aim was to help parents and other concerned citizens understand what current reform efforts in our state were requiring teachers to know and be able to do in classrooms. (Yes, I am a reform advocate of sorts.) My main points were these:

1. State and national science standards ask students to demonstrate basic conceptual knowledge, but that's not all. Students are asked to solve nonroutine problems, to design and carry out investigations themselves, and, finally, to write about these efforts in clear explanatory prose. These are authentic tasks that have value beyond the classroom.

2. To achieve these standards, students need two things. The first is the opportunity to engage in inquiry and problem solving as a part of their regular curriculum — not, however, to the exclusion of learning concepts or facts. The second is to receive regular formative feedback from teachers on their thinking and on their performances.

3. Students need time and opportunity to make sense of scientific ideas as well as disciplinary practices. This means being able to "talk out" their thinking with the teacher and

with others. Although some students can learn fairly well by doing little more than listening to explanations offered by teachers, the great majority cannot reach acceptable levels of understanding without reconstructing their current ideas in the conversational company of other learners (including the teacher).

4. To support this vision of classroom learning, reform-minded teachers need to facilitate activities that are unlike any they experienced themselves as learners. This requires knowing how to elicit students' current understandings of scientific ideas, to orchestrate classroom discourse so that it moves students from everyday ways of talking about phenomena to scientific ways, to mentor students through complex investigative experiences so that they become capable of inquiry without following predetermined protocols, and to use formative feedback to help students understand where their thinking is breaking down.

In the days after these ideas appeared in the paper, I received e-mails from a number of concerned readers. For some, my words struck a chord ("thank you for sharing about the lives of teachers who are trying to make a difference"), and for others my words struck a nerve ("people like you are the reason good science and technology jobs are going overseas"). The e-mails from those who saw my vision as a threat to science learning were painful to read, but I was driven to understand whether we were communicating anything at all or just pitching monologues past one another. I even had further conversations with three of my most energetic critics. What emerged is not a profound revelation but a modest working hypothesis about local conversations around ideas of science education that happen every day in this country.

CORE THEMES OF REFORM VERSUS TRADITIONAL TALK

There are three themes that characterize exchanges between reformists and traditionalists: 1) giving kids "the basics," 2) the value of doing science, and 3) the role of the teacher.

Giving kids the basics. In my conversations with the three traditionalist respondents to my opinion piece, each of them made multiple references to "giving students the basics." One respondent charged that "educators place no value in learning the basic facts of science." Another remarked, "I have no criticism of giving high school students general knowledge about the environment, health, chemistry, and genetics, but don't call it science. Call it 'popular science.' Then offer courses in real science and offer the basics that are challenging."

In traditional talk, basics are fundamentally important facts, concepts, and skills that must be mastered before they can be used in activities like problem solving or scientific investigation. Traditional talk uses inherently convincing metaphors to make its point here. How can you build a house without a foundation? How can you play basketball without learning to dribble? Charges of failing to provide students with the basics always sound ominous, like sending them into the woods without a canteen or compass. What students should eventually do with these basic ideas, however, is not always made clear in traditional talk.

In contrast to the traditionalists' straightforward basics message, the reformist rhetoric about what is most important to teach is more complicated. Reformers typically talk about the "disciplined uses" of knowledge (in problem solving or inquiry) as fundamental abilities all students must develop. They suggest that many concepts and skills should not be taught separately but learned within the context of solving problems. Unfortunately, for most teachers, this idea evokes a sense of uncertainty. When teachers cannot easily imagine how they would organize this less-familiar kind of instruction or specify in some detail what the learning looks like when it happens, reform teaching becomes a high-risk venture. While traditional talk about basics is like a billboard — compelling in its simplicity — reform talk about what is fundamentally important for students to know is like a plotted story that carries more meaning but requires greater commitment to understand.

Anyone's talk about basics is — or should be — linked with talk about student thinking, but this connection rarely gets played out in any productive way. Although both sides acknowledge that students should understand as much scientific knowledge as possible, each group talks about

this goal in different ways. For thoughtful traditionalists, thinking is couched in terms of comprehending, integrating, and applying knowledge. The students' task, however, is comprehending how the *teacher* has integrated or applied the ideas. If the teacher describes how the laws of optics help us explain the way the human eye works, the task for students is to recognize how the teacher made those connections and to reconstruct the teacher's thinking on the next test. Students who can't do this must rely on the brute force of memory to perform well on assessments. This strategy works well for some in the short term — but for none in the long term.

In reform parlance, thinking means sense-making — hard intellectual work that the student is responsible for. This means learners go beyond the information given by the teacher and make connections for themselves that may differ from student to student. For the teacher, this suggests uncertainty (again) about how learning unfolds in the classroom and necessitates a wholesale reconsideration of the role of assessment. The reform talk that valorizes student construction of knowledge can never, in fact, acknowledge in full detail the breadth of instructional changes required by this new world view. Traditional talk describes such a constructivist approach as an instructional liability. Knowledge, in the traditionalist view, can be unproblematically "acquired" from teachers and is no different from what is more laboriously learned via sense-making for one's self.

Regrettably, the whole discourse around prioritizing basics has been sold to and adopted most wholeheartedly by teachers and parents in high-need schools. Academic tasks with low cognitive demand, such as simply recognizing "right answers," are easily administered and unambiguously assessed. ("What is the freezing point of water?") The drill and practice that imprints correct responses in students' brains requires only the lowest levels of teaching expertise and maximizes control over both the social and intellectual activity in the classroom.

The value of doing science. The second recurrent theme in reformist/traditionalist conversations about science teaching is the value of doing science. Reform talk extols the virtues of students posing questions about the natural world and designing ways to answer those questions; traditionalist talk is more conservative about these experiences and often uses the crowded curriculum as a rationale to restrict such time-consuming activities. One of the respondents to my newspaper piece referred to reform methods in general as "the hands-on group learning method" and characterized it as "something that most scientists disdain because it doesn't give you the fundamentals you need to conduct science, and it's very inefficient."

Reform advocates, who consider the ability to "do science" one of their fundamentals, maintain that it is not enough to be familiar with the products of science (facts, concepts, theories, models); students must be able to emulate the disciplinary activities that generate these products. The rift between reformers and traditionalists on this point is that reformers talk about problem solving and inquiry as valuable activities in and of themselves, while traditionalists view these as cumbersome ways to develop concepts that could more easily be communicated directly by the teacher. One respondent offered such a view of classroom inquiry: "What is interesting is having teachers talk about really important experiments that led to major scientific findings and having the teacher be excited about them." Another respondent wrote that "we never did any experiments in elementary school and very few in middle or high school, but we were really learning a lot of advanced material from the teacher."

Some lines of traditionalist argument do promote "labs" as both a form of engaging hands-on work and a connection to the discipline of science. The laboratory experiences they refer to, however, are often prescribed by the teacher in painstaking step-by-step detail for the student. Indeed, the outcomes of such activities are known by everyone ahead of time, and it is often possible to receive passing grades without knowing any science at all.

Reform language, on the other hand, makes reference to a melange of active learning strategies that can be bewildering even to its own advocates. Reformers talk about students getting involved in "authentic practices" or "con-

necting with the discipline." They use such terms as "inquiry," "discovery," "hands-on," "minds-on," "experiments," "problem solving," and "project-based learning." These terms were coined at different times within particular historical and curricular contexts to help teachers organize their thinking around the idea of active learning with students. Today, however, few teachers (or academics) along the reformist/traditionalist spectrum have a clear idea of what the distinctions among these activities are, what they should look like in practice, or what the learning consequences are for each. Definitions and examples of "inquiry" in particular have been offered in authoritative publications, such as *The National Science Education Standards*, but this and other policy instruments do not often figure significantly in local conversations about science teaching. To complicate matters further, reform and traditional teachers alike claim to be doing "investigations" or "minds-on work" with students by fitting the meaning of these terms to whatever their current classroom practices may be.

The role of teachers. The third theme in conversations about reform concerns the role of teachers. Expectations for good teaching are, of course, bound up in the previous arguments about the basics and the value of doing science. Traditional talk confers a type of authority on the act of teaching that is based on a "received wisdom" model: the teacher has knowledge and the student will acquire it. One of my respondents wrote, "The teacher should know the science and pass it on to students in a way that gets them interested, but you don't have to do simple experiments to make science interesting." Another emphasized that "it is the teachers' primary duty to give students the information they need to succeed."

Traditionalists and reformers both agree that teachers need extensive subject-matter knowledge to do their job well, but they talk about using that knowledge in different ways. Traditionalists talk about teachers as master storytellers who generate meaning in the minds of learners by explaining concepts clearly, providing examples of key ideas, and generally engaging the attention of learners. Reformers do not question the need for teacher knowledge, but they talk about instruction less as stagecraft and more as facilitation. In the role of facilitator, reform-oriented teachers need a deeper and more flexible understanding of their field than their traditionalist counterparts. Why? Because they see learning as a process of reconstructing ideas that students already have, which means strategically eliciting kids' ideas about phenomena such as the flow of electricity or the orbits of planets.

In this view, to bring students toward a more scientifically coherent way of talking about and thinking about the world, you have to know where they are starting from. Instructional pathways for teaching about states of matter, for example, will look very different depending on whether your students believe air is simply empty space, a continuous invisible substance, or a gas composed of various types of molecules. To conceive of instruction as a coupling of "working on student ideas" and "presenting the authoritative view" requires that teachers have a larger instructional toolbox of examples, analogies, and lab experiences than those who disregard the unique and often entrenched ideas that students use to reason about scientific phenomena.

This role of facilitation extends beyond students' conceptual learning to their work in actually doing science. Because some of reform instruction is aimed at getting students to design and conduct meaningful inquiries, teachers must understand the disciplinary conventions for how questions are posed and the different ways one goes about collecting and talking about the evidence that addresses these questions. Reform talk portrays facilitation of student-centered work as an intellectually active role for teachers, but when instruction is framed this way, traditionalists consider teachers to be bystanders who abdicate their pedagogical obligations to learners.

DEFENDING OUR POSITIONS

Reformers and traditionalists tend to use two major strategies to make their points regarding these three themes. The first strategy is *the use of imagery as the primary tool of persuasion*. Traditional talk stirs up images we share from our past, such as the teacher lecturing energetically from the front of the room, the students bent dutifully over worksheets, or groups of learners working to find the one correct answer for the distillation exercise. In short, it seeks to convince through the appeal of the orderly classroom.

In contrast, reform talk about active learning describes students in small groups arguing about how to pose questions for a lab experiment, teachers sharing with students the leading of classroom discussions, and learners engaged in projects that demonstrate what they know about a particular scientific idea. While these images reflect potentially powerful learning experiences, they also arouse two deep-seated concerns for teachers: how to control the classroom and how to cover the curriculum.

Having students work in groups, one can argue, gives them an opportunity to air their developing ideas and to learn from conversations with peers. But on a more visceral level, teachers worry about students being outside their direct supervision, aimlessly chatting or engaging in pseu-

doscientific blather. The reformist image of kids as junior scientists (doing background research, devising testable questions, designing investigations, etc.) competes poorly with the sound of that giant curriculum clock ticking away in the back of the room. While the students learn high-level skills that won't be assessed on the state tests, that clock keeps repeating, "It's already April, and you've only made it halfway through the curriculum." For teachers, without the assurances that they can maintain a new kind of order in the classroom and have the explicit blessings of their administrators for a "less-is-more" curriculum, the debate over instruction can become a gut-level choice between order and chaos — and order always wins.

A second strategy both camps use when arguing their own positions is *cobbling together an inflated target for critique*. I had mentioned in my opinion piece, for example, that students should learn enough about science to allow them to participate as knowledgeable citizens in a democracy, but one respondent asserted: "You are not talking about science, but about life skills, citizenship, and current events." Similarly, I had written about students designing and conducting their own investigations, but this was interpreted by another respondent as a kind of superfluous exercise: "I can see that discovery methods may now be the only ones that work with students these days, because they have been led to believe that effort counts as much as product and memorization is not allowed." (Interestingly, the term "discovery method" was mentioned by all respondents but did not appear anywhere in my opinion piece). Another wrote simply: "You want to make science interesting by avoiding as much science as possible." These respondents morphed my talk of reform teaching into scenarios I had never envisioned, with characteristics that were antithetical to my beliefs about education.

Not to be outdone, of course, reformers are also guilty of distortion, but more often of stereotyping. Traditional classrooms are unfairly portrayed as lifeless holding cells where students toil away at meaningless tasks. The teachers are caricatured as control freaks who care little for differences between learners and do little more than read lessons out of textbooks.

The targets of distortion from both sides are, for the most part, illusory. "Traditional teachers" or "reform classrooms" are convenient fictions that we use to simplify how we talk about instruction. In reality, most teachers use active learning strategies *and* direct instruction; they use both group work *and* seatwork; they use paint-by-numbers lab exercises *and* allow students to pursue their own investigations. And of course, they all want their students to make sense of science. Perhaps we all use these reckless fabulations not so much to challenge the views of others, but to make more explicit to ourselves what we don't want the conditions of learning and teaching to become: nonintellectual, arbitrary, or guided by sentimentality. This much we all share.

MOVING TOWARD PRODUCTIVE CONVERSATIONS?

It would be disingenuous to suggest that this analysis points the way toward easy answers for undoing long-lived patterns of divisive talk. David Bohm, the noted scholar of dialogue, says major roadblocks to productive dialogue rise up when participants hang on tenaciously to assumptions and opinions, defending them at every turn.[4] The instinct to judge and defend is embedded in the self-defense mechanisms of our biological heritage. It leads to patterns of thinking and acting that separate people from one another and from the larger reality in which they are attempting to live.

In Bohm's formulation, genuine dialogue means that each person participates with the ultimate goal not of expressing him- or herself but of developing some shared meaning among participants. Perhaps this is what we should aspire to in our faculty retreats and school board meetings. However, finding such common ground is hard work. The emergent friction between contrasting values is at the heart of such dialogue, but it makes it difficult for participants to notice assumptions that are active in the group, including one's own. I offer two modest suggestions in setting the stage for these more productive types of conversations, drawn from the literature on professional development.[5]

First, don't allow personally held images to dominate the conversations. Such images are unsharable and too vague to be the currency of the conversation. Rather, ground the conversation in specific classroom scenarios. Pick some-

thing someone is likely to teach in your school. For example, try the seasons at the elementary school level, mechanical advantage in middle school, or ecosystems at the high school level. Then use these as concrete contexts to explore fundamental questions:

- What is really important for students to understand and be able to do?
- What would it mean for our students to think deeply about this topic?
- What would mark the differences between a superficial understanding of the topic and an in-depth understanding?
- How would you assess the knowledge and skills of your students?

Then consider together how instruction might be designed to meet the goals derived from the discussion of these questions. If the ideas of "discovery," "covering the curriculum," "controlling students," or "the basics" come up, they can at least be talked about in terms of the concrete scenarios you are thinking about together. Thus you can avoid imagining them in the abstract or, worse yet, according to some stereotype. The aim here is not necessarily to come to consensus, but to listen to the thinking of others, to get a better sense of your own understandings, and, perhaps most important, to see what meaning others make of your point of view.

An even more focused way to draw people into shared understandings is to examine actual student work. This requires some brave soul to contribute artifacts from students (lab notebooks, essays, drawings, concept maps, etc.) that are products of their thinking about important scientific ideas. Focusing on these artifacts, the group asks and tries to answer, "What do these reveal about student thinking?" and "What do these products tell us about instruction?"

I have personally seen both traditionalist and reform teachers undergo profound transformations in their thinking as a result of such experiences. They realize that their students have ideas about science that everyday classroom activity never reveals. In addition, many students, especially those most marginalized by the way science is "delivered" in classrooms, have hidden funds of knowledge about all kinds of natural phenomena or technologies that teachers never take advantage of. In looking at student work, reform and traditional teachers are confronted with evidence of the minimal impact that their own favored types of instruction often have on learning. They also realize how most forms of assessment cannot tell whether students understand scientific ideas on any deep level.

These two strategies can establish the grounds for coming to common understandings, but we should not expect a magical consensus to emerge. People's core values and beliefs are not that easily changed. This is especially true about people's perceptions of the value of "doing science." This issue is enmeshed with constraints about how class time should be used, issues of classroom control, beliefs about what kids are capable of doing, questions about whether such activities address valuable learning goals, and concerns about the ability of teachers to design and support such instruction. But being forthright about these issues in a public setting is itself a step in the right direction.

The science education experienced by students in America is largely under local control. Despite the influence of standards and textbooks, the kind of talk that takes place among school board members, teachers, and parents determines to a large degree what science gets taught and how it gets taught. These conversations are too important to become mired in verbal contests that simply balkanize our teaching community. Genuine dialogue is time-consuming, difficult, and often unsatisfying, but it is entirely necessary. Coming to consensus may be an impossible goal for participants, but developing some shared meaning is where progress will occur. Let's look in the mirror together.

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1. John Rudolph, *Scientists in the Classroom: The Cold War Reconstruction of American Science Education* (New York: Palgrave, 2002).
2. Arthur Bestor, *Educational Wastelands* (Urbana: University of Illinois Press, 1953), p. 121.
3. Paul Klinge, "Is Biology a Science Course?," *School Science and Mathematics*, vol. 14, 1950, pp. 379-83.
4. David Bohm, *On Dialogue* (New York: Routledge, 1996).
5. Susan Loucks-Horsley et al., *Designing Professional Development for Teachers of Science and Mathematics*, 2nd ed. (Thousand Oaks, Calif.: Corwin Press, 2003).