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Benefits of Misconceptions – But What Does Learning Leave?

Success

I wax nostalgic for the days of my first NARST conference through which I roamed from session to session, sampling work on students' science misconceptions. What I delighted in was how the literature exposed alternative conceptions – learners' consistent tendency to get things wrong – when thinking about scientific explanations. There are, it seems, so many pieces of nature that are so consistently inconsistent with our most natural ways of thinking. At my first NARST in 1999, I was able to sample the misconceptions in a very live display, tasting a bit of students' inability to grasp the scale of geological time and then five minutes later sampling how students' sense of matter interfered with their concept of heat.

And even now, I still get giddy when open a copy of Driver et al's *Making Sense of Secondary Science* text, a compilation of students' alternative conceptions. I love to watch "Private Universe" clips (see http://www.learner.org/resources/series28.html), especially with a group of preservice science teachers so that I can share in their shock and awe. I love to interview students or listen to students' answers in a classroom so that I can get a sense for how they are thinking so logically and sensibly and so wrong. I love the irony in all this. I love how a student's misconception tells us so much about how well and how much they are thinking. Understanding what students do not understand tells us volumes more about learning than understanding what they do understand.

The literature of conceptual change that began to extend the model into why and how alternative conceptions exist and are so difficult to replace is both valuable to me and yet not completely tapped. This body of work, as I see it, looks at how learners are putting the concepts together and why it may be that they go wrong, usually without even realizing it. Some describe theoretical frameworks that learners construct, and thus have to deconstruct before a new theoretical framework can be realized. Others talk about a much more disorganized set of cognitive pieces from which we throw together explanations on the fly. Still others focus upon the categorization of our ideas, and how the categories themselves guide our understandings and misunderstandings of conceptual entities. And, others describe how our beliefs and attitudes influence and sometimes determine how we conceptualize science. Together, these descriptions point to the very sophisticated processes involved in learning science.

Besides giving us an opportunity to watch the conceptual change process in students, the misconception research literature has made a subtle yet salient contribution to our research methodology. It has demonstrated to us that what a learner answers at first may seem correct, even though his thinking may be flawed. Or, conversely, a student may give a "wrong" answer, yet she may be thinking in very sophisticated ways. The ability to see this comes only through carefully designed instruments, questioning, and interview techniques. Personally, I see this all the time, such as when a student describes the Earth's tilt as the cause of our seasons. This is entirely correct, but often as a student begins to describe this mechanism, he will use the geometry of the planet's tilt to show how a certain hemisphere gets closer or farther from the Sun – the very misconception we try to avoid in physical science. This phenomenon – having a student's true understanding illuminated only after a more thorough collection of his thinking – is something we see repeatedly across science.

Research of science misconceptions shows us something about the learning process itself. This is exactly why I was originally attracted to this line of inquiry, and it is exactly why I believe it is still a fundamental pursuit in science education. If we are to best understand our curricula, pedagogy, and assessment, and consequently inform policy and practice, we must be able to describe the details of learning in a fundamental way. Misconceptions research taps into learning processes, creating a foundation for other research lines, classroom practicalities, and policy decisions.

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Vexation

One of the primary instigators for this conference is the fact that there are so many "vexations" out there. I (and others, no doubt) am vexed about issues ranging from the global to the individual. But, when I deeply consider all of these at once I realize that there is a theme to them all: I don't really understand what learning is. Taylor Mali's title, *What Learning Leaves*, is my question. What exactly does learning leave? What does learning look like, not simply on the external or surface of the learner, but internal to the learner? What does learning itself look like at the cognitive level? Although we continue to pursue "gains" and "outcomes" in the classroom or some other educational environment, I am continually left to wonder what's happening at a more basic level. What is learning, and how is this process assembled?

At first I'm embarrassed to be asking such a basic question. If we do not know what learning looks like, then how on earth could we be teaching? And this is exactly the point. If we really think about it and uncloud our thinking from the obscurity of words (behaviorism, constructivism, conceptual change, etc.) it's clear that we do not understand enough about the gears and guts of the learning process. For me, this issue is both an interesting research line and an imperatively necessary informant of what I do in a classroom, with my curriculum, with assessment, and with teacher training.

When I began graduate school, I became embedded in the research line dealing with alternative conceptions and conceptual change learning and the variety of empirical and theoretical extensions of these lines of research. It seems that we are very capable of identifying when learning is not occurring, so long as we can see the pictures that a six-year-old draws of Earth, or those that a high school student draws to describe lunar phases. But how do we know that they "know" it? They must be able to say so? They must be able to answer a test question? They must be able to do something in particular? They must be able to teach it? These are all very fine goals, but they indicate something that may or may not be what we want to identify as "learning."

This is a vexation to me as a researcher, teacher, and as a learner myself. As a researcher, I really want to understand the understanding process itself. Where, how, and when does learning happen? We can only answer this research question if and when we can identify what it is that we are looking for. How do I get my students to reach a certain level of scientific literacy, whether I'm concerned about their understandings of the philosophical underpinnings of science itself or a concept such as Newton's second law? I cannot identify the process of teaching these unless I can clearly understand the process of learning. Additionally, assessing student learning cannot be possible until we understand what learning is.

(I hesitate to even start to write about myself as a learner, and not understanding what this means. How does someone who teaches teachers admit that he doesn't understand learning, not even for his own self?)

All of this is important because the very question, "What is learning?" informs everything else that we do in education. It informs my classroom, my goals, and my definition of science literacy itself. The presupposition of "what learning leaves" determines exactly what our educational system looks like, not only in the context of a single tutoring session, but on a global scale. Because of this (and here comes the ultimate vexation upon a vexation), I don't want to have an answer to my very question. As soon as we define what learning is (as I think we have assumed we have) we no longer question it. The prevailing assumption that we know what learning is leads to an environment that we currently exist in, in which "learning" itself may have been removed for the sake of testing, performance, or some other achievement. I will be most satisfied when the discussion of learning is more problematized than it currently is.