Misunderstanding misconceptions

by Page Keeley

Preexisting ideas held by students that are contrary to modern scientific thinking about the natural world are generally referred to as *misconceptions*. Today there is tremendous interest among practitioners in learning how to use various tools and techniques to elicit students' misconceptions in science. Since the release of the first book in the Uncovering Student Ideas in Science series (Keeley, Eberle, and Farrin, 2005), I have worked with thousands of educators to help them effectively use formative assessment probes to reveal their students' thinking and make instructional decisions based on their students' ideas. During my professional development work with teachers and other practitioners interested in using the probes, I have encountered several "practitioner misunderstandings" about misconceptions that I'd like to share:

- *All misconceptions are the same.* The word *misconception* is frequently used to describe all ideas students bring to their learning that are not completely accurate. In contrast, researchers often use labels such as *alternative frameworks*, *naïve ideas*, *phenomenological primitives*, *children's ideas*, etc., to imply that these ideas are not completely "wrong" in a students' common-sense world. Scientifically inaccurate ideas have also been categorized in a variety of ways, including *preconceived notions*, *nonscientific beliefs*, *conceptual misunderstandings*, *vernacular misconceptions*, and *factual misconceptions* (NRC, 1997). It is important to understand that the word *misconception* is a general way of lumping together students' scientifically inaccurate or partially accurate ideas. Once a misconception is identified, teachers should delve further to understand the type of misconception the student holds. Identifying a specific type of misconception can help teachers make better decisions for addressing students' ideas. For example, vernacular misconceptions arise from the way we use words in our every day language (the use of *food* to describe "plant food" or *acceleration* to mean going faster) versus the scientific use of words. Knowing that a misconception originated from a students' everyday encounter with a word or phrase can help teachers identify strategies for helping students be more aware of the impact word use has on their scientific thinking.
- *All misconceptions are major barriers to learning.* Just as some learning standards have more weight in promoting conceptual learning than others, the same is true of misconceptions. For example, the idea that when once-living material decays, it simply disappears and no longer exists, presents a significant conceptual barrier to understanding what happens to the flow of matter in ecosystems. In contrast, students who think the blood in our veins is blue also have a misconception. While scientifically incorrect, this "blue blood" idea does not significantly affect students' conceptual understanding of blood flow and the circulatory system. A conceptual misconception warrants greater attention than a trivial factual misconception. When developing assessments that probe for students' misconceptions, it is important to focus on key conceptual ideas rather than minor facts.
- *Only "those" students have misconceptions.* I have worked with some teachers who initially believed that their low-performing students or students in the general classes were the ones who primarily had misconceptions about fundamental ideas in science. Wrong! Everyone harbors misconceptions, regardless of age, socioeconomic background, or academic achievement. Even science teachers hold some deeply rooted misconceptions that remained unchallenged throughout

their K–16 education. The assumption that misconceptions are more apt to surface among certain types of students is generally false. As the Private Universe series has shown us, even the brightest students who go on to top universities like Harvard and MIT have misconceptions about basic, fundamental ideas (Private Universe Project 1995). Probing for basic misconceptions is important for all students.

- *Misconceptions are a bad thing.* I have observed that the word *misconception* seems to have a pejorative connotation to most practitioners. Students do not come to the classroom as blank slates. In fact, they come with many preconceived ideas about how the world works that make sense to them. According to constructivist theory, when new ideas are encountered, they are either accepted, rejected, or modified to fit existing conceptions. It is the cognitive dissonance students experience when they realize an existing mental model no longer works for them that makes students willing to give up a preexisting idea in favor of a scientific one. Having ideas to work from, even if they are not completely accurate, leads to deeper understanding when students engage in a conceptual-change process (Watson and Konicek 1990). Starting with students' existing conceptions is like building a bridge from where they currently are to where you want them to be conceptually. Researcher Philip Sadler (1998) describes misconceptions as "steppingstones" that are absolutely essential for helping our students gradually change their mental models, so they can understand the modern scientific view of our natural world and the universe around us.
- *Misconceptions must be fixed.* Teachers have often told me they feel compelled to correct a misconception on the spot. This tendency to "fix" misconceptions is common. The longer a misconception remains unchallenged, the stronger a student will hold on to it. Yet that does not mean misconceptions go away by merely correcting students. As described above, misconceptions can be useful. Rather than trying to "fix" students by correcting their inaccurate ideas on the spot, it is important to provide instructional experiences that will confront students with their thinking and guide them through a process of conceptual change that allows them to willingly give up the misconception. However, there comes a point when you can't let a misconception linger indefinitely.
- *Misconceptions come mostly from experiences outside of the classroom.* Many preconceptions students bring to their learning come from their everyday encounters with the natural world or things they have read in books or seen in the media. However, it is harder for teachers to accept that misconceptions can also arise from students' experiences inside their classroom, whether taught intentionally or unintentionally. For example, a surprising number of high school students, even after taking chemistry, think that a chemical bond is a structural part of an atom that links it to other atoms (Keeley, Eberle, and Tugel 2007). While a teacher most likely did not teach this, the use of ball-and-stick models or structural diagrams inadvertently led to this misconception. It is important to know that students make their own meaning out of activities they experience in the classroom, representations and models they use, and words they hear in the classroom.
- *Identifying misconceptions is formative assessment.* Teachers from all over the country have shared with me their enthusiasm for using the probes in the Uncovering Student Ideas in Science series to identify their students' misconceptions. Some teachers erroneously think that formative assessment is mostly about identifying students' misconceptions. Using probes to identify students' misconceptions is a form of diagnostic assessment. Diagnostic assessment does not become formative assessment until you use the information you have gathered about students' misconceptions to change or modify your instruction in order to help students achieve conceptual understanding. That is the essence of formative assessment, with the focus placed on instructional and conceptual change, not the act of identifying misconceptions.

I use the word *misconception* throughout my publications because of its familiarity in the practitioner community. However, familiarity can lead to complacency when practitioners are not clear about what a misconception is and how to best address it. Recognizing that the word *misconception* is a general way of referring to views students hold about the natural world that differ from conventional scientific explanations is the first step in dispelling some of the misunderstandings practitioners

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NSTA National Science Teachers Association have about misconceptions. Second, it is important to take the time to understand what type of misconception a student has and how it may have developed. Third, resist the urge to immediately correct a misconception; instead, use students' ideas as springboards to guide them through a process of conceptual change. Understanding is a continuous process that happens throughout a students' education as well as teachers' practice. Understanding what underlies the word *misconception* will ultimately improve student learning and strengthen teaching. ■

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