RESEARCH-BASED INFORMATION ABOUT STUDENT LEARNING

Students all arrive at school with their own often quite elaborate ideas and explanations about a variety of natural phenomena. They are not "blank slates." Some of these ideas are difficult to change. (Osborne et al., 1980; Driver, et al., 1994).

Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom (*How People Learn*, 2000, p. 14).

... teachers need to pay attention to the incomplete understandings, the false beliefs, and the naive renditions of concepts that learners bring with them to a given subject. Teachers then need to build on these ideas in ways that help each student achieve a more mature understanding. If students' initial ideas and beliefs are ignored, the understandings that they develop can be very different from what the teacher intends. (How People Learn, p. 10)

Students' prior ideas, their "common sense," and "everyday thinking," are often intelligent and useful. If those ideas are not exposed and evaluated, students often dismiss science teaching as irrelevant. (Hammer & Van Zee, 2006, *Seeing the Science in Children's Thinking*, p. 14)

Too often, the classroom has been dominated by teacher talk. (Flanders 1973; Goodlad, 1984; Nystrand, 1997; Scott, 2009; Hattie, 2009; Smith et al., 2004). While 21st century teacher education has certainly demonstrated the importance of more open-ended discussion, Lingard, Hayes, & Mills (2003) noted that in classrooms with higher numbers of students living in poverty, teachers talk more and students talk less. Also, English language learners in many classrooms are asked easier questions or no questions at all, so less often have to talk in the classroom (Guan Eng Ho, 2005). In addition, emphasis on testing and accountability for both students and teachers have placed strictures on curricular focus and time. In this context, a study of three representative districts has found that teachers seek to maintain student-centered practices when they can, but, at best, wind up "hugging the middle" in a "hybrid classroom" (Cuban, L., 2007).

Echoes of John Dewey's comment on an earlier generation of progressive education in 1952 reverberate today: "There is a great deal of talk about education being a cooperative enterprise in which students and teachers participate democratically, but there is far more talk about it than the doing of it" (Dworkin, 1959, Dewey on Education, pp. 129–130).

Teachers vastly overestimate gains in knowledge their students achieve after a course they've presented. This is especially true with concepts (as opposed to facts) for which students often have strong, underlying misconceptions. (Lightman & Sadler, March, 1993, "Teacher Predictions Versus Actual Student Gains," *The Physics Teacher*, Vol. 31.)

Perseverance effect is when people/students stick to their beliefs even when the evidence for those beliefs has been refuted (Ross et al., 1975).

Confirmation bias is the tendency to search for, interpret, and/or recall information in a way that confirms one's beliefs or hypotheses (Plous, 1993).

Higher mental/cognitive functions have social origins that are first expressed between individuals before they are internalized within the individual. In other words, meanings are rehearsed and made explicit as a result of conversations and interactions. (Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA, Harvard University Press.)

Learning is perceived as an active process of engaging with and/or manipulating objects, experiences, and conversations in order to construct a mental picture of the world. (Dewey, 1938; Piaget, 1964; Vygotsky, 1986;

How People Learn, 2000; Osborne, 1996.)

Social and cultural interactions with peers and educators (or with novices and experts) are necessary for the construction of knowledge to take place. In this way, learners are constructing their own learning within a social context where they share ideas, and meaning making is created and expanded by interaction with their environment (Rogoff, 1998; *How People Learn*, 2000).

Students (K–12 to University) show greater understanding when they engage in collaborative dialogue with peers where they provide explanations as part of arguments and justifications and seeking and providing help (Mercer et al., 2004; van Blankenstein et al., 2011; Veenman et al., 2005; Venville & Dawson, 2010).