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Table of Contents

If you're viewing this document online, you can click any of the topics below to link directly to that section.

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Conceptual Change among Students in Science. ERIC Digest.

"Blue, clear, I mean clear, it's clear but when you look at the ocean it's blue. But water is always clear." Thato

Thato, a 13 year old, responded with the words above when asked about the color of water. Her response indicates that there are some ideas about water that she has not yet reconciled. She is convinced that her ideas are correct and will do all she can to defend them. Her constructed knowledge, not scientifically accepted, is called "naive knowledge" or "prior conceptions." Vosniadou (2002) asserts that children begin the knowledge acquisition process by organizing their sensory experiences under the influence of everyday culture and language into narrow, but coherent, explanatory frameworks that may not be the same as currently accepted science.

Students' constructed knowledge typically has two properties: it can be incorrect, and it can often impede the learning of conventionally accepted knowledge (Chi & Roscoe, 2002). Chi and Roscoe differentiate two forms of naive knowledge: preconceptions that can be easily and readily revised through instruction, and misconceptions that is robust and highly resistant to change, even when not supported by observations.

THEORETICAL FRAMEWORK

Constructivism in its many forms has become a familiar view of learning among science educators. From Piaget's work, assimilation has become identified with constructivism and denotes the fitting of new experiences into existing mental schemes. Accommodation, a related term, describes the changing of mental schemes that are unable to explain one's new experiences (Geelan, 2000). Building on these fundamental concepts, other theorists have articulated a theory that explains and describes the "substantive dimensions of the process by which people's central, organizing concepts change from one set of concepts to another set, incompatible with the first" (Posner, Strike, Hewson, & Gertzog, 1982, p. 211), a "conceptual change" learning model. The central commitment of the conceptual change learning model is that learning is a rational activity that can be defined as coming to comprehend and accept ideas because they are seen as intelligible and rational; the "ahaa" experience is of utmost importance in learning.
Posner et al. used Thomas Kuhn's idea of paradigms and Irme Lakatos's notion of theoretical hard core ideas to formulate their model of learning. Paradigms and theoretical hard core ideas are characterized as the "background of central commitments which organize research" (p. 212). For students, concoctions of experiences-physical, mental, and cultural-and beliefs constitute highly personal conceptual ecologies that increase in complexity with age.

WHAT EXACTLY IS CONCEPTUAL CHANGE?

Posner et al. (1982), provided no formal definition of conceptual change, but examples of what it entails were given. A student's conceptual ecology is key to the conceptual

change model because "without such concepts it is impossible for the learner to ask a question about the phenomenon, to know what would count as an answer to the question, or to distinguish relevant from irrelevant features of the phenomenon" (p. 212).

Four Views

In an attempt to clarify the concept of conceptual change, various theorists have offered competing views of the central process.

* To Vosniadou (2002), conceptual change is a process that enables students to synthesize models in their minds, beginning with their existing explanatory frameworks. This is conceived to be a gradual process that can result in a progression of mental models. Mortimer (1995) argues for what he calls a conceptual profile change because "it is possible to use different ways of thinking in different domains" and "the process of construction of meaning does not always happen through an accommodation of previous conceptual frameworks in the face of new events or objects, but may sometimes happen independently of previous conceptions" (p. 268). Though their arguments differ, the views of Mortimer and Vosniadou are related and acknowledge the importance of prior knowledge to learning.

* Chi and Roscoe (2002) conceive of conceptual change as repair of misconceptions. Starting with naive conceptions, students must identify their faulty conceptions and repair them. In this view, misconceptions are miscategorizations of concepts, so conceptual change is the reassignment of concepts to correct categories.

*Conceptual change to diSessa (2002) is the reorganization of diverse kinds of knowledge into complex systems in students' minds. In this view, conceptual change is really about cognitively organizing fragmented naive knowledge.

*Ivarsson, Schoultz, and Saljo (2002) take a more radical stance in that they think naive conceptions do not serve a purpose in conceptual change because conceptual change is the appropriation of intellectual tools. In this view, conceptual change results from changes in the way that students use the tools in various contexts, and the change actually occurs at the societal level.

How should science educators respond to these four competing views of conceptual change? Mayer (2002) advises that there is need to specify testable theories about the mechanisms of conceptual change and find ways to test them empirically. Geeland (2000) contends that these views of conceptual change treat learning as mere accommodation. White (2002) points out that advocates of conceptual change have narrowly focused on mathematics and science, but that a closer look at other subject areas such as history indicate that conceptual change might be discipline, or even topic, specific. While the diverging views of conceptual change illustrate the ongoing interaction of epistemology and the psychology of learning, the challenges serve as cautions to curriculum developers and teachers that open questions remain.

IMPLICATIONS FOR CLASSROOM PRACTICE

On a practical level, Posner et al. (1982) listed four conditions that foster accommodation in student thinking:

1. There must be dissatisfaction with existing conceptions

2. A new conception must be intelligible

3. A new conception must appear initially plausible

4. A new concept should suggest the possibility of a fruitful research program.

Teachers who accept these four conditions as necessary for conceptual change to occur are encouraged to take deliberate steps to create classroom interactions that produce these conditions. Students organize their lives around views that they hold about phenomena, so some conceptual changes that teachers consider desirable may be highly resistant to change, and potentially threatening to students. To become more effective in nurturing conceptual change, teachers should seek to understand students' naive conceptions so they can be addressed directly by instruction. There is a large volume of professional literature documenting specific student misconceptions, particularly in the area of physics. Over 700 documents in the ERIC database report research or practices relating to the combined ERIC Descriptors "misconceptions" and

"science education."

Though there remains a range of views on the process of conceptual change, progress has been made in identifying instructional methods that promote conceptual change through critically examining and defending ideas. Wiser and Amin (2002) suggest the use of computer models coupled with verbal interactions, with the teacher promoting the scaffolding of ideas in accordance with Vygotsky's theory of learning. Niaz, Aguilera, Maza, & Liendo (2002, p. 523) have also concluded that if students are given the opportunity to argue and discuss their ideas, their "understanding can go beyond the simple regurgitation of experimental detail." It was further suggested that teachers include more attention to the history and philosophy of science during instruction. Mikkila-Erdmann (2002) suggested the use of written questions and statements or text that guide students to accepted conceptions.

These suggestions imply that teacher preparation courses and professional development opportunities for experienced teachers should include attention to both the theoretical background of conceptual change, and instructional methods that nurture conceptual change.

CONCLUSIONS

The conceptual change model is widely accepted among science educators. Though there are competing views of how conceptual change occurs, there seems to be no argument about whether conceptual change occurs; it is central to learning in science. While theorists continue to debate the process of conceptual change, teachers can nurture conceptual change by creating the conditions that promote conceptual change. This task can be guided by attending to the quickly growing professional literature that documents the various misconceptions common among students.

RESOURCES ON THE WEB

Conceptual Change
SciEd Resource Assistant (ERIC)

http://www.ericse.org/~ericseorg/CD-1/CD/sciedtopics.htm

Teaching for Conceptual Change: Confronting Children's Thinking

Phi Delta Kappan

http://www.mdk12.org/instruction/success_mspap/general/projectbett er/ science/s-52-53.html

Teaching for Conceptual Change

http://www.mdk12.org/practices/good_instruction/projectbetter/ science/s-52-53.html

Enhancing Learning Through Conceptual Change Teaching

National Association for Research in Science Teaching

http://www.educ.sfu.ca/narstsite/publications/research/concept.htm

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