Conceptions, Cognition, and Change: Student Thinking about the Earth

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Significant research has demonstrated that students at all levels hold explanations of natural phenomena that are at odds with scientific ideas. These non-scientific explanations (alternative conceptions, misconceptions, or common-sense beliefs, among other names) are often resistant to change and can persist despite the best efforts of instructors. Students may overprint their alternative conceptions with material taught in the classroom, creating blended conceptions that are still removed from scientific ideas. Other students may simply reject the scientific conception in favor of ideas that have thus far proven adequate. As a consequence, learners may never integrate scientific conceptions into their explanations of the world. Clearly, alternative conceptions can interfere with learning, suggesting that instruction must be carefully designed to address preexisting ideas. Over the past several decades, curriculum developers for both K-12 and college science have addressed the issue of conceptual change, documenting techniques that engender student learning in a number of scientific disciplines. Existing work suggests intriguing links between nontraditional teaching approaches and conceptual change, although uncertainty surrounds the transferability of instructional techniques to all disciplines and age groups. Unraveling the complex relationships between teaching and learning for a specific discipline and group of learners requires both an understanding of common alternative conceptions and valid and reliable methodologies for assessing conceptual change.

Conceptions and conceptual change research in the geological sciences lags behind work in other scientific fields. Although geologists are actively adopting alternative teaching strategies in primary, secondary and college classrooms, our understanding of student conceptual states and the effects of instruction on alternative geoscience conceptions is quite limited. In addition, although several decades of research have documented alternative conceptions in physics, chemistry, and biology, relatively few studies have focused on the geosciences. Existing Earth-related studies primarily focus on the Earth as a cosmic body, where physical concepts such as gravity are addressed, or focus on astronomy-related concepts, such as the Moon. In recent years, significant work has emerged that addresses core topics in the geologic sciences, including geologic time, rivers, mountains, and the Earth's interior. We are just now beginning to discover the host of alternative geoscience conceptions held by students at all levels, as well as the origin of these conceptions, their persistence in the face of instruction, and their impact on mental models and cognitive reasoning.

The geological sciences focus on explaining natural phenomena, usually through integration of fundamental physics, chemistry, and biology into larger models. Understanding of many geologic concepts presupposes knowledge in other fields; for example, sedimentary rock formation involves an understanding of gravity, dissolution, and microorganisms. Conceptual change approaches developed for other sciences have proven valuable and effective for these human scale concepts, although the geological sciences overall are often not amenable to common alternative conceptual change methods. Specifically, geology rests on phenomena, such as evolution, that occur on very long time scales outside of normal human perception, or phenomena that occur over large spatial scales, such as plate tectonics. As a consequence, the teaching and learning of concepts unique to the geological sciences, as well as the cognitive peculiarities of geological reasoning, are all fertile areas for research.

The papers included in this special volume represent a significant contribution to the literature on student conceptions, cognition, and conceptual change specifically related to the geosciences. Researchers with homes in geology and other sciences, education, and psychology have contributed. A wide range of methodologies that can be used to study learning are represented here, from case studies to interviews to quantitative approaches. Documentation of student conceptions and cognition, from elementary to university, as well as analyses of the effects of instruction are presented on a variety of topics important to the geological sciences. We hope these papers will provide a basis for continued communication between workers in different disciplines striving to answer the question: "What works in the geoscience classroom?"

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