# Hypothesis Testing in Introductory Laboratories and Conceptual Change Theory

Jeffrey C. Owen

Center for Science and Mathematics Education Research, University of Maine, Orono, ME 04469, jeffrey.owen@umit.maine.edu

Hannula (2003) presents an important and efficient strategy for bringing additional critical thinking into geology laboratory exercises. Her strategy involves asking students to make predictions prior to engaging in the exercises, and requires some revision of the exercises themselves such that they more closely resemble hypothesis-testing. If the students' backgrounds are sufficient they may additionally be asked to provide justification for their predictions and later, after making their observations, to reflect on the implications of those predictions. Modifying exercises in this manner adds an element of critical thinking to the laboratory process and provides the students with some additional exposure to the scientific method.

Laboratory sections are included in many science courses to help students meet two goals: (1) exposure to and practice with the scientific method (as Hannula contends), and (2) develop accurate conceptual understanding of some of the concepts integral to the course. This latter goal deserves some examination. Assume that the 12 laboratory exercises, typically occurring in introductory courses over the course of a semester, target the 12 scientific concepts deemed by the instructor to be most essential to the discipline. This makes sense—those are the concepts most worthy of additional time spent beyond the lecture. Thus, it is important for the students to use the laboratory sessions to develop correct conceptual understandings of those scientific concepts.

Hannula's strategy likely works toward the accomplishment of both of the goals typical of laboratory sessions. She articulates the benefits her students appear to derive regarding the scientific method. Additionally, her strategy is notably similar to establishing *cognitive conflict* within students, which is a pedagogy typical of one version of conceptual change theory (CCT).

Conceptual change theory was formally offered as a learning theory by Posner et al. (1982). In this pedagogy, students are confronted with something that contradicts their previously held understanding, resulting in the development of a cognitive conflict between the implications of what they are seeing and what they believe to be true. (In Hannula's strategy this occurs when students make observations that contradict their predictions.) Through CCT this cognitive conflict may lead to the development of correct understanding if the students are shown (through a variety of possible means) the correct reasoning in a form that is intelligible, plausible, and fruitful (Posner et al., 1982).

In Hannula's strategy, when their backgrounds are sufficient, students are asked to reflect on the implications of their predictions. The goal of this reflection, from the perspective of CCT, would be to acknowledge and resolve the cognitive conflict that exists when observations don't support predictions. But is reflection sufficient for this purpose? In a summative paper on the topic, Limón (2001) demonstrates that CCT **can** work to develop accurate student understanding, but that it typically does not. Although the cognitive aspects of the theory appear to be sound, there are myriad non-cognitive influences that limit its educative productivity. Among many others, these influences include the students' levels of cognitive engagement in the task, their emotional state, their epistemological beliefs about science and learning, their social interactions with their peers, and their interest and excitement for the topic being studied. Although our forum for learning (the laboratory sessions of introductory courses) seems ideal to bear the fruits of CCT, it is easy to see how these extraneous influences may shape the learning of our students.

I urge all laboratory instructors to read the Limón paper and consider the applicability of CCT to the instruction of laboratory sessions. Adoption of this theory into practice would require significant and on-going revisions of the laboratory exercises. This process will be iterative until the activities comprising the exercises bring the students face-to-face with their cognitive conflicts *and* successfully encourage them to actively pursue scientifically-valid explanations that resolve them. Discussing the naïve bases for some of the common cognitive conflicts later in lecture may also help the students develop their scientific understanding. The CCT pedagogical approach is virtually inherent in what we already do (especially with the application of Hannula's strategy). Many of the influences that limit its success may be minimized through committed and collaborative efforts involving faculty, teaching assistants, and students.

## REFERENCES

Hannula, K.A., 2003, Revising Geology Labs to explicitly use the scientific method, Journal of Geoscience Education, v. 51, p. 194-200.

Limón, Margarita, 2001, On the cognitive conflict as an instructional strategy for conceptual change: a critical appraisal, Learning and Instruction, v. 11, p. 357-380.

Posner, G.J., Strike, K.A., Hewson, P.W., and Gertzog, W.A., 1982, Accommodation of a scientific conception: toward a theory of conceptual change, Science Education, v. 66, p. 211-227.