TIEE Review by Nancy Stamp

Conceptual assessment in Biological Sciences: NSF workshop 3-4 March, 2007 Boulder, CO

The impetus for conceptual assessment in the Biological Sciences stems from these questions: Are students learning what we are trying to teach? Are we trying to teach what is important? What works for teaching what is important?

Background

Research on the Force Concept Inventory used in introductory physic courses around the nation for over a decade suggests that using concept inventories can catalyze student learning and effectively guide instructors. Most concept inventories focus on core concepts in a discipline and are based on constructivism learning theory. The premise is that students have a naïve world-view that they hang onto unless their gaps in understanding are identified and their preconceptions, misconceptions, and faulty thinking skills are directly challenged. Concept inventories help identify those problems. Development of inventories that are valid and reliable requires gathering considerable information from students about what they think and why, plus an iterative process of composing increasingly honed questions for the inventory.

Workshop

In recent years the National Science Foundation (NSF) has funded several groups of biology educators to begin developing concept inventories in the Biological Sciences. Representatives of these groups and others met in Boulder, CO to exchange information about the challenges and successes in these efforts. The meeting was organized by Mike Klymkowsky and colleagues at the University of Colorado - Boulder and supported by the Course, Curriculum, and Laboratory Improvement program in the Division of Undergraduate Education at NSF.

There were 14 presentations (see below) on a range of topics. For instance, Joel Michael described his work on students' misunderstandings in physiology, Susan Elrod explained her development of a genetics concept inventory, and Kathy Garvin-Doxas brought the group up to date with the Klymkowsky group's progress towards development of a concept inventory for General Biology.

Following the presentations, there was discussion of conceptual coverage by the inventories in the Biological Sciences. Discussion also included the perennial complaints about biology textbooks trying to cover too much and not being organized in terms of the big ideas. Over the course of the workshop, there was increasing discussion of the approach taken in introductory biology by the Michigan State University group (Parker, Anderson, and Merrill). Rather than a "horizontal" piling of sub-disciplines (e.g., cell and molecular, genetics, physiology, ecology, evolution), material is presented "vertically" in terms of three themes: keeping track of matter, keeping track of energy and energy transformations, and keeping track of information flow.

Breakout groups talked about the next steps for conceptual inventory for these areas: nature of science, introductory biology, genetics, evolution, and ecology. The ecology group focused on

students being able to develop models of systems (e.g., concept mapping a system) and discussed the components of students' doing that: observing, connecting, inferring, predicting, evaluating, plus handling the concepts of "random" and "probability" appropriately. For an ecology unit in introductory biology or for ecology courses (so a more advanced level of presentation), the ecology group suggested that the three vertical themes (the Michigan State University approach) might be: biogeochemical cycle (tracing matter in systems), population growth and interactions (tracking energy flow), and evolution of ecosystems (tracking information flow via myriad feedback mechanisms). Concept inventories could consist of ecological problems or scenarios, similar to that previously developed for evolution, and conducted as pre- and post-assessments. At the conclusion, workshop participants decided that further workshops should focus on content of introductory biology for the time being, with the next workshop within a year to follow up on progress made and future goals.

Papers, in order of presentation:

Teaching and Learning Biology at the Undergraduate Level
Joyce Parker, Andy Anderson, and John Merrill
Michigan State University

Cataloging Physiology Misconceptions
Joel Michael
Rush Medical College (also, Physiology Educational Research Consortium – PERC)

Developing Assessments of Conceptual Understanding Using "Big Ideas"
Terry P. Vendlinski, Joan L. Herman, Sam Nagashima, and Eva L. Baker
University of California, Los Angeles (CRESST)

C-Tools: Concept-Connector Tools for Online Learning in Science
Team representatives in Boulder: Douglas Luckie and Diane Ebert-May
Michigan State University

Teaching and Learning Ecology in Undergraduate Courses
Nancy Stamp
Binghamton University – SUNY

Changing Teaching Practice: Much More Than a Diagnostic Test
Charlene D'Avanzo
Hampshire College (TIEE)

Genetics Concepts Inventory
Susan Elrod
California Polytechnic State University, San Luis Obispo

Drawing Out Misconceptions: Assessing Student Mental Models in Biology
William J. Hoese and Merri Lynn Casem
California State University, Fullerton

Building the Biology Concept Inventory
Kathy Garvin-Doxas and Michael Klymkowsky
University of Colorado, Boulder

Learning Gains in a Lecture-Based and a Web-Enhanced, Interactive Introductory Biology Course
Carl N. McDaniel, Bradford C. Lister, Michael Hanna, and Harry Roy
Rensselaer Polytechnic Institute

Inventorying Conceptual Understanding of Basic Biology Ideas
Kathleen Fisher*, Kathy Williams*, Dianne Anderson**, and Mike Smith***
*San Diego State University, **Point Loma Nazarene University, and ***Mercer University

Thinking Ahead: the FIRST Assessment Database
Diane Ebert-May*, Everett Weber*, Mark Urban-Luain*, Ryan McFall**, and Matt Jones***
*Michigan State University, **Hope College – Michigan, ***University of California – Santa Barbara

Pre-Instructional Assessment of the Basic Chemical and Moleccular Literacy of BioChemistry Students
Duane W. Sears and Scott E. Thompson
University of California, Santa Barbara

Tree-Thinking Research in Evolution Education (TREE)
Sam Donovan
University of Pittsburgh

Short papers and contact information are available at: << url >>

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Resources

DL Anderson, KM Fisher*, and GJ Norman. 2002. Development and evaluation of the conceptual inventory of natural selection. J Res Sci Teaching 30: 952-978

KM Fisher. 1985. A misconception in biology: amino acids and translation. J Res Sci Teach 22: 53-62

M Klymkowsky, K Garvin-Doxas, and M Zelik. 2003. Bioliteracy and teaching efficacy: what biologists can learn from physicists. Cell Bio Ed 2: 155-161

N Stamp, M Armstrong, and J Biger. 2006. Ecological misconceptions survey III: the challenge of identifying sophisticated understanding. Bulletin Ecol Soc Amer 87(2):168-174 http://ecomisconceptions.binghamton.edu/index.htm .