A Sample of Classroom Assessment Instruments

Attitude Inventories

Biology

*Biology Self-Efficacy Instrument for Nonmajors (BSEIN).* The Biology Self-Efficacy Instrument for Nonmajors is a 23-item scale that asks students to rate on a five-point scale their level of confidence in three key areas: 1) in writing and critiquing biological ideas through the use of laboratory reports; 2) in general skills used in a typical biology course (e.g., analyzing data, asking meaningful questions); and 3) in ability to apply biological concepts to every day life.


*Biology Attitude Scale.* The biology attitude scale investigates students attitudes toward biology with 14 Likert-like questions (five points, strongly agree to strongly disagree) and eight "semantic differential" scale questions. An example of a Likert-like question used is: "Biology is fascinating and fun." An example of a "semantic differential question used is: "Biology is Cruel A B C D E Kind" (students are asked to circle the letter that reflects their view of where biology fits relative to the end points).


Chemistry

*Chemistry Attitudes and Experiences Questionnaire (CAEQ).* The CAEQ is a closed-ended survey that asks students to rate their attitudes about chemistry (22 items), their self-efficacy with respect to chemistry (20 items), and their learning experiences in their chemistry courses (35 items). The article below includes the CAEQ and describes the instrument development and testing.


Engineering

*Pittsburgh Freshman Engineering Attitudes Survey (PFEAS).* The Pittsburgh Freshman Engineering Attitudes Survey (PFEAS) is a 50 item multiple-choice survey that gathers information about incoming engineering students' attitudes in the 13 key areas.

URL: http://www.engr.pitt.edu/%7Eoutcomes/

Mathematics

Questionnaire on attitudes about mathematics. This 81-item questionnaire (with 70 closed and 11 open items) asks students to answer questions regarding elements which contribute to success/failure in mathematics, perceptions of mathematics, English, and social science (as comparison), how mathematics is taught, the nature of proofs, reasoning and constructions; motivation; and personal performance. There is no discussion in the article of how the questionnaire was developed, and how it was tested for validity/reliability.


Modified Fennema-Sherman Scale. Elizabeth Fennema and Julia A. Sherman constructed an attitude scale in the early 1970's that capture students views on mathematics and views on gender and mathematics. The scale consists of four subscales (i.e., set of questions that is intended to reflect a concept, like confidence): a confidence scale, a usefulness scale, a scale that measures mathematics as a male domain and a teacher perception scale. Each of these scales consists of 12 items. Six of them measure a positive attitude and six measure a negative attitude. The URL below provides the Fennema-Sherman Scale and an adaptation of the scale to science.

URL: http://www.woodrow.org/teachers/math/gender/08scale.html


Physics

Maryland Physics Expectation (MPEX) Survey. The Maryland Physics Expectation (MPEX) survey has been developed by the Maryland Physics Education Research Group (PERG) as part of a project to study the attitudes, beliefs, and expectations of students that have an effect on what they learn in an introductory calculus-based physics course. Students are asked to agree or disagree on a five-point scale with 34 statements about how they see physics and how they think about their work in their physics course.

URL: http://www.physics.umd.edu/rgroups/ripe/perg/expects/mpex.htm


Science

Epistemological Beliefs Assessment for Physical Science (EBAPS) Instrument. The EBAPS is a forced-choice instrument designed to assess students' epistemologies (i.e., their views about the nature of knowledge and learning) in the physical sciences. EBAPS has 30 items and most student need 15-22 minutes to complete the EBAPS.

URL: http://www2.physics.umd.edu/~elby/EBAPS/home.htm.


<http://www2.physics.umd.edu/~elby/EBAPS/idea.htm>.

Views About Sciences Survey (VASS). The Views About Science Survey (VASS) is designed to survey student views about knowing and learning science, and to assess the relation of these views to student understanding of science and course achievement (Grades 8-16).


Views on Science-Technology-Society (VOSTS). The Views on Science-Technology-Society (VOSTS) survey that investigates students' perceptions of the social nature of science and how science is conducted. The VOSTS has 114 multiple-choice questions and the multiple-choice responses are grounded in the literature and on an extended process of analyzing student comments, creating potential responses, and verifying those comments with students. (The question in the figure below is illustrative of the kinds of questions VOSTS asks.) The validity of the survey arises from its development, which is grounded in student views (Aikenhead & Ryan, 1992).

URL: http://www.usask.ca/education/people/aikenhead/


Scientific Attitude Inventory II. The SAI II asks students to rate their level of agreement on a five-point scale to 40 statements about the nature of science and potential attitudes about science, both positive and negative. An example statement is: "The laws and/or theories of science are approximations of truth and are subject to change."


Modified Nature of Scientific Knowledge Scale (MNSKS). The Nature of Scientific Knowledge Scale (NSKS) was revised to create the MNSKS scale. The MNSKS asked students to rate their level of agreement on a five-point scale to 32 statements about four dimensions of nature of science (creativity of science, development of science, testability of science, and unity of science). As an example, one statement from the MNSKS is "A scientific theory and a work of art are similar in that they both represent creative work of people." The MNSKS does not appear in the article.


Views on the Nature of Science Questionnaire (Forms A-C). The VNOS-A, B, or C ask students write their responses to a series of between 6 and 10 questions (depending upon the form). An example question is, "Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example."


Statistics
Survey of Attitudes Toward Statistics (SATS). The Survey of Attitudes Toward Statistics (SATS) contains 28 seven-point Likert items designed to assess four components of students' attitudes toward statistics.

URL: http://www.unm.edu/~cschau/infopage.htm.


Writing
Views about Writing Survey (VAWS). The VAWS is 26-item survey that asks students to rate on an eight-point scale their attitudes and beliefs about writing and composition. The structure is based on the "contrasting alternative design" developed for to measure students' attitudes towards physics (Halloun & Hestenes, 1996). The paper that presents VAWS data does not describe testing or validation of the VAWS instrument (Rhoads et al., 1998). The authors do indicate that they will conduct validation via focus group interviews with students. The instrument was used to measure change in attitudes toward writing of students
enrolled in English class that was geared for students in an engineering learning community (50 students)
and of students in a traditional English class (155 students).
Attitudinal Survey Applied to Engineering Students. Paper presented at the Frontiers In Education
Conference, Tempe, AZ.
Meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Classroom Environment

Learning Context Questionnaire. This 50-item questionnaire investigates students' level of agreement with
statements describing student's view of himself/herself and his/her education (e.g., "I enjoy courses most
when they are more theoretical.").
Carolina: Davidson College.

Constructivist Learning Environment Questionnaire (CLES). The CLES is a 42-item questionnaire that asks
students to rate on a five-point scale where and how they learn science; the extent to which their classroom
environment enables them to present their own views, manage their own learning, and talk with other
students about science; and their interest and motivation in the classroom.
URL: http://www.letus.northwestern.edu/msta/surveys/source-documents/cles.html
Tayler, P.C., Fraser, B.J., and White, L.R. (1994). CLES: An instrument for monitoring the development
of constructivist learning environments. Paper presented at the annual meeting of the American
Educational Research Association, New Orleans. Available at:
http://www.letus.northwestern.edu/msta/surveys/source-documents/index.html

Learning Approach Questionnaire (LAQ). This 49-item questionnaire was developed to measure students' 
"preferences of using learning strategies that are consistent with either rote or meaningful learning
orientations" (Bretz, 1994). Students are asked to rate their level of agreement/disagreement to 44
statements, and the remaining 5 items ask demographic information. An example item is: “I try to relate new
material, as I am reading it, to what I already know on that topic.”
literacy and meaningful learning: the case of a college chemistry course for nonscience majors.
Dissertation: Cornell University.

Metacognition

Metacognition Awareness Inventory (MAI). The Metacognition Awareness Inventory (MAI) is a 52-item test
intended to measure the metacognitive awareness. Students are asked to rate statements on a 7 point Likert-
like scale (1=not at all true of me, to 7=Very true of me). The MAI includes two factors: knowledge about
cognition and regulation of cognition.
Psychology, 19, 460-475.

Motivated Strategies for Learning Questionnaire (MSLQ). The Motivated Strategies for Learning
Questionnaire (MSLQ) is an 81-item self-report instrument that has two sections: a motivation section (31
items) and a learning strategies section (50 items). Students are asked to rate statements on a 7 point Likert-
like scale (1=not at all true of me, to 7=Very true of me). The learning strategies scales incorporate the
metacognition construct and seek to measure rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, effort regulation, peer learning, and help seeking.


**Motivation**

Achievement Goal Questionnaire (ACG). The Achievement Goal Questionnaire (ACG) has 12 items that look at motivation. Three items assess mastery-approach, three items assess mastery avoidance, three items measure performance approach, and three items measure performance avoidance. Students are asked to rate statements on a 7 point Likert-like scale (1=not at all true of me, to 7=Very true of me).


**Concept Maps**

**Biology**

*Using concept maps to assess declarative knowledge.* The authors of the paper below used concept maps to assess lower-order knowledge and compared the concept maps against multiple-choice tests, finding high reliability and inter-rater agreement. Students were provided with a small number of terms (5-7) and had to link them in appropriate ways. For example, to "replace" a multiple-choice item which asked, "Which of the following is not a type of protozoan? A) paramecium; b) amoeba; c) Euglena; d) bacteria" (d is correct), a student would be provided with the terms (kingdom, Protozoa, Monera, Euglena, paramecium, amoeba, bacteria) and asked to draw a concept map using these terms. Three scoring rubrics were used to measure understanding and had high inter-rater agreement. Scoring rubric A assigned a "0" if students used all pertinent answers and the stem (question) on their map (and assigned a "-1" otherwise). Scoring rubric B assessed whether students linked relationships to the appropriate kingdoms in their map: a "+1" was given if they correctly linked bacteria to kingdom Monera (and not Protozoa); a "−1" was given if they incorrectly did so; and a "0" was given if the terms were not on the map. Finally, scoring rubric C was used to assess misinformation: a "−1" was given if the student linked anything incorrectly to the kingdoms, and a "0" was given otherwise.


*Using a concept mapping to identify students' misconceptions in biology.* This article presents numerous student-generated concept maps and the misconceptions that they reveal.


*Concept maps as a diagnostic tool.* The researchers in the study below investigated the sensitivity of student-generated concept maps as methods for documenting changes in student understanding. The researchers used an experimental pre/post design. Students in an elementary science methods course were randomly divided into two groups. Both sets took a "Life Zones in the Ocean" multiple-choice exam and...
constructed concept maps on the topic at the start of the experiment. The experimental group received 45 minutes of computer instruction on the marine life zones; the control group received similar instruction on an unrelated topic. Following this, both sets took a "Life Zones in the Ocean" multiple-choice exam and constructed concept maps on the topic at the start of the experiment. The researchers found that the experimental students' concept maps were much more detailed than the control students. Example student-generated concept maps are provided, as is an explanation of the scoring rubric used.


**Concept Tests**

**Astronomy**

*ConcepTests for Astronomy.* A library of ConcepTests for astronomy is available at the URL below. Users/contributors need a login id and password and can access this library by contacting Paul Green (pgreen@cfa.harvard.edu).


**Chemistry**

*Journal of Chemical Education On-Line Library of Conceptual Questions (CQs).* The American Chemical Society's Division of Chemical Education offers a library of Conceptual Questions (or CQs) in their Journal of Chemical Education OnLine that would be useful as ConcepTest questions. The site offers questions in a variety of topics, techniques for creating CQs, and accepts submissions of CQs.

URL: http://jchemed.chem.wisc.edu/JCEWWW/Features/CQandChP/CQs/CQIntro.html

*Chemistry ConcepTests.* The ConcepTests website offers a range of conceptest questions on a variety of topics. Readers can download sets of questions on various chemistry topics in Adobe Acrobat (*.pdf) and Microsoft Word (*.doc) format.

URL: http://www.chem.wisc.edu/~concept/


*ConcepTests for General Chemistry.* This site offers additional conceptests (without answers) for classroom use. URL: http://people.brandeis.edu/~herzfeld/conceptests.html

**Mathematics**

*Better file cabinet.* This site has a searchable database of questions covered in calculus classes.

URL: http://betterfilecabinet.com/
Physics

Project Galileo: Your gateway to innovations in science education. The Project Galileo site has a variety of teaching materials that are based on research in science education. The site, maintained by Harvard Professor Eric Mazur and colleagues, includes an extensive set of resources for teaching with ConcepTests in astronomy, biology, chemistry, and physics. Physics ConcepTests are stored in a database, from which users can select sets of ConcepTests for use in their classes.

URL: http://galileo.harvard.edu

Conceptual Diagnostic Tests

Astronomy

Astronomy Diagnostic Test (ADT). The ADT consists for 33 questions, with the first 21 questions collecting the content portion, and the final 12 questions collecting demographic information. The test can be accessed at the URL below. This site also offers comparative data by institution to the ADT question and links to research articles on the development of the ADT.

URL: http://solar.physics.montana.edu/aae/adt/

Lunar Phases Concept Inventory. The LPCI was developed based upon interviews with 14 undergraduate students around their conceptual understanding of lunar phases. The LPCI consist of 14 multiple-choice items.

Biology

Conceptual Inventory of Natural Selection (CINS). The Conceptual Inventory of Natural Selection (CINS) was developed to identify student’s knowledge about natural selection, as well as their misconceptions. The 20 item multiple choice asks students to reflect on scenarios regarding Galapagos finches, Venezuelan guppies, and Canary Island lizards, and select options that best reflect what an evolutionary biologist would select.
URL: http://www.biologylessons.sdsu.edu/CINS6_03.pdf

Chemistry

Chemical Concepts Inventory. The Chemical Concepts Inventory (CCI) can be used to identify chemistry misconceptions held by students. The inventory is a multiple-choice instrument composed of non-mathematical conceptual questions (22 questions total). The questions are based on commonly-observed student misconceptions about topics generally covered in the first semester of a college chemistry course. A question from the inventory appears in the figure below.

URL:
http://jchemed.chem.wisc.edu/JCEWWW/Features/CQandChP/CQs/ConceptsInventory/CCIIntro.html
Earth Science

Test on students' alternative conceptions of earth and space. This article lists the common misconceptions as identified by a survey on students' alternative conceptions of earth and space. The survey was described as having 18 multiple-choice questions, but was not listed in the article.


Engineering

The Foundation Coalition has a variety of concept inventories spanning a wide variety of areas in engineering: chemistry, circuits, computer engineering, dynamics, electromagnetics, electronics, fluid mechanics, heat transfer, materials, material strength, signals and systems, and thermodynamics. Information about these instruments can be accessed at:

http://www.foundationcoalition.org/home/keycomponents/assessment_evaluation.html

Environmental Science

Test on the Greenhouse Effect, Ozone Depletion, and Acid Rain. This diagnostic test asks students to report "yes," "no," or "don't know" to a set of 29 research-based misconception questions about the greenhouse effect, ozone depletion, and acid rain. The survey was adopted from a questionnaire developed by Jane Dove (1996).


Mathematics

Basic Skills Diagnostic Test (BSDT). The Basic Skills Diagnostic Test (BSDT) is a 24-item free-response test on basic mathematics understanding. Eleven questions (two with two parts) assess pre-algebra level (division, multiplication and ordering of numbers represented in fractions and in decimals), concept of area and volume, proportional reasoning. Eight questions assess basic algebra (concept of a variable, order of operations, simplifying expressions, particularly inappropriate cancellation, linear equations), and 3 questions assess intermediate level, concept of a function, graph of a function, concept of a logarithm.

The tool can be sent to colleges and universities by contacting the author, Jerome Epstein ((718) 260-3572, jepstein@duke.poly.edu).

Epstein, J. "What is the real level of our students? or What do diagnostic tests really measure?" to be published.

Physics

Force Concept Inventory (FCI) Instrument. The Force Concept Inventory (FCI) instrument is designed to assess student understanding of the most basic concepts in Newtonian physics. This forced-choice instrument has 30 questions and looks at six areas of understanding: kinematics, Newton's First, Second, and Third Laws, the superposition principle, and types of forces (such as gravitation, friction). Each question offers only one correct Newtonian solution, with common-sense distractors (incorrect possible answers) that are based upon student's misconceptions about that topic, gained from interviews.


The Mechanics Baseline Test (MBT). The Mechanics Baseline Test (MBT) instrument is an advanced companion to the Force Concept Inventory (FCI). The forced-choice MBT has 26 questions that were based upon interviews with students about their misconceptions on basic topics in Newtonian mechanics. The test covers concepts in kinematics (linear and curvilinear motion), basic principles (Newtons' First, Second, and Third Laws, superposition principle, energy conservation, impulse-momentum, and work) and special forces (gravity and friction).


Conceptual Survey of Electricity and Magnetism (CSEM). The 32-item multiple-choice CSEM was developed to assess students' knowledge about electricity and magnetism.

Other diagnostic tests. Physicists are quite active in the development of diagnostic tests. A large number can be found at the North Carolina State University's Physics Education Research group at http://www.ncsu.edu/per/ and specifically at their test instruments page at www.ncsu.edu/per/TestInfo.html. There are many other Physics Education Research groups around the country.

Known misconceptions in physics. Additionally, the "Student Difficulties in Physics Information Center" lists common misconceptions students have in areas of physics, as well as the research articles that have investigated/uncovered those misconceptions.
URL: http://www.physics.montana.edu/physed/misconceptions/index.html

Reasoning

Classroom Test of Scientific Reasoning (revised). 12-item test asks about conservation of weight/volume, proportional thinking, probabilistic/proportional thinking, combinatorial thinking, and correlational thinking. Scores on test classify students into three groups: empirical/inductive reasoners, transitional reasoners, and hypothetical/deductive reasoners.

Contact Anthony Lawson directly for tool at: anton1@asu.edu

Interviews

Biology

Interviews of students' conceptions of genetics. The article provides an interview protocol, as well as excerpts from interviews, of the concepts of inheritance, genetic structure, genetic processes, and extension.
Chemistry

*Interviews of students' conceptions of equilibrium and fundamental thermodynamics.* Article provides a set of interview questions surrounding a chemical reaction and the codes used to score those interviews. Interviews provided information on the type and extent of student misconceptions regarding the first and second law of thermodynamics, among others.


**Performance Assessment**

**Critical Thinking**

*Performance Assessments of Critical Thinking.* The article below describes the development and testing of four critical thinking performance tasks, and provides a rubric for scoring the tasks. The rubric used had high inter-rater reliability, with 95% of papers having exact or close agreement on scores between raters. Correlations of the tasks against various closed-ended critical thinking tests were low (0.25-0.30); however, high school teachers who used the tasks found them to provide good information on students' skills.


**Scoring Rubrics**

**Rubrics for Oral Presentations**

*Rubric for Oral Presentation.* The scoring rubric is an adaptation of several evaluation instruments that have been demonstrated strong inter-rater reliability and validity (Carlson and Smith-Howell, 1995).


**Rubrics for Written Presentations**

"*Presentation Sandwich" Checklist.* The "Presentation Sandwich" checklist is the mnemonic used in an introductory engineering course to describe the presentation requirements for all technical work. The checklist has two major sections: Section I concerns the Presentation Sandwich itself and Section II concerns Graphical Work. Section I has three sub-sections (A, B, and C), one concerning problem context, one concerning the technical work (i.e., the "sandwich filling"), and one concerning the discussion. Students who do not meet all of the yes/no are required to re-submit their work. Space is left for students demonstrating exemplary work. The checklist is provided to students prior to their assignment.


http://ceaspub.eas.asu.edu/mcneill/word_documents/papers/using_checklists_v10.doc

*Scoring Rubric for Evaluating Writing.*


*Scoring Rubric for an Assignment which Examines a Consumer Product.* The rubric shown here involves an assessment of student reports on a product (like a consumer report). These tools were originally developed by pharmacy faculty at Eastern Illinois University to develop and grade students' reports about a health-care product.
Scoring Rubric for Evaluating a Persuasive Argument Paper. This rubric evaluates a paper that is intended to present a persuasive argument on some topic. The rubric is divided into four categories (organization, content, usage, and mechanics), each of which is weighted to reflect the relative importance of that category.


Computer Modeling Checklist. The "Computer Modeling" checklist is used for computer modeling assignments. This checklist has five major sections. Section I concerns the correctness of the model. Section II defines what is expected when charts are present. Section III states how Spreadsheet models must be presented. Section IV is concerned with the written responses given to the questions posed in the assignment.

http://ceaspub.eas.asu.edu/mcneill/word_documents/papers/using_checklists_v10.doc

Scoring rubrics for projects that model a real life solution. Charles Emenaker (University of Cincinnati, Raymond Walters College) outlines two scoring rubrics for projects which require students to model a real-life situation mathematically, to interpret and to present their results. One rubric sums the score from four categories: problem understanding, problem plan, problem solution and problem presentation. The other rubric uses a "holistic" four-point scoring system and can be used for problems that require a less-detailed assessment.


Rubrics for Problem Solving
Rubrics for Assessing Skill in Addressing Open-Ended Problems. This rubric for the assessment of students' skills in addressing open-ended problems is founded on empirical data on the developmental process in problem solving. This four-step process is outlined in Figure 1 below. Essentially, these steps are: Step 1 -- Identify the problem, relevant information, and uncertainties; Step 2 – Explore interpretations and connections; Step 3 – Prioritize alternatives and communicate conclusions; and, Step 4 – Integrate, monitor, and refine strategies for re-addressing the problem (Lynch and Walcott, 2001). The rubric measures students' skill level against each of the four steps outlined above.
URL: http://www.wolcottlynch.com/index_files/page0002.html

Scoring Rubric for Evaluating an Inquiry Project. This rubric can be used to evaluate an inquiry project: namely, a project in which students formulate and pursue questions using multiple sources of information and multiple investigative methods. This rubric is based on the research on the nature of inquiry in the learning of professional practitioners and is intended to give weight to the critical processes of investigation while preventing the uncontrolled factors of working in a real-world environment from counting against the student.

Scoring Rubric for Writing in a Mathematics Class. Annalisa Crannell (at Franklin & Marshall College) has developed writing assignments and a rubric for grading them in her mathematics classes.

Rubric URL: http://server1.fandm.edu/departments/Mathematics/writing_in_math/checklist.html
Assignment URL:
http://www.fandm.edu/DEPARTMENTS/MATHEMATICS/writing_in_math/writing_index.html

Rubrics for evaluating questions students ask. This rubric evaluates the number and type of questions students pose in thinking about a problem-based case study situation. Students were asked to read a scenario and then to write down every question they had about the scenario. The set of questions students posed were evaluated along three dimensions: Orientation (i.e., whether question is descriptive, or whether asks about potential solutions/treatments) Relation to Case Study (i.e., whether question could be answered by the case study); and Complexity (i.e., whether question involved a response that involved higher-order thinking). A metric was assigned to the questions that enabled a numeric grading of the set of questions.


Rubrics for Discussions
Scoring Rubric for Evaluating a Discussion Conducted via a Listserv. This rubric evaluates a list-serv discussion in four areas: mechanics (grammar), participation (five postings required per week), content, and critical thinking. One can evaluate all the posts or a random sample of posts. The selected postings are rated on the four constructs and then summed for a total score. An instructor can also create two scores from the rubric: the sum of mechanics and participation describes the students' use of technology and the sum of the content and critical-thinking ratings describes the students' content understanding.


Scoring Rubric for Whole-Class Participation. This rubric is a holistic scoring rubric to be used in classes that use a combination of whole-class discussion with occasional small group work. A holistic scoring rubric rates student skills, attitudes, knowledge, and behavior in one score, rather than as a sum of different scores measuring specific competencies.


Rubrics for Evaluating a Portfolio
Scoring Rubric for Evaluating a Portfolio. These two rubrics were developed in a course as a negotiation between the students (pre-service elementary education students) and the faculty, and were based upon the recent literature on how to grade proposals. The rubrics emphasize in particular students’ growth over time, and attempt to take into consideration contextual factors that students may have faced in the class (which involved work in their field). In addition, having the students grade themselves promoted their ability to reflect on their own learning, a life long skill.

AUTONOMOUS REAL-TIME LEARNING SYSTEMS

LINKING MIND TO BRAIN BY MODELING HOW THE BRAIN LEARNS
A mature science of learning requires that we understand how BRAIN MECHANISMS give rise to BEHAVIORAL FUNCTIONS

SCIENCE
Brain and behavioral modeling
Interdisciplinary experiments

TECHNOLOGY
Brain models inspire new algorithms
Website: http://cns.bu.edu/techlab

EDUCATION
Brain models in science and math curricula

DIVERSITY
Permeates all activities

PROJECT THRUSTS
Learning in:
Visual perception and recognition: laminar neocortical dynamics of adaptive behavior
Audition, speech, and language
Cognitive-emotional interactions and planned sequential behaviors
Episodic memory: encoding and retrieval
Concept formation and rule discovery
Attentive recognition and neuromorphic technology
Educational technology, curriculum development, and outreach
Diversity outreach

SOCIETAL IMPACT
Communicating knowledge about how the mind works
Developing biomimetic computer science, engineering, math, technology
Explaining brain mechanisms of behavioral disorders

FACULTY
Daniel Bullock
Gail Carpenter
Robert Devaney
Howard Eichenbaum
Stephen Grossberg
Frank Guenther
Michael Hasselmo
Michael Kahana
Kathleen Kantak
Jacqueline Liederman
Earl Miller
Ennio Mingolla
Robert Sekuler
Barbara Shinn-Cunningham
Eugene Stanley
Chantal Stern
Takeo Watanabe

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Center of Excellence for Learning in Education, Science, and Technology
Stephen Grossberg, Principal Investigator
Boston University, Brandeis University, Massachusetts Institute of Technology, University of Pennsylvania
https://cns.bu.edu/CELEST
Recommended Reading List
(Submitted by Conference Speakers)


National Institute for Science Education, College Level 1 Team. (2002). The Field-tested Learning Assessment Guide Website. [http://www.flaguide.net] [This site provides introduction to assessment, self-instructional modules on different assessment techniques, and links to assessment instrument].


**Approaches to Biology Teaching (with key words and web sites)**


... has permitted an evolution of teaching style ... material, attempt to uncover misconceptions, and orchestrate ...


... students enter our classrooms with misconceptions about the ... is deeper when students learn biology by acting ... agrees that the most effective teaching strategy is ...


... Teaching Evolutionary Mechanisms: Genetic Drift and M&M's. ... to correct such misconceptions about evolution ...


... once had two large sections of nonmajor biology students (more ... categories ranging from common misconceptions about the ... learning to our classroom teaching as we ...


Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmedid=12587030


... a longitudinal study of conceptual change in biology. ... tests to evaluate students' misconceptions in science ... Handbook of Research on Science Teaching and Learning ...

Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1103711#N0x88e6dc0.0x840c45c


... Issues related to biological misconceptions, curriculum and didactic material are discussed, and some proposals are presented with the objective of aiding .... (2004).
Cooperative/Collaborative/Group Learning:


(For higher education faculty in all areas. The authors have used cooperative learning in diverse settings. Good balance of research results and practical application.)

(Examines 39 high-quality studies from 1980 and later in STEM areas. Finds overall, robust gains for achievement, persistence, and attitudes).

Misconceptions:


http://faculty.pepperdine.edu/dmulford/thesis/title.html


Misconceptions Web Sites:
http://www.oise.utoronto.ca/~science/miscon.html
http://www.physics.montana.edu/phyed/misconceptions
http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html
http://faculty.pepperdine.edu/dmulford/thesis/title.html
Other Useful Web Sites:
FLAG (Field-tested Learning Assessment Guide: http://flagguilde.org Web site contains assessment primer, CATs (Classroom Assessment Techniques, Matching Goals to Assessments, Resources, etc.

SALG (Student Assessment of Learning Gains): http://www.flaguide.org/cat/salg/salg1.php or http://www.wcer.wisc.edu/salgains/instructor/ Web site that contains a powerful tool that allows assessment of any/all components of classroom/laboratory practices’ impact on learning. Instructors create their own versions of the SALG from template and can save over them for multiple courses over multiple semesters. Students take SALG on-line and data is returned to faculty as raw or statistically analyzed data.

Bibliography STCSE (Students' and Teachers' Conceptions and Science Education). Documents research on teaching and learning science. Role students' and teachers' conceptions in the teaching and learning process given particular attention. http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html Searchable and downloadable in html or Endnote.

http://www.first2.org/resources/wrkshopmaterials/workshop_table.html

Richard Hake’s web site: http://www.physics.indiana.edu/~sdi/

Rich Felder’s web site: http://www2.ncsu.edu/unity/lockers/users/f/felder/public/

1999-2000 SUCCEED Faculty Survey of Teaching Practices and Perceptions of Institutional Attitudes toward Teaching. SUCCEED Coalition Report, December 2001. View full report (95 pages) or executive summary (9 pages). Reports frequencies of use of active and cooperative learning, learning objectives, writing assignments, and faculty development services, and perceptions of the value ascribed to teaching quality by faculty, administrators, and the faculty reward system. Survey respondents were 586 engineering faculty members at 8 institutions.
http://www2.ncsu.edu:8080/unity/lockers/users/f/felder/public/#WhatsNew

Project Galileo has ConcepTests that have been field-tested. http://galileo.harvard.edu/


PKAL (Project Kaleidoscope: http://www.pkal.org - pkal@pkal.org) has an on-line publication on "What Works, What Matters and What Lasts." The goal of this collection of stories and essays is to capture, analyze and disseminate lessons learned from the experience of leading agents of change: institutional, organizational and individual so to inform the work of the larger community.

Teaching Large Lecture Classes, TA Professional Development, Cognitive Apprenticeship Model, etc. with downloadable files: http://groups.physics.umn.edu/physed/

More on Bloom’s Taxonomy: http://www.kcmetro.cc.mo.us/longview/ctac/blooms.html
Web Sites With Scientific Teaching Examples:

**Group problem-solving in lecture**
www.ibscore.org/courses.htm
http://yucca.uoregon.edu/wb/index.html
http://mazur-www.harvard.edu/education/educationmenu.php

**Problem-based learning**
www.udel.edu/pbl/
www.microbelibrary.org
www.ncsu.edu/per/scaleup.html
http://webphysics.iupui.edu/jitt/jitt.html

**Case studies**
www.bioquest.org/lifelines/
http://ublib.buffalo.edu/libraries/projects/cases.case.html
http://brighamrad.harvard.edu/education/online/tcd/tcd.html

**Inquiry-based labs**
http://chemistry.Beloit.edu
http://mc2.chem.berkeley.edu
www.plantpath.wisc.edu/fac/joh/bbtl.htm
www.bioquest.org/
http://biology.dbs.umt.edu/biol101/default.htm
http://campus.murraystate.edu/academic/faculty/terry.derting/ccli/cclihomepage.html

**Interactive computer learning**
www.bioquest.org/
www.dnai.org
http://evangelion.mit.edu/802TEAL3D/
http://ctools.msu.edu/

**General Papers:**
D. Ebert-May et al., Bioscience 47, 601 (1997).
D. Udovic et al., Bioscience 52, 272 (2002).


**Scholarship of Teaching and Learning**


**Quotable Quotes**

“Science not as a noun…but as a process, a set of activities, a way of proceeding and thinking.”
(Tinker & Thornton, 1992, p. 155).

"There is no neutral pedagogical practice. Every single one is based on a given conception of the learning process and of the object of such a process. Most probably, those practices much more than the methods themselves are exerting the greatest lasting effects in the domain of literacy, as in any field of knowledge."
(Ferreiro, Emilia, 1991).

Elementary and high school students perceive science largely as a passive process of observing and recording events. They view good scientists as ones who make careful observations and keep complete and accurate records of all they observe.”

‘The structure of our institutions conveys a more powerful message than their contents." (Jay Lemke)