

**Center for Teaching and Learning**



**CLASSROOM  
ASSESSMENT TOOLS**

## CONTENTS\*

Matching Outcomes to Assessment Tools.....	1
Classroom Assessment Tools.....	5
Attitude Surveys.....	5
Concept Tests .....	8
Concept Mapping.....	11
Conceptual Diagnostic Tests.....	14
Interviews.....	18
Performance Assessments.....	22
Portfolios.....	25
Scoring Rubrics.....	28
Weekly Reports.....	31

\* Note: These materials and additional information may be found at <http://www.flaguide.org/cat/cat.php>.

# Matching Outcomes to Assessment Tools

(Charts from [www.flaguide.org/goals/goaltab.php](http://www.flaguide.org/goals/goaltab.php))

To find appropriate CAT(s) use the Student Learning Outcomes table below:

- Reflect on your own course goals.
- Identify the goals within the list that most closely approximate your own (5 or 6 goals is adequate).
- Click the check boxes next to those goals.
- Click the "Submit" button.
- A chart of the goals and corresponding CAT(s) will be made which can be printed out.



**Student Learning Outcomes      Classroom Assessment Techniques**

Knowledge	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Demonstrates basic knowledge of facts and terms			X	X		X		X		X
Demonstrates basic knowledge of concepts and theories			X	X	X	X	X			X
Demonstrates synthesis and integration of information and ideas			X	X	X	X		X		X
Develops skill in using materials, tools and technology central to subject						X	X	X		
Learns techniques and methods used to gain new knowledge in subject							X			
Learns to evaluate methods and materials of this subject					X		X			
Learns modeling methods appropriate for subject			X				X			
Learns to appreciate important contributions of this subject										
Develops an informed understanding of the role of science and technology										

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Analytical Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Analyzes problems from different points of view			X		X	X		X		X
Recognizes interrelationships among problems and issues			X	X	X	X		X		
Analyzes and interprets experimental data effectively						X	X			X
Applies principles and generalizations to new problems and situations			X		X	X	X			
Organizes information into meaningful categories				X	X			X		
Uses order of magnitude estimation effectively					X					

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Communication Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Communicates in writing effectively			X		X	X		X		X
Communicates in speaking effectively			X			X				
Uses facts to get points across to others			X			X				
Uses graphs effectively to support points being made			X	X		X	X	X		

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Research Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Designs an appropriate experiment to answer a question							X			
Carries out a designed experiment							X			
Brings in information from outside sources						X				
Uses computer-based and other resources effectively						X	X	X		
Seeks information on problems from multiples sources						X		X		
Understands importance of what has already been done to solve problems										
Uses appropriate synthetic/analytic methods to solve problems			X		X	X	X			
Uses instrumentation appropriately and effectively							X			
Demonstrates ability to formulate effective questions						X				X
Challenges the way things are done										
Improves on what has been done before			X							
Generates many potential solutions to a given problem						X				

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Teamwork Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Helps reconcile differences of opinion among team members										
Shares credit for success with others										
Cooperates with others			X							
Encourages participation among all team members										X
Shares information with others			X							
Contributes his/her share of project workload										
Demonstrates ability to work on multidisciplinary team										
Demonstrates ability to take leadership role in support of team goals										

**Student Learning Outcomes      Classroom Assessment Techniques**

Attitudes	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Identifies desirable course components		X								
Identifies desirable course pedagogies		X								
Identifies perceived lab/lecture match		X								
Identifies beliefs about the nature of a field		X								
Indicates perceptions about interdisciplinary connections		X								
Indicates student's perceived level of understanding		X								
Indicates student's level of confidence		X								

**Student Learning Outcomes      Classroom Assessment Techniques**

Instructor Goals	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Answers student questions on a regular basis										X
Use assessment regularly to assure learning is occurring			X							X
Communicates desire for student success			X							X
Develops and refines instruction based on student feedback			X							X
Receives regular feedback from students			X							X
Tracks typical questions										X
Retention of material										
Subsequent performance in next course										
Improvement in attendance			X							
Equitable performance for all students										

## Attitude Surveys

Eileen Lewis  
Department of Chemistry  
Canada College

Elaine Seymour  
Bureau of Sociological Research  
University of Colorado, Boulder

### What is an attitude survey?

While attitudinal surveys may take many forms and address a range of issues, they typically consist of a series of statements that students are asked to express their agreement or disagreement using a scale.

### Why use attitude surveys?

This type of survey provides valuable information on student perceptions of and emotions regarding their classroom experience. This includes general attitudes toward the course, the discipline, and their own learning. The results from this survey can also help you identify elements in your course that best support student learning.

### An example

Please use the 7-point scale to indicate your agreement or disagreement with each statement.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Don't know
Often in lab I didn't understand the concept behind the lab experiment.	1	2	3	4	5	6	7
I like labs where I get to help design an experiment to answer a question.	1	2	3	4	5	6	7
This course provided opportunities for me to help design experiments to answer a question.	1	2	3	4	5	6	7
It was clear how the lab experiments fit into this course.	1	2	3	4	5	6	7

### Assessment purposes

- To provide information about students' learning styles or preferences for ways of learning, allowing instructors to choose among instructional approaches that would best meet the needs of the students
- To discover which components of the course contribute most significantly to students' learning
- To provide feedback helpful for designing activities to foster a more realistic view of a discipline and what members of that discipline do
- To prompt students to reflect on their own learning preferences, strengths, or styles

## Teaching goals

### *Student learning outcomes*

- Learn the techniques and methods used to gain new knowledge in the subject
- Develop appropriate study skills, strategies, and habits
- Develop awareness of learning processes and control over those processes
- Develop a knowledge and appreciation for the subject

### *Instructor teaching outcomes*

- Develop and refine instruction based on student feedback

## What is involved?

Instructor preparation time	Very little time is needed to use a valid, existing survey. Large amounts of time are required to develop a survey that is reliable and measures what is intended.
Preparing your students	No training is required, but a description of the survey's goals and scales should be read to students as well as included in the survey form itself.
Class time	Varies with length, but rarely more than 20 minutes.
Disciplines	Appropriate for all.
Class size	Appropriate for all.
Special classroom / technical requirements	None, although an optical scanning device may be useful to read and analyze data in large classes.
Individual or group involvement	Typically individual.
Analyzing results	Depends very much on class size and length of the survey. In large classes, the use of scanning forms and optical readers make the task easier.
Other things to consider	To insure meaningful results, student responses must be guaranteed anonymity. These surveys can be given pre and post to measure gains over a course or to provide mid-course corrections to classroom teaching methods. Demographic data may be included in the survey so that correlation with gender, major, or ethnicity can be made.

## Description

An attitudinal survey can provide information on student perceptions of their classroom experience. It can reveal perceptions on the content of a course, specific components of a course, course components that aid or are detrimental to learning, and the effects of course innovations. Attitudinal surveys may also focus on students' needs in taking a course, how well those needs are met, student interest in or appreciation for the subject matter or field, student confidence in their ability to perform in a course, or their beliefs about the nature of the discipline itself.

## Limitations

Constructive questions or statements on an attitudinal survey are the result of considerable work in both designing the question/statement so that it measures what it was intended to measure and has reliability across students and groups. Additionally, for best results, students must be guaranteed anonymity. This means if the instructor analyzes the data, no student identification should be requested. You may ask for demographic information like gender, ethnicity, major, etc. and look for correlation across those variables. If you want to correlate student responses to their performance, you must have someone else gather and analyze the data, explicitly letting the students know you are doing so. Data analysis can be very time consuming in large classes unless you have optical scanning response forms and an optical reader. For small classes, you may provide additional space for students to elaborate on their ideas.

## Sources

- Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2<sup>nd</sup> ed.). San Francisco: Jossey-Bass.
- Braskamp, L., & Ory, J. (1994). *Assessing faculty work: Enhancing individual and institutional performance*. San Francisco: Jossey-Bass.
- Centra, J. A. (1973). Effectiveness of student feedback in modifying college instruction. *Journal of Educational Psychology*, 65(3), 395-401.
- Davis, B. G. (1993). *Tools for teaching*. San Francisco: Jossey-Bass.
- Fowler, F. J. (1993). *Survey research methods*. Newbury Park, CA: Sage.
- Gramson, Z., & Chickering, A. (1977). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 39, 5-10.
- Henderson, M. E., Morris, L. L., & Firz-Gibbon, C. T. (1987). *How to measure attitudes*. Newbury Park, CA: Sage.
- Murray, H. G. (1991). Effective teaching behaviors in the college classroom. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research*, Vol. 7 (pp. 135-172). New York: Agathon.
- National Research Council (1997). *Science teaching reconsidered: A handbook*. Washington, D. C.: National Academy Press.
- Reynolds, A. (1992). What is competent beginning teaching? A review of the literature. *Review of educational research*, 62, 1-35.
- Shulman, L. S. (1990). *Aristotle had it right: On knowledge and pedagogy* (Occasional paper no. 4). East Lansing, MI: The Holmes Group.
- Shulman, L. S. (1991). Ways of seeing, ways of knowing – ways of teaching, ways of learning about teaching. *Journal of Curriculum Studies*, 23(5), 393-395.
- Theall, M., & Franklin, J. (Eds.) (1990). Student ratings of instruction: Issues for improving practice. *New Directions for Teaching and Learning*, No. 43. San Francisco: Jossey-Bass.

## ConcepTests

Arthur B. Ellis, Clark R. Landis, Kathleen Meeker  
Department of Chemistry  
University of Wisconsin-Madison

### What is a ConcepTest?

The instructor presents one or more questions during class involving key concepts, along with several possible answers. Students in the class indicate by, for example, a show of hands, which answer they think is correct. If most of the class has not identified the correct answer, students are given a short time in lecture to try to persuade their neighbor(s) that their answer is correct. The question is asked a second time by the instructor to gauge class mastery.

### Why use ConcepTests?

The instructor obtains immediate feedback on the level of class understanding. Students have an opportunity to enhance teamwork and communication skills. Many instructors have reported substantial improvements in class attendance and attitude toward the course.

### An example

During an experiment, the class is asked to vote - "How many of you think that a quarter of the laser light will now reach the solar cell? How many of you think none of the light will now get to the solar cell?" If most of the class has correctly noted that one-quarter of the light will be transmitted, you can quickly affirm why this is correct and continue with the lesson. If the majority of the class does not select the correct answer, ask your students to convince their neighbor(s) that their answer is correct. After a short discussion period, have the class vote a second time. If the class has now selected the correct answer, a quick explanation is again appropriate. If the majority of the class has not reached the correct answer, a more detailed explanation can be presented.

### Assessment purposes

- To obtain real-time feedback regarding student understanding
- To determine the pace and direction of the remainder of the lecture

### Teaching goals

#### *Student learning outcomes*

- Apply ideas and concepts while communicating verbally
- Integrate concepts
- Work cooperatively with others

#### *Instructor teaching outcomes*

- Obtain real-time feedback regarding student misconceptions and understanding
- Communicate the instructor's desire for students to be successful in the course

**What is involved?**

Instructor preparation time	Some time is needed to create ConcepTests. For some disciplines, hundreds of sample questions exist on websites as a time-saving resource.
Preparing your students	Students require minimal training. Through sustained use in class, students become comfortable with the method.
Class time	ConcepTests typically last from less than a minute to several minutes.
Disciplines	Appropriate for all.
Class size	Best with classes of at least a dozen students. Successfully used in large lecture classes.
Special classroom / technical requirements	None. The method can be used in conjunction with worksheets, lecture demonstrations, computer animations, and film clips.
Individual or group involvement	Small group of 2 or 3 students.
Analyzing results	Minimal.
Other things to consider	It is more difficult to predict how much material will be covered in a lecture. It may take a sustained effort for an instructor and class to become comfortable and work effectively with ConcepTests.

**Description**

Questions in a ConcepTest inform or calibrate students as to how well they understand what the instructor has identified as key ideas, and they calibrate instructors as to class mastery of these ideas at the time of their presentation. ConcepTests thus make the lecture a vehicle for bringing student and instructor expectations into alignment.

**Limitations**

If the class size is too small, students may feel more conspicuous and self-conscious, hindering their participation. Instructors may need to encourage students to sit together to participate in ConcepTests if the lecture room has many more chairs than students. Some instructors group students into teams to work on ConcepTests during their lectures.

### **Links & sources**

Mazur, E. (1997). *Peer instruction: A user's manual*. Upper Saddle River, NJ: Prentice Hall.

New Traditions Project. (1997). *Establishing new traditions: Revitalizing the chemistry curriculum*. Retrieved August 24, 2005, from <http://newtraditions.chem.wisc.edu>.

Project Galileo. (2005). *Project Galileo: Your gateway to innovations in science education*. Retrieved August 24, 2005, from <http://galileo.harvard.edu>.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.

Tobias, S. (1992). *Revitalizing undergraduate science: Why some things work and most don't*. Tucson, AZ: Research Corporation.

The Trustees of Beloit College and the Regents of the University of California (2004). *ChemConnections: Systemic change initiatives in chemistry*. Retrieved August 24, 2005, from <http://chemlinks.beloit.edu>.

The University of Wisconsin Board of Regents. (1996). *Chemistry ConcepTests*. Retrieved August 24, 2005, from <http://www.chem.wisc.edu/~concept>.

## Concept Mapping

Michael Zeilik  
Department of Physics & Astronomy  
University of New Mexico

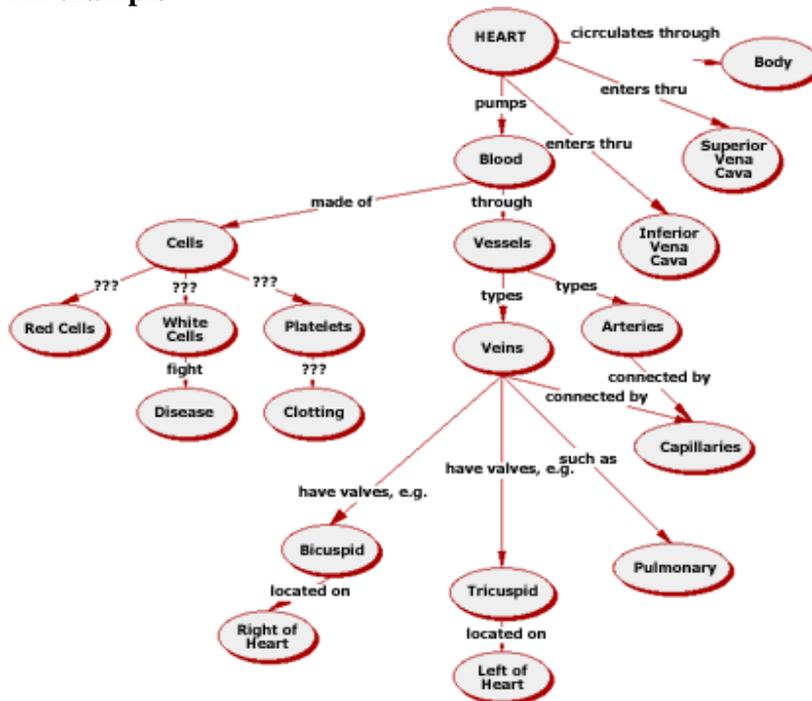
### What is a concept map?

A concept map is a diagram of nodes containing concept labels that are linked together with labeled directional lines. The concept nodes are arranged in hierarchical levels that move from general to specific concepts.

### Why use concept maps?

Concept maps assess how well students see the “big picture.” They have been used for over 25 years to provide a useful and visually appealing way of illustrating students’ conceptual knowledge.

### An example



### Assessment purposes

- To investigate how well students understand the correct connections among concepts in a subject
- To document the nature and frequency of students’ misconceptions
- To capture the development of students’ ideas over time

## Teaching goals

### *Student learning outcomes*

- Learn terms, facts, and concepts of this subject
- Organize information into meaningful categories
- Synthesize and integrate information, ideas, and concepts
- Think about the “big picture” and see connections among concepts
- Think creatively about the subject
- Improve long-term memory skills for accessible knowledge
- Develop higher-level thinking skills, strategies, and habits
- Use graphics effectively

### *Instructor teaching outcomes*

- Gain insight into the way students view a scientific topic
- Examine the valid understandings and misconceptions students hold
- Assess the structural complexity of the relationships students depict

## What is involved?

Instructor preparation time	Minimal if students construct maps; large for designing “fill-in” maps.
Preparing your students	Students need training (about an hour) and continual practice.
Class time	At least 30 minutes.
Disciplines	Appropriate for all.
Class size	Small classes if students construct maps individually; cooperative teams constructing maps will work with large (or small) classes.
Special classroom / technical requirements	None.
Individual or group involvement	Either.
Analyzing results	Intensive for formal scoring for large classes; concept maps are generally not graded.
Other things to consider	Very demanding cognitive task for students.

## Description

A concept map is a two-dimensional, hierarchical node-link diagram that depicts the structure of knowledge within a scientific discipline as viewed by a student, an instructor, or an expert in a field or sub-field. The map is composed of concept labels, each enclosed in a box or oval, a series of labeled linking lines, and an inclusive, general-to-specific organization.

## Limitations

Concepts maps provide a useful and visually appealing way of depicting the structure of conceptual knowledge that people have stored in long-term memory. As a result, they offer a readily accessible way of assessing how well students see “the big picture.” They are not designed to tap into the kind of process knowledge that students also need to solve novel problems or for the routine application of algorithmic solutions. Because they probe an individual’s or group’s cognitive organization, they are very idiosyncratic and difficult to compare, either among individuals or groups, or across time for the same individuals or groups.

## Links & sources

- Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). San Francisco: Jossey-Bass Publishers.
- Austin, L. B., & Shore, B. M. (1995). Using concept mapping for assessment in physics. *Physics Education*, 30(1): 41-45.
- Inspiration Software, Inc. (2005). *Inspiration Software, Inc.* Retrieved August 24, 2005, from <http://www.inspiration.com>.
- Markham, K., Mintzes, J., & Jones, G. (1994). The concept map as a research and evaluation tool: Further evidence of validity. *Journal of Research in Science Teaching*, 31(1): 91-101.
- Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (1998). *Teaching science for understanding: A human constructivist view*. San Diego, CA: Academic Press.
- The National Association for Research in Science Teaching. (2004). *The National Association for Research in Science Teaching*. Retrieved August 28, 2005, from <http://www.educ.sfu.ca/narstsite/>.
- Novak, J. D. (1998). Learning, creating and using knowledge: *Concept maps as facilitative tools in schools and corporations*. Mahwah, NJ: Lawrence Erlbaum.
- Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge University Press.
- Novak, J. D., & Wandersee, J. D. (Eds.). (1990). Perspectives on concept mapping. *Journal of Research in Science Teaching*, 20(10).
- Pearsall, R., Skipper, J., & Mintzes, J. Knowledge restructuring in the life sciences: A longitudinal study of conceptual change in biology. *Science Education*, 81, 193-215.
- Pendley, B. D., Bretz, R. L., & Novak, J. D. (1994). Concept maps as a tool to assess learning in chemistry. *Journal of Chemical Education*, 71(1): 9-15.
- Ruiz-Primo, M., & Shavelson, R. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching*, 33(6): 569-600.
- Schau, C., & Mattern, N. (1997). Use of map techniques in teaching statistics courses. *The American Statistician*, 51(2): 171-175.
- Wallace, J., & Mintzes, J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching*, 27(10): 1033-1052.
- Zeilik, M., Schau, C., Mattern, N., Hall, S., Teague, K., & Bisard, W. (1997). Conceptual astronomy: A novel model for teaching postsecondary science courses. *American Journal of Physics*, 65(10): 987-996.

## Conceptual Diagnostic Tests

Michael Zeilik  
Department of Physics and Astronomy  
University of New Mexico

### What is a conceptual diagnostic test?

A conceptual diagnostic test is a test with items in a multiple-choice or short-answer format that has been designed with common misconceptions in mind.

### Why use conceptual diagnostic tests?

Using conceptual diagnostic tests assesses how well students understand key concepts in a SMET field prior to, during, and after instruction.

### An example

The following is a sample item from the Astronomy Diagnostic Test. As seen from your location, when is the Sun directly overhead at noon (so that no shadows are cast)?

- A. Every day
- B. On the day of the summer solstice
- C. On the day of the winter solstice
- D. At both of the equinoxes (spring and fall)
- E. Never from the latitude of your location

The correct answer is E.

### Assessment purposes

- To reveal the misconceptions students bring as prior knowledge to a class
- To measure the conceptual gains of a class as a whole
- To identify concepts that are weak areas of understanding

### Teaching goals

#### *Student learning outcomes*

- Learn concepts and terms of a subject
- Develop higher-level thinking skills, strategies, and habits
- Recognize common misconceptions in order to avoid or change them

#### *Instructor teaching outcomes*

- Tracks students' misconceptions, conceptual change, and the impact of your instruction
- Allows for evaluation of student comprehension

**What is involved?**

Instructor preparation time	Minimal for using available tests; moderate for designing your own questions.
Preparing your students	Nothing special.
Class time	At least 30 minutes for a complete test.
Disciplines	Appropriate for all.
Class size	Small and large.
Special classroom / technical requirements	Machine scoring of scannable forms.
Individual or group involvement	Either.
Analyzing results	Can be machine scored for large classes; diagnostic tests are generally not graded.
Other things to consider	Need to match tests to course goals.

**Description**

A conceptual diagnostic test aims to assess students' conceptual understanding of key ideas in a discipline, especially those that are prone to misconceptions. Hence, they are discipline-specific rather than generic. The format typically is multiple-choice so that a conceptual diagnostic test can be given efficiently to large numbers of students and machine scored. Unlike traditional multiple-choice items, the distracters are designed to elicit misconceptions known from the research base. A student must have a clear understanding of a concept in order to select the correct response. Because conceptual diagnostic tests can be scored quickly, they can be used as formative as well as summative assessments.

**Limitations**

To develop reliable and valid conceptual diagnostic tests is a major, long-term undertaking. Only a limited number of such tests are currently available and those may not match your course goals. Your field may be one in which no such tests have been developed.

**Links & sources****Misconceptions research**

Driver, R. (1993). *The pupil as scientist?* London: Milton Keynes.

Pfundt, H. and Duit, R. (1994). *Bibliography: Students' Alternative Frameworks and Science Education* (4th ed.). Germany: Kiel.

**Astronomy**

Nussbaum, J. (1979). Children's conception of the earth as a cosmic body: A cross-age study. *Science Education*, 63, 83-93.

Sneider, C., & Pulos, S. (1983). Children's cosmographies: Understanding the earth's shape and gravity. *Science Education*, 67, 205-221.

Vosniadou, S. (1990). Conceptual development in astronomy. In S. Glynn, R. Yeany, & B. Britton (Eds.), *The psychology of learning science* (pp. 149-177). Hillsdale, NJ: Lawrence Erlbaum.

## **Biology**

- Arnaudin, M. W., & Mintzes, J. J. (1985). Students' alternative conceptions of the circulatory system: A cross-age study. *Science Education*, 69, 721-733.
- Bell, B. (1981). When is an animal not an animal? *Journal of Biological Education*, 15, 213-218.
- Wandersee, J. H. (1986). Can the history of science help science educators anticipate students' misconceptions? *Journal of Research in Science Teaching*, 23, 581-597.

## **Chemistry**

- American Chemical Society. (2005). *Division of chemical education*. Retrieved August 24, 2005 from <http://tigerched.clemson.edu/exams>.
- Ben-Zvi, N., & Gai, R. (1994). Macro- and micro-chemical comprehension of real work phenomena. *Journal of Chemical Education*, 71, 730-732.
- Hackling, M., & Garnett, D. (1985). Misconceptions of chemical equilibria. *European Journal of Science Education*, 7, 205-214.
- Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of Chemical Education*, 69, 191-196.
- Novik, S., & Menis, J. (1976). A study of student perceptions of the mole concept. *Journal of Chemical Education*, 53, 720-722.
- Stavy, R. (1988). Children's conception of gas. *International Journal of Science Education*, 10, 553-560.

## **Physics**

- American Association of Physics Teachers. (2005). *American Association of Physics Teachers*. Retrieved August 24, 2005, from <http://aapt.org>.
- Champagne, A., Klopfer, L., & Anderson, J. (1980). Factors influencing the learning of classical mechanics. *American Journal of Physics*, 48, 1074-1079.
- Clement, J. (1982). Studies of preconceptions in introductory mechanics. *American Journal of Physics*, 50, 66-71.
- Fredette, N., & Clement, J. (1981). Student misconceptions of an electric current: What do they mean? *Journal of College Science Teaching*, 10, 280-285.
- Watts, D. M. (1985). Students' conceptions of light - A case study. *Physics Education*, 20, 183-187.

## **Diagnostic tests**

- Bisard, W., & Zeilik, M. (1998). Conceptually centered astronomy with actively engaged students. *Mercury*, 27(4), 16-19.
- Hake, R. R. (1998). Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64-74.
- Hestenes, D., & Wells, M. (1992). A mechanics baseline test. *The Physics Teacher*, 30, 159-166.
- Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, 30(3): 141-151.
- Lightman, A., & Sadler, P. (1993). Teacher predictions versus actual student gains. *The Physics Teacher*, 31(3): 162-167.

- Odom, A. L., & Barrow, L. H. (1995). Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion and osmosis after a course of instruction. *Journal of Research in Science Teaching*, 32(1): 45-61.
- Russell, A. A. (1994). A rationally designed general chemistry diagnostic test. *Journal of Chemical Education*, 71(4): 314-317.
- Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education*, 10(2), 159-169.
- Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science (pp. 177-210). *Handbook of Research of Science Teaching and Learning*. New York: Macmillan Publishing.
- Zeilik, M., Schau, C., & Mattern, N. (1998). Misconceptions and their change in university-level astronomy courses. *The Physics Teacher*, 36: 104-107.
- Zeilik, M., Schau, C., Mattern, N., Hall, S., Teague, K., & Bisard, W. (1997). Conceptual astronomy: A novel model for teaching postsecondary science courses. *American Journal of Physics*, 65(10): 987-996.

## **Interviews**

Mike U. Smith  
Department of Internal Medicine  
Mercer University School of Medicine

Sherry A. Southerland  
Science Education  
University of Utah

### **What is an interview?**

A formal interview consists of a series of well-chosen questions (and often a set of tasks or problems) that are designed to elicit a portrait of a student's understanding about a scientific concept or set of related concepts. The interview may be videotaped or audiotaped for later analysis.

### **Why use interviews?**

In-depth structured interviews with a handful of carefully selected students will enable you to readily judge the extent of understanding your students have developed with respect to a series of well-focused, conceptually-related scientific ideas. This form of assessment provides feedback that is especially useful to instructors who want to improve their teaching and the organization of their courses.

### **An example**

The interview should begin with a focus question that requires application of the concept to be investigated without forcing the student into an explicit definition. Specific definitions of the concept, if needed, should be sought only after understanding the student's response to the focusing question. It is important for the interviewer to wait at least 3 to 5 seconds after each prompt before trying to interpret the question or ask another.

### **Assessment purposes**

- To investigate how well students understand and can apply a concept
- To identify gaps in understanding that may be common among students
- To document the general and content-specific procedures that students employ in application tasks and the sequences and manner in which processes are employed
- To document how student understanding and problem-solving skills change over time or with instruction
- To obtain verbal feedback from students about course structure, teaching techniques, and other aspects of the course or program of instruction

## Teaching goals

### *Student learning outcomes*

- Analyzes problems from different viewpoints and communicates effectively
- Recognizes interrelationships among problems and issues
- Applies principles and generalizations to new problems and situations
- Demonstrates a basic knowledge of the concepts and theories of the subject
- Demonstrates synthesis and integration of information and ideas
- Uses appropriate synthetic and analytic methods to solve problems

### *Instructor teaching outcomes*

- Answers students' questions and provides feedback from students
- Bridges gap between learning and assessment
- Tracks typical questions and problems

## What is involved?

Instructor preparation time	Several hours required to develop a set of good questions, tasks, and problem sets. Additional time to locate appropriate props and recording equipment, if desired.
Preparing your students	Interviews are most fruitful when the student has developed a good rapport with you. It is essential that the student feels relaxed and at ease.
Class time	One-on-one or small group interviews may be conducted in less than an hour in your office or other convenient private space. Some practice will reduce the time required to conduct a good interview.
Disciplines	No disciplinary restraints. Appropriate for all SMET fields.
Class size	Normally, structured interviews are conducted outside of class. It is important that subjects be carefully selected to represent a range of abilities and interest levels among students enrolled in a course.
Special classroom / technical requirements	Interview protocol, props, recording equipment, and small private space.
Individual or group involvement	The most useful interviews are those conducted with individuals or small groups outside of class. Sometimes this is done well in laboratory sections, but TAs will need special training or assistance.
Analyzing results	For formative assessment, the instructor may want to review taped interviews with special attention to potential misconceptions. If used for summative evaluation, a type of scoring rubric may be developed.
Other things to consider	None.

## **Description**

During a structured interview, the instructor uses a set of questions called probes designed in advance of the interview to elicit a portrait of the learner's understanding about a specific concept/topic. The student may be asked to use their own words to explain an idea, but is typically required to go beyond simple recognition of a concept to construct a detailed personal explanation. Generally, the student is also asked to use that concept to solve a problem or other application task. Additional questions may be added in response to the answers given. It is this freedom to follow the interviewee, to ask for clarifications, and to focus on errors, misconceptions, and gaps in knowledge, that makes the interview so much more fruitful than more traditional methods of assessment.

## **Limitations**

Time is a major inhibiting factor in using structured interviews to inform teaching. To prevent this issue from being prohibitive, selective sampling of a broad range of students in a classroom may be employed to make the technique more practical, yet still provide a portrait of how different students in a class are engaging with course material. A second limitation of structured interviews lies in the extreme content specificity of students' thinking. For instance, when dealing with biological knowledge, the type of organism included in an interview prompt has been shown to radically change the nature of a student's response. Thus, if an instructor would like to probe a student's reasoning pattern about a specific process, the nature of the exemplar included in the probe must be taken into account.

## **Sources**

- Bishop, B. A., & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution. *Journal of Research in Science Teaching*, 27, 415-427.
- Demastes-Southerland, S., Good, R., & Peebles, P. (1995). Students' conceptual ecologies and the process of conceptual change in evolution. *Science Education*, 79, 637-666.
- Demastes-Southerland, S., & Good, R. G. (1995). The crisis of representation: Concept mapping, written explanations, and students' conceptual frameworks in evolution. Presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA.
- Demastes-Southerland, S., Good, R., & Peebles, P. (1996). Patterns of conceptual change in evolution. *Journal of Research in Science Teaching*, 33, 407-431.
- Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent students. *Studies in Science Education*, 5, 61-84.
- Fredette, N., & Clement, J. (1981). Student misconceptions of an electric current: What do they mean? *Journal of College Science Teaching*, 10, 280-285.
- Lewis, E. L., & Linn, M. C. (1994). Heat energy and temperature concepts of adolescents, adults, and experts: Implications for curricular improvements. *Journal of Research in Science Teaching*, 31, 657-677.
- Rowe, M. B. (1974). Wait-time and rewards as instructional variables. *Journal of Research in Science Teaching*, 11, 81-94.

- Smith, M. U. (1992). Expertise and the organization of knowledge: Unexpected differences among genetic counselors, faculty, and students on problem categorization tasks. *Journal of Research in Science Teaching*, 29, 179-205.
- Smith, M. U., & Good, R. (1984). Problem solving and classical genetics: Successful versus unsuccessful performance. *Journal of Research in Science Teaching*, 21, 895-912.
- Songer, C., & Mintzes, J. (1994). Understanding cellular respiration: An analysis of conceptual change in college biology. *Journal of Research in Science Teaching*, 31, 621-637.
- Southerland, S. A., Smith, M. U., & Cummins, C. L. (2000). "What do you mean by that?" Using Structured Interviews to Assess Science Understanding. In J. J. Mintzes, J. H. Wandersee, & J. P. Novak (Eds.), *Assessing science understanding: A human constructivist view* (Chapter 6). Academic Press.
- Tamir, P., & Zohar, A. (1992). Anthropomorphism and teleology in reasoning about biological phenomena. *Journal of Biological Education*, 25, 57-67.
- White, R., & Gunstone, R. (1992). *Probing understanding*. New York: The Falmer Press.

## Performance Assessments

Timothy F. Slater  
Department of Physics  
Montana State University

### **What is a performance assessment?**

Performance assessments are designed to judge students' abilities to use specific knowledge and research skills. Most performance assessments require the student to manipulate equipment to solve a problem or make an analysis. Rich performance assessments reveal a variety of problem-solving approaches, thus providing insight into a student's level of conceptual and procedural knowledge.

### **Why use performance assessments?**

Student growth in knowledge of methods, procedures, and analysis skills prove somewhat difficult to evaluate, particularly with conventional multiple-choice examinations. Performance assessments, used in concert with more traditional forms of assessment, are designed to provide a more complete picture of student achievement.

### **An example**

The following is a holistic scoring example with a telescope task. Your task is to set up and align the 8" telescope, find three different sky objects, and accurately describe some aspects of these objects that astronomers consider to be important.

*Level 3:* Student completes all aspects of task quickly and efficiently and is able to answer questions about the equipment used and objects observed beyond what is obvious. The tasks are: align telescope mount with north celestial pole, align finder telescope with primary telescope, center on target object, select and focus appropriate eyepiece, provide information about the target beyond the literal descriptive level, and answer questions about the target correctly.

*Level 2:* Student completes all aspects of task and provides descriptive information about the equipment and objects observed.

*Level 1:* Student is not able to complete all aspects of task or is not able to sufficiently provide information about the equipment used or objects observed.

*Level 0:* No attempt or meaningful effort obvious.

### **Assessment purposes**

The purpose of performance assessment is to evaluate the actual process of doing science or mathematics. Performance assessments examine students' actual application of knowledge to solve problems. In some cases, the solution of the problem may imply the application of a specific procedure or combination of procedures learned in class, or a thoughtful adaptation of students' knowledge. The assessment of students' knowledge focuses on the performance and the result.

## Teaching goals

### *Student learning outcomes*

- Develop ability to apply systematic procedures
- Authentically utilize resource tests, laboratory equipment, and computers
- Develop ability to use scientific methodology and solve complex problems
- Apply and evaluate multiple approaches

### *Instructor teaching outcomes*

- Bridges gap between learning and assessment

## What is involved?

Instructor preparation time	Medium.
Preparing your students	None.
Class time	10-40 minutes depending on complexity of task.
Disciplines	Appropriate for laboratory-based sciences.
Class size	Small for direct applications, unlimited for embedded assessments using student-completed forms.
Special classroom / technical requirements	Varies according to task.
Individual or group involvement	Both.
Analyzing results	Low.
Other things to consider	Manipulative materials are often required, as well as room monitors.

## Description

Performance assessment strategies are composed of three distinct parts: a performance task, a format in which the student responds, and a predetermined scoring system. Tasks are assignments designed to assess a student's ability to manipulate equipment for a given purpose. Students can either complete the task in front of a panel of judges or use a written response sheet. The student is then scored by comparing the performance against a set of written criteria. When used with students with highly varying abilities, performance tasks can take maximum advantage of judging student abilities by using tasks with multiple correct solutions.

## Limitations

Performance assessments are typically inappropriate for measuring student knowledge of facts.

### Sources

- Kulm, G., & Malcom, S. M. (1991). Science assessment in the service of reform. *American Association for the Advancement of Science*. Washington, D. C.
- Shavelson, R. J., Baxter, G. P., & Pine, J. (1991). Performance assessment in science. *Applied Measurement in Education*, 4(4): 347.
- Slater, T. F., & Ryan, J. M. (1993). Laboratory performance assessment. *The Physics Teacher*, 31(5): 306-309.
- Tobias, S., & Raphael, J. (1995). In-class examinations in college science – new theory, new practice. *Journal of College Science Teaching*, 24(4): 240-244.
- Wiggins, G. (1989). A true test: Toward a more authentic and equitable assessment. *Phi Delta Kappa*, 70(9): 703.

## **Portfolios**

Timothy F. Slater  
Department of Physics  
Montana State University

### **What is a portfolio?**

Student portfolios are a collection of evidence, prepared by the student and evaluated by the faculty member, to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. To create a high quality portfolio, students must organize, synthesize, and clearly describe their achievements and effectively communicate what they have learned.

### **Why use portfolios?**

Portfolio assessment strategies provide a structure for long-duration, in-depth assignments. The use of portfolios transfers much of the responsibility of demonstrating mastery of concepts from the professor to the student.

### **An example**

The following is a list of course learning objectives for Introductory Environmental Geology where a portfolio supports student learning and assessment for these objectives.

1. The size of the human population, and the causes for change in its size in various areas of the world.
2. The source, use, pollution, and cleanup of the world's water resources.
3. The origin and evolution of soils and the way soils are affected by agriculture.
4. Current and alternative sources of food.
5. The origin, advantages, and disadvantages of current sources of energy.

### **Assessment purposes**

The overall goal of the preparation of a portfolio is for the learner to demonstrate and provide evidence that he or she has mastered a given set of learning objectives. More than just thick folders containing student work, portfolios are typically personalized, long-term representations of a student's own efforts and achievements. Whereas multiple-choice tests are designed to determine what the student doesn't know, portfolio assessments emphasize what the student does know.

## Teaching goals

### *Student learning outcomes*

- Develop ability to communicate scientific conceptions accurately
- Develop ability to write effectively using graphics as support
- Develop ability to relate principle concepts to real-world applications
- Develop ability to cite sources and references appropriately
- Develop ability to synthesize and integrate information and ideas
- Develop ability to be reflective and effectively conduct self-assessment
- Develop ability to think creatively and critically

### *Instructor teaching outcomes*

- Bridge gap between learning and assessment

## What is involved?

Instructor preparation time	Minimal, after the course learning objectives have been clearly identified. Can be high if multiple graders are to be trained when used in large classes.
Preparing your students	Clear expectations must be provided to students at the beginning of the course.
Class time	None.
Disciplines	Appropriate for all.
Class size	Most applicable in small classes; possible in large classes with pre-existing infrastructure and less “open ended” character of evidence allowed.
Special classroom / technical requirements	None.
Individual or group involvement	Individual.
Analyzing results	Intense and requires a scoring rubric.
Other things to consider	Materials are presented in the natural language of the student and will vary widely within one class.

## Description

Student portfolios are a collection of evidence to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. The evidence can be presented in a three-ring binder, a multimedia tour, or a series of short papers. A unique aspect of a successful portfolio is that it also contains explicit statements of self-reflection. Statements accompanying each item describe how the student went about mastering the material, why the presented piece of evidence demonstrates mastery, and why mastery of such material is relevant to contexts outside the classroom.

## Limitations

Portfolio assessments provide students and faculty with a direct view of how students organize knowledge into overarching concepts. As such, portfolios are inappropriate for measuring students' levels of factual knowledge or for drill-and-skill activities and accordingly should be used in concert with more conventional forms of assessment. Similarly, student work completed beyond the context of the classroom is occasionally subject to issues of academic dishonesty.

## Sources

- Astwood, P. M., & Slater, T. F. (1996). Portfolio assessment in large-enrollment courses: Effectiveness and management. *Journal of Geological Education*, 45(3).
- Berlak, H., Newmann, F. M., Adams, E., Archbald, D. A., Burgess, T., Raven, J., & Romberg, T. A. (1992). *Toward a new science of educational testing and assessment*. New York: Albany State University of New York Press.
- Collins, A. (1993). Performance-based assessment of biology teachers. *Journal of College Science Teaching*, 30(9): 1103-1120.
- Collins, A. (1992). Portfolios for science education: Issues in purpose, structure, and authenticity. *Science Education*, 76(4): 451-463.
- Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Newbury Park, CA: Sage Publications, Inc.
- Kuhs, T. M. (1994). Portfolio assessment: Making it work for the first time. *The Mathematics Teacher*, 87(5): 332-335.
- Rischbieter, M. O., Ryan, J. M., & Carpenter, J. R. (1993). Use of microethnographic strategies to analyze some affective aspects of learning-cycle-based minicourses in paleontology for teachers. *Journal of Geological Education*, 41(3): 208-218.
- Slater, T. F. (1994). Portfolio assessment strategies for introductory physics. *The Physics Teacher*, 32(6): 415-417.
- Slater, T. F. (1997). The effectiveness of portfolio assessments in science. *Journal of College Science Teaching*, 26(5).
- Slater, T. F., & Astwood, P. M. (1995). Strategies for grading and using student assessment portfolios. *Journal of Geological Education*, 45(3), 216-220.
- Slater, T. F., Ryan, J. M., & Samson, S. L. (1997). The impact and dynamics of portfolio assessment and traditional assessment in college physics. *Journal of Research in Science Teaching*, 34(3).
- Tobias, S., & Raphael, J. (1995). In-class examinations in college science – new theory, new practice. *Journal of College Science Teaching*, 24(4): 240-244.
- Wiggins, G. (1989). A true test: Toward more authentic and equitable assessment. *Phi Delta Kappan*, 70(9): 703-713.
- Wolf, D. (1989). Portfolio assessment: Sampling student work. *Educational Leadership*, 46(7): 35-37.

## Scoring Rubrics

Diane Ebert-May  
Department of Botany and Plant Pathology  
Michigan State University

### What is a scoring rubric?

Rubrics are a way of describing evaluation criteria based on the expected outcomes and performances of students. Typically, rubrics are used in scoring or grading written assignments or oral presentations. They may be used, however, to score any form of student performance. Each rubric consists of a set of scoring criteria and point values associated with these criteria. In most rubrics, the criteria are grouped into categories so the instructor and the student can discriminate among the categories by level of performance. In classroom use, the rubric provides an objective external standard against which student performance may be compared.

### Why use scoring rubrics?

Rubrics provide a readily accessible way of communicating and developing our goals with students and the criteria we use to discern how well students have reached them.

### An example

Level of Achievement	General Approach	Comprehension
Exemplary (5 pts)	<ul style="list-style-type: none"><li>- Addressed the question</li><li>- States a relevant, justifiable answer</li><li>- Presents arguments in a logical order</li><li>- Uses acceptable style and grammar (no errors)</li></ul>	<ul style="list-style-type: none"><li>- Demonstrates an accurate and complete understanding of the question</li><li>- Backs conclusions with data and warrants</li><li>- Uses 2 of more ideas, examples, and/or arguments that support the answer</li></ul>
Adequate (4 pts)	<ul style="list-style-type: none"><li>- Does not address the question explicitly, although does so tangentially</li><li>- States a relevant and justifiable answer</li><li>- Presents arguments in a logical order</li><li>- Uses acceptable style and grammar (one error)</li></ul>	<ul style="list-style-type: none"><li>- Demonstrates accurate but only adequate understanding of question because does not back conclusions with warrants and data</li><li>- Uses only one idea to support the answer</li><li>- Less thorough than above</li></ul>
Needs Improvement (3 pts)	<ul style="list-style-type: none"><li>- Does not address the question</li><li>- States no relevant answers</li><li>- Indicates misconceptions</li><li>- Is not clearly or logically organized</li><li>- Fails to use acceptable style and grammar (two or more errors)</li></ul>	<ul style="list-style-type: none"><li>- Does not demonstrate accurate understanding of the question</li><li>- Does not provide evidence to support their answer to the question</li></ul>
No Answer (0 pts)		

### Assessment purposes

- To improve the reliability of scoring written assignments and oral presentations
- To convey goals and performance expectations of students in an unambiguous way
- To convey grading standards or point values and relate them to performance goals
- To engage students in critical evaluation of their own performance

### Teaching goals

#### *Student learning outcomes*

- Communicating about the discipline in a variety of ways
- Improve writing skills
- The quality of reasoning and logic increases

#### *Instructor teaching outcomes*

- Gather a variety of data about students' understanding and performance

### What is involved?

Instructor preparation time	Medium to high.
Preparing your students	Continuous, but students catch on fairly quickly.
Class time	Variable. As students use rubrics, they become better writers and oral presenters, hence the time instructors spend evaluating students' work is reduced.
Disciplines	All.
Class size	All. Rubrics are easy to use in small classes and are particularly useful in large classes to facilitate scoring a large number of written or oral assignments.
Special classroom / technical requirements	None.
Individual or group involvement	Both.
Analyzing results	The level of analysis depends on the instructor's intended goal of the assessment task and the type of data desired about students' performance. For detailed analysis of students' responses, each section of the rubric can be scored independently then totaled. For a holistic analysis of students' responses, all sections of the rubric can be blended and an overall score assigned.
Other things to consider	Rubrics must be readily available to students before they begin an assignment or written test. Posting rubrics on the web and including them in the course materials promotes their usefulness.

### Description

Scoring rubrics are scoring tools that enable instructors to assign points to students' assignments and tests.

### **Limitations**

One challenge in developing and using rubrics is that of describing performance expectations and defining the criteria that differentiate several levels of performance. Quantitative descriptors may be helpful in differentiating among performance levels, whereas variables such as vague or concise must be described clearly so that students see the differences between a statement that is vague and a statement that is concise. Additionally, no assessment tool is effective if it is not used on a regular basis. Developing effective rubrics requires revision based on feedback from students.

### **Sources**

- Ebert-May, D., Brewer, C., & Allred, S. (1997). Innovation in large lectures-teachings for active learning. *Bioscience*, 47: 601-607.
- Freeman, R. H. (1994). *Open-ended questioning: a handbook for educators*. Menlo Park, California: Innovative Learning.
- King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass Publishers.
- MacGregor, J. (1993). *Student self-evaluation: fostering reflective learning*. San Francisco, CA: Jossey-Bass Publishers.
- Magolda, M. B. (1992). *Knowing and reasoning in college: gender-related students' intellectual development*. San Francisco, CA: Jossey-Bass Publishers.
- National Research Council. (1996). *National science education standards*. Washington, D.C.: National Academy Press.
- Novak, J. D., Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.

## Weekly Reports

Eugenia Etkina  
Graduate School of Education  
Rutgers, the State University of New Jersey

### What is a weekly report?

Weekly reports are papers written by students each week that address the following 3 questions:

1. What did I learn this week?
2. What remained unclear to you?
3. If you were the professor, what questions would you ask your students to find out if they understood the material?

### Why use weekly reports?

Weekly reports provide rapid feedback regarding what students believe they are learning and various conceptual difficulties they are experiencing.

### An example

The following example is a student's response to questions 2 and 3.

2. What remained unclear to you? I don't quite understand what defines one ecosystem from another when so many factors are overlapping. I did not fully understand Professor E's reference to squirrels having visual adaptation and yellow lens light. He was speaking rapidly and I don't know if I heard all he said.
3. If you were the professor, what questions would you ask your students to find out if they understood the material? A) What are the three conditions that must be present for evolution by natural selection? B) What is ecology? C) What does an ecosystem consist of? D) What do we mean by saying natural selection is survival of the fittest? E) Why do birds that live on surface water catch fish? F) Name three different types of orientations cues.

### Assessment purposes

- To document students' understanding of their own learning
- To investigate how well students understand the content and logical relationships in the material they are learning
- To document students' questions and select the most typical ones
- To give students feedback concerning the content and the level of difficulty of questions they consider important
- To capture the development of students' reasoning and writing skills over time
- To provide a measure of students' emotional satisfaction with the course and their levels of frustration with its content

## Teaching goals

### *Student learning outcomes*

- Understand the difference between observational facts, concepts, principles, and theories
- Communicate in writing effectively
- Ask important questions
- Reflect on own knowledge and learning

### *Instructor teaching outcomes*

- Answer students' questions on a regular basis
- Bridge gap between learning and assessment
- Communicate desire for student success
- Develop and refine instruction based on student feedback
- Receive regular feedback from students
- Track typical questions

## What is involved?

Instructor preparation time	Minimal. Questions may be written on blackboard or provided in hard copy form.
Preparing your students	Students need explanations on the purpose of the reports and training on structuring the answer to the first question.
Class time	None – done at home.
Disciplines	Appropriate for all ages.
Class size	Any class size. In recitation sections, teaching assistants grade the reports and provide feedback.
Special classroom / technical requirements	None.
Individual or group involvement	Individual.
Analyzing results	Reports need careful grading. The instructor should find a way to answer atypical responses individually and typical responses in class.
Other things to consider	Students must see how reports help them learn – otherwise, the reports will not be taken seriously.

## Description

A weekly report is a paper that students compose each week to analyze and reflect on what they have learned. It consists of three questions aimed at general concepts, uncertainties, and evaluation of comprehension.

## Limitations

When done well, weekly reports may provide a useful and easily accessible way of probing three aspects of students' knowledge.

- Cognitive aspects: To be useful, students must provide a well-structured, in-depth exposition of the concepts, principles, and theories they have studied, trying to explain how they learned what they think they did.
- Affective aspects: Ideally, the response provides evidence of students' feelings, attitudes, and beliefs about the content, the course, and the instructor.
- Metacognitive aspects: Responses to all three questions provide information about students' understanding of their own learning.

Perhaps the most significant limitation of weekly reports is that students need practice with the technique in order to provide useful feedback to the instructor. Normally, however, this limitation can be overcome in a matter of a few weeks.

## Sources

- Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: A cognitive view*. New York: Holt, Rinehart, and Winston.
- Bagley, T., & Gallenberger, C. (1992). Assessing students' dispositions: Using journals to improve students' performance. *Mathematics Teacher*, 85, 660-663.
- Baird, J. R. (1990). Metacognition, purposeful inquiry and conceptual change. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum*. London: Routledge.
- Cizek, G. I. (1997). Learning, achievement, and assessment. In G. D. Phye (Ed.), *Classroom assessment: Learning, achieving and adjustment* (pp. 2-29). San Diego, CA: Academic Press.
- Gunstone, R. F. & Mitchell, I. J. (1998). Metacognition and Conceptual Change. In J. J. Mintzes, J. H. Wandersee, & J. Novak (Eds.), *Teaching science for understanding: A human constructivist view* (pp. 133-163). San Diego, CA: Academic Press.
- Lester, F. K., Lambdin, D. V., & Preston, R. V. (1997). A New Vision of the Nature and Purposes of Assessment in the Mathematics Classroom. In G. D. Phye (Ed.), *Classroom assessment: Learning, achieving and adjustment* (pp. 287-319). San Diego, CA: Academic Press.
- Mintzes, J. J., Wandersee, J. H., & Novak, J. (Eds.). (1998). *Teaching Science for Understanding: A human constructivist view*. San Diego, CA: Academic Press.
- Novak, J. D. & Gowin, D. B. (1984). *Learning how to learn*. Cambridge: Cambridge University Press.
- Redish, E. F. (1994). Implications of cognitive studies for teaching physics. *American Journal of Physics*, 62, 796-803.

**Center for Teaching and Learning**



**CLASSROOM  
ASSESSMENT TOOLS**

## CONTENTS\*

Matching Outcomes to Assessment Tools.....	1
Classroom Assessment Tools.....	5
Attitude Surveys.....	5
Concept Tests .....	8
Concept Mapping.....	11
Conceptual Diagnostic Tests.....	14
Interviews.....	18
Performance Assessments.....	22
Portfolios.....	25
Scoring Rubrics.....	28
Weekly Reports.....	31

\* Note: These materials and additional information may be found at <http://www.flaguide.org/cat/cat.php>.

# Matching Outcomes to Assessment Tools

(Charts from [www.flaguide.org/goals/goaltab.php](http://www.flaguide.org/goals/goaltab.php))

To find appropriate CAT(s) use the Student Learning Outcomes table below:

- Reflect on your own course goals.
- Identify the goals within the list that most closely approximate your own (5 or 6 goals is adequate).
- Click the check boxes next to those goals.
- Click the "Submit" button.
- A chart of the goals and corresponding CAT(s) will be made which can be printed out.



**Student Learning Outcomes      Classroom Assessment Techniques**

Knowledge	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Demonstrates basic knowledge of facts and terms			X	X		X		X		X
Demonstrates basic knowledge of concepts and theories			X	X	X	X	X			X
Demonstrates synthesis and integration of information and ideas			X	X	X	X		X		X
Develops skill in using materials, tools and technology central to subject						X	X	X		
Learns techniques and methods used to gain new knowledge in subject							X			
Learns to evaluate methods and materials of this subject					X		X			
Learns modeling methods appropriate for subject			X				X			
Learns to appreciate important contributions of this subject										
Develops an informed understanding of the role of science and technology										

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Analytical Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Analyzes problems from different points of view			X		X	X		X		X
Recognizes interrelationships among problems and issues			X	X	X	X		X		
Analyzes and interprets experimental data effectively						X	X			X
Applies principles and generalizations to new problems and situations			X		X	X	X			
Organizes information into meaningful categories				X	X			X		
Uses order of magnitude estimation effectively					X					

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Communication Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Communicates in writing effectively			X		X	X		X		X
Communicates in speaking effectively			X			X				
Uses facts to get points across to others			X			X				
Uses graphs effectively to support points being made			X	X		X	X	X		

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Research Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Designs an appropriate experiment to answer a question							X			
Carries out a designed experiment							X			
Brings in information from outside sources						X				
Uses computer-based and other resources effectively						X	X	X		
Seeks information on problems from multiples sources						X		X		
Understands importance of what has already been done to solve problems										
Uses appropriate synthetic/analytic methods to solve problems			X		X	X	X			
Uses instrumentation appropriately and effectively							X			
Demonstrates ability to formulate effective questions						X				X
Challenges the way things are done										
Improves on what has been done before			X							
Generates many potential solutions to a given problem						X				

**Student Learning Outcomes      Classroom Assessment Techniques**

<b>Teamwork Skills</b>	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Helps reconcile differences of opinion among team members										
Shares credit for success with others										
Cooperates with others			X							
Encourages participation among all team members										X
Shares information with others			X							
Contributes his/her share of project workload										
Demonstrates ability to work on multidisciplinary team										
Demonstrates ability to take leadership role in support of team goals										

**Student Learning Outcomes      Classroom Assessment Techniques**

Attitudes	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Identifies desirable course components		X								
Identifies desirable course pedagogies		X								
Identifies perceived lab/lecture match		X								
Identifies beliefs about the nature of a field		X								
Indicates perceptions about interdisciplinary connections		X								
Indicates student's perceived level of understanding		X								
Indicates student's level of confidence		X								

**Student Learning Outcomes      Classroom Assessment Techniques**

Instructor Goals	<input checked="" type="checkbox"/>	AS	CT	CM	CD	IN	PA	PO	SR	WR
Answers student questions on a regular basis										X
Use assessment regularly to assure learning is occurring			X							X
Communicates desire for student success			X							X
Develops and refines instruction based on student feedback			X							X
Receives regular feedback from students			X							X
Tracks typical questions										X
Retention of material										
Subsequent performance in next course										
Improvement in attendance			X							
Equitable performance for all students										

## Attitude Surveys

Eileen Lewis  
Department of Chemistry  
Canada College

Elaine Seymour  
Bureau of Sociological Research  
University of Colorado, Boulder

### What is an attitude survey?

While attitudinal surveys may take many forms and address a range of issues, they typically consist of a series of statements that students are asked to express their agreement or disagreement using a scale.

### Why use attitude surveys?

This type of survey provides valuable information on student perceptions of and emotions regarding their classroom experience. This includes general attitudes toward the course, the discipline, and their own learning. The results from this survey can also help you identify elements in your course that best support student learning.

### An example

Please use the 7-point scale to indicate your agreement or disagreement with each statement.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Don't know
Often in lab I didn't understand the concept behind the lab experiment.	1	2	3	4	5	6	7
I like labs where I get to help design an experiment to answer a question.	1	2	3	4	5	6	7
This course provided opportunities for me to help design experiments to answer a question.	1	2	3	4	5	6	7
It was clear how the lab experiments fit into this course.	1	2	3	4	5	6	7

### Assessment purposes

- To provide information about students' learning styles or preferences for ways of learning, allowing instructors to choose among instructional approaches that would best meet the needs of the students
- To discover which components of the course contribute most significantly to students' learning
- To provide feedback helpful for designing activities to foster a more realistic view of a discipline and what members of that discipline do
- To prompt students to reflect on their own learning preferences, strengths, or styles

## Teaching goals

### *Student learning outcomes*

- Learn the techniques and methods used to gain new knowledge in the subject
- Develop appropriate study skills, strategies, and habits
- Develop awareness of learning processes and control over those processes
- Develop a knowledge and appreciation for the subject

### *Instructor teaching outcomes*

- Develop and refine instruction based on student feedback

## What is involved?

Instructor preparation time	Very little time is needed to use a valid, existing survey. Large amounts of time are required to develop a survey that is reliable and measures what is intended.
Preparing your students	No training is required, but a description of the survey's goals and scales should be read to students as well as included in the survey form itself.
Class time	Varies with length, but rarely more than 20 minutes.
Disciplines	Appropriate for all.
Class size	Appropriate for all.
Special classroom / technical requirements	None, although an optical scanning device may be useful to read and analyze data in large classes.
Individual or group involvement	Typically individual.
Analyzing results	Depends very much on class size and length of the survey. In large classes, the use of scanning forms and optical readers make the task easier.
Other things to consider	To insure meaningful results, student responses must be guaranteed anonymity. These surveys can be given pre and post to measure gains over a course or to provide mid-course corrections to classroom teaching methods. Demographic data may be included in the survey so that correlation with gender, major, or ethnicity can be made.

## Description

An attitudinal survey can provide information on student perceptions of their classroom experience. It can reveal perceptions on the content of a course, specific components of a course, course components that aid or are detrimental to learning, and the effects of course innovations. Attitudinal surveys may also focus on students' needs in taking a course, how well those needs are met, student interest in or appreciation for the subject matter or field, student confidence in their ability to perform in a course, or their beliefs about the nature of the discipline itself.

## Limitations

Constructive questions or statements on an attitudinal survey are the result of considerable work in both designing the question/statement so that it measures what it was intended to measure and has reliability across students and groups. Additionally, for best results, students must be guaranteed anonymity. This means if the instructor analyzes the data, no student identification should be requested. You may ask for demographic information like gender, ethnicity, major, etc. and look for correlation across those variables. If you want to correlate student responses to their performance, you must have someone else gather and analyze the data, explicitly letting the students know you are doing so. Data analysis can be very time consuming in large classes unless you have optical scanning response forms and an optical reader. For small classes, you may provide additional space for students to elaborate on their ideas.

## Sources

- Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2<sup>nd</sup> ed.). San Francisco: Jossey-Bass.
- Braskamp, L., & Ory, J. (1994). *Assessing faculty work: Enhancing individual and institutional performance*. San Francisco: Jossey-Bass.
- Centra, J. A. (1973). Effectiveness of student feedback in modifying college instruction. *Journal of Educational Psychology*, 65(3), 395-401.
- Davis, B. G. (1993). *Tools for teaching*. San Francisco: Jossey-Bass.
- Fowler, F. J. (1993). *Survey research methods*. Newbury Park, CA: Sage.
- Gramson, Z., & Chickering, A. (1977). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 39, 5-10.
- Henderson, M. E., Morris, L. L., & Firz-Gibbon, C. T. (1987). *How to measure attitudes*. Newbury Park, CA: Sage.
- Murray, H. G. (1991). Effective teaching behaviors in the college classroom. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research*, Vol. 7 (pp. 135-172). New York: Agathon.
- National Research Council (1997). *Science teaching reconsidered: A handbook*. Washington, D. C.: National Academy Press.
- Reynolds, A. (1992). What is competent beginning teaching? A review of the literature. *Review of educational research*, 62, 1-35.
- Shulman, L. S. (1990). *Aristotle had it right: On knowledge and pedagogy* (Occasional paper no. 4). East Lansing, MI: The Holmes Group.
- Shulman, L. S. (1991). Ways of seeing, ways of knowing – ways of teaching, ways of learning about teaching. *Journal of Curriculum Studies*, 23(5), 393-395.
- Theall, M., & Franklin, J. (Eds.) (1990). Student ratings of instruction: Issues for improving practice. *New Directions for Teaching and Learning*, No. 43. San Francisco: Jossey-Bass.

## ConcepTests

Arthur B. Ellis, Clark R. Landis, Kathleen Meeker  
Department of Chemistry  
University of Wisconsin-Madison

### What is a ConcepTest?

The instructor presents one or more questions during class involving key concepts, along with several possible answers. Students in the class indicate by, for example, a show of hands, which answer they think is correct. If most of the class has not identified the correct answer, students are given a short time in lecture to try to persuade their neighbor(s) that their answer is correct. The question is asked a second time by the instructor to gauge class mastery.

### Why use ConcepTests?

The instructor obtains immediate feedback on the level of class understanding. Students have an opportunity to enhance teamwork and communication skills. Many instructors have reported substantial improvements in class attendance and attitude toward the course.

### An example

During an experiment, the class is asked to vote - "How many of you think that a quarter of the laser light will now reach the solar cell? How many of you think none of the light will now get to the solar cell?" If most of the class has correctly noted that one-quarter of the light will be transmitted, you can quickly affirm why this is correct and continue with the lesson. If the majority of the class does not select the correct answer, ask your students to convince their neighbor(s) that their answer is correct. After a short discussion period, have the class vote a second time. If the class has now selected the correct answer, a quick explanation is again appropriate. If the majority of the class has not reached the correct answer, a more detailed explanation can be presented.

### Assessment purposes

- To obtain real-time feedback regarding student understanding
- To determine the pace and direction of the remainder of the lecture

### Teaching goals

#### *Student learning outcomes*

- Apply ideas and concepts while communicating verbally
- Integrate concepts
- Work cooperatively with others

#### *Instructor teaching outcomes*

- Obtain real-time feedback regarding student misconceptions and understanding
- Communicate the instructor's desire for students to be successful in the course

**What is involved?**

Instructor preparation time	Some time is needed to create ConcepTests. For some disciplines, hundreds of sample questions exist on websites as a time-saving resource.
Preparing your students	Students require minimal training. Through sustained use in class, students become comfortable with the method.
Class time	ConcepTests typically last from less than a minute to several minutes.
Disciplines	Appropriate for all.
Class size	Best with classes of at least a dozen students. Successfully used in large lecture classes.
Special classroom / technical requirements	None. The method can be used in conjunction with worksheets, lecture demonstrations, computer animations, and film clips.
Individual or group involvement	Small group of 2 or 3 students.
Analyzing results	Minimal.
Other things to consider	It is more difficult to predict how much material will be covered in a lecture. It may take a sustained effort for an instructor and class to become comfortable and work effectively with ConcepTests.

**Description**

Questions in a ConcepTest inform or calibrate students as to how well they understand what the instructor has identified as key ideas, and they calibrate instructors as to class mastery of these ideas at the time of their presentation. ConcepTests thus make the lecture a vehicle for bringing student and instructor expectations into alignment.

**Limitations**

If the class size is too small, students may feel more conspicuous and self-conscious, hindering their participation. Instructors may need to encourage students to sit together to participate in ConcepTests if the lecture room has many more chairs than students. Some instructors group students into teams to work on ConcepTests during their lectures.

### **Links & sources**

Mazur, E. (1997). *Peer instruction: A user's manual*. Upper Saddle River, NJ: Prentice Hall.

New Traditions Project. (1997). *Establishing new traditions: Revitalizing the chemistry curriculum*. Retrieved August 24, 2005, from <http://newtraditions.chem.wisc.edu>.

Project Galileo. (2005). *Project Galileo: Your gateway to innovations in science education*. Retrieved August 24, 2005, from <http://galileo.harvard.edu>.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.

Tobias, S. (1992). *Revitalizing undergraduate science: Why some things work and most don't*. Tucson, AZ: Research Corporation.

The Trustees of Beloit College and the Regents of the University of California (2004). *ChemConnections: Systemic change initiatives in chemistry*. Retrieved August 24, 2005, from <http://chemlinks.beloit.edu>.

The University of Wisconsin Board of Regents. (1996). *Chemistry ConcepTests*. Retrieved August 24, 2005, from <http://www.chem.wisc.edu/~concept>.

## Concept Mapping

Michael Zeilik  
Department of Physics & Astronomy  
University of New Mexico

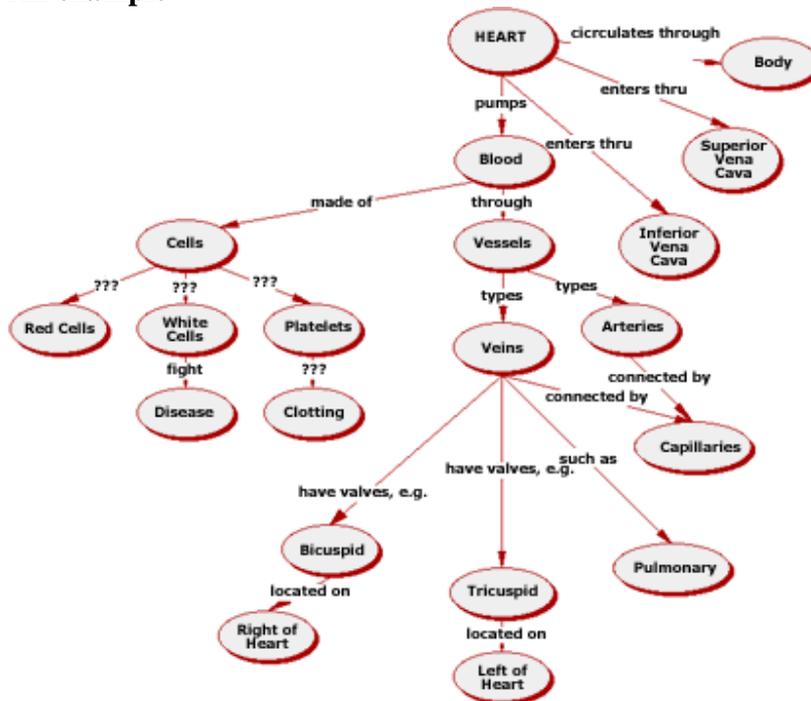
### What is a concept map?

A concept map is a diagram of nodes containing concept labels that are linked together with labeled directional lines. The concept nodes are arranged in hierarchical levels that move from general to specific concepts.

### Why use concept maps?

Concept maps assess how well students see the “big picture.” They have been used for over 25 years to provide a useful and visually appealing way of illustrating students’ conceptual knowledge.

### An example



### Assessment purposes

- To investigate how well students understand the correct connections among concepts in a subject
- To document the nature and frequency of students’ misconceptions
- To capture the development of students’ ideas over time

## Teaching goals

### *Student learning outcomes*

- Learn terms, facts, and concepts of this subject
- Organize information into meaningful categories
- Synthesize and integrate information, ideas, and concepts
- Think about the “big picture” and see connections among concepts
- Think creatively about the subject
- Improve long-term memory skills for accessible knowledge
- Develop higher-level thinking skills, strategies, and habits
- Use graphics effectively

### *Instructor teaching outcomes*

- Gain insight into the way students view a scientific topic
- Examine the valid understandings and misconceptions students hold
- Assess the structural complexity of the relationships students depict

## What is involved?

Instructor preparation time	Minimal if students construct maps; large for designing “fill-in” maps.
Preparing your students	Students need training (about an hour) and continual practice.
Class time	At least 30 minutes.
Disciplines	Appropriate for all.
Class size	Small classes if students construct maps individually; cooperative teams constructing maps will work with large (or small) classes.
Special classroom / technical requirements	None.
Individual or group involvement	Either.
Analyzing results	Intensive for formal scoring for large classes; concept maps are generally not graded.
Other things to consider	Very demanding cognitive task for students.

## Description

A concept map is a two-dimensional, hierarchical node-link diagram that depicts the structure of knowledge within a scientific discipline as viewed by a student, an instructor, or an expert in a field or sub-field. The map is composed of concept labels, each enclosed in a box or oval, a series of labeled linking lines, and an inclusive, general-to-specific organization.

## Limitations

Concepts maps provide a useful and visually appealing way of depicting the structure of conceptual knowledge that people have stored in long-term memory. As a result, they offer a readily accessible way of assessing how well students see “the big picture.” They are not designed to tap into the kind of process knowledge that students also need to solve novel problems or for the routine application of algorithmic solutions. Because they probe an individual’s or group’s cognitive organization, they are very idiosyncratic and difficult to compare, either among individuals or groups, or across time for the same individuals or groups.

## Links & sources

- Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). San Francisco: Jossey-Bass Publishers.
- Austin, L. B., & Shore, B. M. (1995). Using concept mapping for assessment in physics. *Physics Education*, 30(1): 41-45.
- Inspiration Software, Inc. (2005). *Inspiration Software, Inc.* Retrieved August 24, 2005, from <http://www.inspiration.com>.
- Markham, K., Mintzes, J., & Jones, G. (1994). The concept map as a research and evaluation tool: Further evidence of validity. *Journal of Research in Science Teaching*, 31(1): 91-101.
- Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (1998). *Teaching science for understanding: A human constructivist view*. San Diego, CA: Academic Press.
- The National Association for Research in Science Teaching. (2004). *The National Association for Research in Science Teaching*. Retrieved August 28, 2005, from <http://www.educ.sfu.ca/narstsite/>.
- Novak, J. D. (1998). Learning, creating and using knowledge: *Concept maps as facilitative tools in schools and corporations*. Mahwah, NJ: Lawrence Erlbaum.
- Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge University Press.
- Novak, J. D., & Wandersee, J. D. (Eds.). (1990). Perspectives on concept mapping. *Journal of Research in Science Teaching*, 20(10).
- Pearsall, R., Skipper, J., & Mintzes, J. Knowledge restructuring in the life sciences: A longitudinal study of conceptual change in biology. *Science Education*, 81, 193-215.
- Pendley, B. D., Bretz, R. L., & Novak, J. D. (1994). Concept maps as a tool to assess learning in chemistry. *Journal of Chemical Education*, 71(1): 9-15.
- Ruiz-Primo, M., & Shavelson, R. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching*, 33(6): 569-600.
- Schau, C., & Mattern, N. (1997). Use of map techniques in teaching statistics courses. *The American Statistician*, 51(2): 171-175.
- Wallace, J., & Mintzes, J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching*, 27(10): 1033-1052.
- Zeilik, M., Schau, C., Mattern, N., Hall, S., Teague, K., & Bisard, W. (1997). Conceptual astronomy: A novel model for teaching postsecondary science courses. *American Journal of Physics*, 65(10): 987-996.

## Conceptual Diagnostic Tests

Michael Zeilik  
Department of Physics and Astronomy  
University of New Mexico

### What is a conceptual diagnostic test?

A conceptual diagnostic test is a test with items in a multiple-choice or short-answer format that has been designed with common misconceptions in mind.

### Why use conceptual diagnostic tests?

Using conceptual diagnostic tests assesses how well students understand key concepts in a SMET field prior to, during, and after instruction.

### An example

The following is a sample item from the Astronomy Diagnostic Test. As seen from your location, when is the Sun directly overhead at noon (so that no shadows are cast)?

- A. Every day
- B. On the day of the summer solstice
- C. On the day of the winter solstice
- D. At both of the equinoxes (spring and fall)
- E. Never from the latitude of your location

The correct answer is E.

### Assessment purposes

- To reveal the misconceptions students bring as prior knowledge to a class
- To measure the conceptual gains of a class as a whole
- To identify concepts that are weak areas of understanding

### Teaching goals

#### *Student learning outcomes*

- Learn concepts and terms of a subject
- Develop higher-level thinking skills, strategies, and habits
- Recognize common misconceptions in order to avoid or change them

#### *Instructor teaching outcomes*

- Tracks students' misconceptions, conceptual change, and the impact of your instruction
- Allows for evaluation of student comprehension

**What is involved?**

Instructor preparation time	Minimal for using available tests; moderate for designing your own questions.
Preparing your students	Nothing special.
Class time	At least 30 minutes for a complete test.
Disciplines	Appropriate for all.
Class size	Small and large.
Special classroom / technical requirements	Machine scoring of scannable forms.
Individual or group involvement	Either.
Analyzing results	Can be machine scored for large classes; diagnostic tests are generally not graded.
Other things to consider	Need to match tests to course goals.

**Description**

A conceptual diagnostic test aims to assess students' conceptual understanding of key ideas in a discipline, especially those that are prone to misconceptions. Hence, they are discipline-specific rather than generic. The format typically is multiple-choice so that a conceptual diagnostic test can be given efficiently to large numbers of students and machine scored. Unlike traditional multiple-choice items, the distracters are designed to elicit misconceptions known from the research base. A student must have a clear understanding of a concept in order to select the correct response. Because conceptual diagnostic tests can be scored quickly, they can be used as formative as well as summative assessments.

**Limitations**

To develop reliable and valid conceptual diagnostic tests is a major, long-term undertaking. Only a limited number of such tests are currently available and those may not match your course goals. Your field may be one in which no such tests have been developed.

**Links & sources****Misconceptions research**

Driver, R. (1993). *The pupil as scientist?* London: Milton Keynes.

Pfundt, H. and Duit, R. (1994). *Bibliography: Students' Alternative Frameworks and Science Education* (4th ed.). Germany: Kiel.

**Astronomy**

Nussbaum, J. (1979). Children's conception of the earth as a cosmic body: A cross-age study. *Science Education*, 63, 83-93.

Sneider, C., & Pulos, S. (1983). Children's cosmographies: Understanding the earth's shape and gravity. *Science Education*, 67, 205-221.

Vosniadou, S. (1990). Conceptual development in astronomy. In S. Glynn, R. Yeany, & B. Britton (Eds.), *The psychology of learning science* (pp. 149-177). Hillsdale, NJ: Lawrence Erlbaum.

## **Biology**

- Arnaudin, M. W., & Mintzes, J. J. (1985). Students' alternative conceptions of the circulatory system: A cross-age study. *Science Education*, 69, 721-733.
- Bell, B. (1981). When is an animal not an animal? *Journal of Biological Education*, 15, 213-218.
- Wandersee, J. H. (1986). Can the history of science help science educators anticipate students' misconceptions? *Journal of Research in Science Teaching*, 23, 581-597.

## **Chemistry**

- American Chemical Society. (2005). *Division of chemical education*. Retrieved August 24, 2005 from <http://tigerched.clemson.edu/exams>.
- Ben-Zvi, N., & Gai, R. (1994). Macro- and micro-chemical comprehension of real work phenomena. *Journal of Chemical Education*, 71, 730-732.
- Hackling, M., & Garnett, D. (1985). Misconceptions of chemical equilibria. *European Journal of Science Education*, 7, 205-214.
- Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of Chemical Education*, 69, 191-196.
- Novik, S., & Menis, J. (1976). A study of student perceptions of the mole concept. *Journal of Chemical Education*, 53, 720-722.
- Stavy, R. (1988). Children's conception of gas. *International Journal of Science Education*, 10, 553-560.

## **Physics**

- American Association of Physics Teachers. (2005). *American Association of Physics Teachers*. Retrieved August 24, 2005, from <http://aapt.org>.
- Champagne, A., Klopfer, L., & Anderson, J. (1980). Factors influencing the learning of classical mechanics. *American Journal of Physics*, 48, 1074-1079.
- Clement, J. (1982). Studies of preconceptions in introductory mechanics. *American Journal of Physics*, 50, 66-71.
- Fredette, N., & Clement, J. (1981). Student misconceptions of an electric current: What do they mean? *Journal of College Science Teaching*, 10, 280-285.
- Watts, D. M. (1985). Students' conceptions of light - A case study. *Physics Education*, 20, 183-187.

## **Diagnostic tests**

- Bisard, W., & Zeilik, M. (1998). Conceptually centered astronomy with actively engaged students. *Mercury*, 27(4), 16-19.
- Hake, R. R. (1998). Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64-74.
- Hestenes, D., & Wells, M. (1992). A mechanics baseline test. *The Physics Teacher*, 30, 159-166.
- Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, 30(3): 141-151.
- Lightman, A., & Sadler, P. (1993). Teacher predictions versus actual student gains. *The Physics Teacher*, 31(3): 162-167.

- Odom, A. L., & Barrow, L. H. (1995). Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion and osmosis after a course of instruction. *Journal of Research in Science Teaching*, 32(1): 45-61.
- Russell, A. A. (1994). A rationally designed general chemistry diagnostic test. *Journal of Chemical Education*, 71(4): 314-317.
- Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education*, 10(2), 159-169.
- Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science (pp. 177-210). *Handbook of Research of Science Teaching and Learning*. New York: Macmillan Publishing.
- Zeilik, M., Schau, C., & Mattern, N. (1998). Misconceptions and their change in university-level astronomy courses. *The Physics Teacher*, 36: 104-107.
- Zeilik, M., Schau, C., Mattern, N., Hall, S., Teague, K., & Bisard, W. (1997). Conceptual astronomy: A novel model for teaching postsecondary science courses. *American Journal of Physics*, 65(10): 987-996.

## **Interviews**

Mike U. Smith  
Department of Internal Medicine  
Mercer University School of Medicine

Sherry A. Southerland  
Science Education  
University of Utah

### **What is an interview?**

A formal interview consists of a series of well-chosen questions (and often a set of tasks or problems) that are designed to elicit a portrait of a student's understanding about a scientific concept or set of related concepts. The interview may be videotaped or audiotaped for later analysis.

### **Why use interviews?**

In-depth structured interviews with a handful of carefully selected students will enable you to readily judge the extent of understanding your students have developed with respect to a series of well-focused, conceptually-related scientific ideas. This form of assessment provides feedback that is especially useful to instructors who want to improve their teaching and the organization of their courses.

### **An example**

The interview should begin with a focus question that requires application of the concept to be investigated without forcing the student into an explicit definition. Specific definitions of the concept, if needed, should be sought only after understanding the student's response to the focusing question. It is important for the interviewer to wait at least 3 to 5 seconds after each prompt before trying to interpret the question or ask another.

### **Assessment purposes**

- To investigate how well students understand and can apply a concept
- To identify gaps in understanding that may be common among students
- To document the general and content-specific procedures that students employ in application tasks and the sequences and manner in which processes are employed
- To document how student understanding and problem-solving skills change over time or with instruction
- To obtain verbal feedback from students about course structure, teaching techniques, and other aspects of the course or program of instruction

## Teaching goals

### *Student learning outcomes*

- Analyzes problems from different viewpoints and communicates effectively
- Recognizes interrelationships among problems and issues
- Applies principles and generalizations to new problems and situations
- Demonstrates a basic knowledge of the concepts and theories of the subject
- Demonstrates synthesis and integration of information and ideas
- Uses appropriate synthetic and analytic methods to solve problems

### *Instructor teaching outcomes*

- Answers students' questions and provides feedback from students
- Bridges gap between learning and assessment
- Tracks typical questions and problems

## What is involved?

Instructor preparation time	Several hours required to develop a set of good questions, tasks, and problem sets. Additional time to locate appropriate props and recording equipment, if desired.
Preparing your students	Interviews are most fruitful when the student has developed a good rapport with you. It is essential that the student feels relaxed and at ease.
Class time	One-on-one or small group interviews may be conducted in less than an hour in your office or other convenient private space. Some practice will reduce the time required to conduct a good interview.
Disciplines	No disciplinary restraints. Appropriate for all SMET fields.
Class size	Normally, structured interviews are conducted outside of class. It is important that subjects be carefully selected to represent a range of abilities and interest levels among students enrolled in a course.
Special classroom / technical requirements	Interview protocol, props, recording equipment, and small private space.
Individual or group involvement	The most useful interviews are those conducted with individuals or small groups outside of class. Sometimes this is done well in laboratory sections, but TAs will need special training or assistance.
Analyzing results	For formative assessment, the instructor may want to review taped interviews with special attention to potential misconceptions. If used for summative evaluation, a type of scoring rubric may be developed.
Other things to consider	None.

## **Description**

During a structured interview, the instructor uses a set of questions called probes designed in advance of the interview to elicit a portrait of the learner's understanding about a specific concept/topic. The student may be asked to use their own words to explain an idea, but is typically required to go beyond simple recognition of a concept to construct a detailed personal explanation. Generally, the student is also asked to use that concept to solve a problem or other application task. Additional questions may be added in response to the answers given. It is this freedom to follow the interviewee, to ask for clarifications, and to focus on errors, misconceptions, and gaps in knowledge, that makes the interview so much more fruitful than more traditional methods of assessment.

## **Limitations**

Time is a major inhibiting factor in using structured interviews to inform teaching. To prevent this issue from being prohibitive, selective sampling of a broad range of students in a classroom may be employed to make the technique more practical, yet still provide a portrait of how different students in a class are engaging with course material. A second limitation of structured interviews lies in the extreme content specificity of students' thinking. For instance, when dealing with biological knowledge, the type of organism included in an interview prompt has been shown to radically change the nature of a student's response. Thus, if an instructor would like to probe a student's reasoning pattern about a specific process, the nature of the exemplar included in the probe must be taken into account.

## **Sources**

- Bishop, B. A., & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution. *Journal of Research in Science Teaching*, 27, 415-427.
- Demastes-Southerland, S., Good, R., & Peebles, P. (1995). Students' conceptual ecologies and the process of conceptual change in evolution. *Science Education*, 79, 637-666.
- Demastes-Southerland, S., & Good, R. G. (1995). The crisis of representation: Concept mapping, written explanations, and students' conceptual frameworks in evolution. Presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA.
- Demastes-Southerland, S., Good, R., & Peebles, P. (1996). Patterns of conceptual change in evolution. *Journal of Research in Science Teaching*, 33, 407-431.
- Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent students. *Studies in Science Education*, 5, 61-84.
- Fredette, N., & Clement, J. (1981). Student misconceptions of an electric current: What do they mean? *Journal of College Science Teaching*, 10, 280-285.
- Lewis, E. L., & Linn, M. C. (1994). Heat energy and temperature concepts of adolescents, adults, and experts: Implications for curricular improvements. *Journal of Research in Science Teaching*, 31, 657-677.
- Rowe, M. B. (1974). Wait-time and rewards as instructional variables. *Journal of Research in Science Teaching*, 11, 81-94.

- Smith, M. U. (1992). Expertise and the organization of knowledge: Unexpected differences among genetic counselors, faculty, and students on problem categorization tasks. *Journal of Research in Science Teaching*, 29, 179-205.
- Smith, M. U., & Good, R. (1984). Problem solving and classical genetics: Successful versus unsuccessful performance. *Journal of Research in Science Teaching*, 21, 895-912.
- Songer, C., & Mintzes, J. (1994). Understanding cellular respiration: An analysis of conceptual change in college biology. *Journal of Research in Science Teaching*, 31, 621-637.
- Southerland, S. A., Smith, M. U., & Cummins, C. L. (2000). "What do you mean by that?" Using Structured Interviews to Assess Science Understanding. In J. J. Mintzes, J. H. Wandersee, & J. P. Novak (Eds.), *Assessing science understanding: A human constructivist view* (Chapter 6). Academic Press.
- Tamir, P., & Zohar, A. (1992). Anthropomorphism and teleology in reasoning about biological phenomena. *Journal of Biological Education*, 25, 57-67.
- White, R., & Gunstone, R. (1992). *Probing understanding*. New York: The Falmer Press.

## Performance Assessments

Timothy F. Slater  
Department of Physics  
Montana State University

### **What is a performance assessment?**

Performance assessments are designed to judge students' abilities to use specific knowledge and research skills. Most performance assessments require the student to manipulate equipment to solve a problem or make an analysis. Rich performance assessments reveal a variety of problem-solving approaches, thus providing insight into a student's level of conceptual and procedural knowledge.

### **Why use performance assessments?**

Student growth in knowledge of methods, procedures, and analysis skills prove somewhat difficult to evaluate, particularly with conventional multiple-choice examinations. Performance assessments, used in concert with more traditional forms of assessment, are designed to provide a more complete picture of student achievement.

### **An example**

The following is a holistic scoring example with a telescope task. Your task is to set up and align the 8" telescope, find three different sky objects, and accurately describe some aspects of these objects that astronomers consider to be important.

*Level 3:* Student completes all aspects of task quickly and efficiently and is able to answer questions about the equipment used and objects observed beyond what is obvious. The tasks are: align telescope mount with north celestial pole, align finder telescope with primary telescope, center on target object, select and focus appropriate eyepiece, provide information about the target beyond the literal descriptive level, and answer questions about the target correctly.

*Level 2:* Student completes all aspects of task and provides descriptive information about the equipment and objects observed.

*Level 1:* Student is not able to complete all aspects of task or is not able to sufficiently provide information about the equipment used or objects observed.

*Level 0:* No attempt or meaningful effort obvious.

### **Assessment purposes**

The purpose of performance assessment is to evaluate the actual process of doing science or mathematics. Performance assessments examine students' actual application of knowledge to solve problems. In some cases, the solution of the problem may imply the application of a specific procedure or combination of procedures learned in class, or a thoughtful adaptation of students' knowledge. The assessment of students' knowledge focuses on the performance and the result.

## Teaching goals

### *Student learning outcomes*

- Develop ability to apply systematic procedures
- Authentically utilize resource tests, laboratory equipment, and computers
- Develop ability to use scientific methodology and solve complex problems
- Apply and evaluate multiple approaches

### *Instructor teaching outcomes*

- Bridges gap between learning and assessment

## What is involved?

Instructor preparation time	Medium.
Preparing your students	None.
Class time	10-40 minutes depending on complexity of task.
Disciplines	Appropriate for laboratory-based sciences.
Class size	Small for direct applications, unlimited for embedded assessments using student-completed forms.
Special classroom / technical requirements	Varies according to task.
Individual or group involvement	Both.
Analyzing results	Low.
Other things to consider	Manipulative materials are often required, as well as room monitors.

## Description

Performance assessment strategies are composed of three distinct parts: a performance task, a format in which the student responds, and a predetermined scoring system. Tasks are assignments designed to assess a student's ability to manipulate equipment for a given purpose. Students can either complete the task in front of a panel of judges or use a written response sheet. The student is then scored by comparing the performance against a set of written criteria. When used with students with highly varying abilities, performance tasks can take maximum advantage of judging student abilities by using tasks with multiple correct solutions.

## Limitations

Performance assessments are typically inappropriate for measuring student knowledge of facts.

### Sources

- Kulm, G., & Malcom, S. M. (1991). Science assessment in the service of reform. *American Association for the Advancement of Science*. Washington, D. C.
- Shavelson, R. J., Baxter, G. P., & Pine, J. (1991). Performance assessment in science. *Applied Measurement in Education*, 4(4): 347.
- Slater, T. F., & Ryan, J. M. (1993). Laboratory performance assessment. *The Physics Teacher*, 31(5): 306-309.
- Tobias, S., & Raphael, J. (1995). In-class examinations in college science – new theory, new practice. *Journal of College Science Teaching*, 24(4): 240-244.
- Wiggins, G. (1989). A true test: Toward a more authentic and equitable assessment. *Phi Delta Kappa*, 70(9): 703.

## **Portfolios**

Timothy F. Slater  
Department of Physics  
Montana State University

### **What is a portfolio?**

Student portfolios are a collection of evidence, prepared by the student and evaluated by the faculty member, to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. To create a high quality portfolio, students must organize, synthesize, and clearly describe their achievements and effectively communicate what they have learned.

### **Why use portfolios?**

Portfolio assessment strategies provide a structure for long-duration, in-depth assignments. The use of portfolios transfers much of the responsibility of demonstrating mastery of concepts from the professor to the student.

### **An example**

The following is a list of course learning objectives for Introductory Environmental Geology where a portfolio supports student learning and assessment for these objectives.

1. The size of the human population, and the causes for change in its size in various areas of the world.
2. The source, use, pollution, and cleanup of the world's water resources.
3. The origin and evolution of soils and the way soils are affected by agriculture.
4. Current and alternative sources of food.
5. The origin, advantages, and disadvantages of current sources of energy.

### **Assessment purposes**

The overall goal of the preparation of a portfolio is for the learner to demonstrate and provide evidence that he or she has mastered a given set of learning objectives. More than just thick folders containing student work, portfolios are typically personalized, long-term representations of a student's own efforts and achievements. Whereas multiple-choice tests are designed to determine what the student doesn't know, portfolio assessments emphasize what the student does know.

## Teaching goals

### *Student learning outcomes*

- Develop ability to communicate scientific conceptions accurately
- Develop ability to write effectively using graphics as support
- Develop ability to relate principle concepts to real-world applications
- Develop ability to cite sources and references appropriately
- Develop ability to synthesize and integrate information and ideas
- Develop ability to be reflective and effectively conduct self-assessment
- Develop ability to think creatively and critically

### *Instructor teaching outcomes*

- Bridge gap between learning and assessment

## What is involved?

Instructor preparation time	Minimal, after the course learning objectives have been clearly identified. Can be high if multiple graders are to be trained when used in large classes.
Preparing your students	Clear expectations must be provided to students at the beginning of the course.
Class time	None.
Disciplines	Appropriate for all.
Class size	Most applicable in small classes; possible in large classes with pre-existing infrastructure and less “open ended” character of evidence allowed.
Special classroom / technical requirements	None.
Individual or group involvement	Individual.
Analyzing results	Intense and requires a scoring rubric.
Other things to consider	Materials are presented in the natural language of the student and will vary widely within one class.

## Description

Student portfolios are a collection of evidence to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. The evidence can be presented in a three-ring binder, a multimedia tour, or a series of short papers. A unique aspect of a successful portfolio is that it also contains explicit statements of self-reflection. Statements accompanying each item describe how the student went about mastering the material, why the presented piece of evidence demonstrates mastery, and why mastery of such material is relevant to contexts outside the classroom.

## Limitations

Portfolio assessments provide students and faculty with a direct view of how students organize knowledge into overarching concepts. As such, portfolios are inappropriate for measuring students' levels of factual knowledge or for drill-and-skill activities and accordingly should be used in concert with more conventional forms of assessment. Similarly, student work completed beyond the context of the classroom is occasionally subject to issues of academic dishonesty.

## Sources

- Astwood, P. M., & Slater, T. F. (1996). Portfolio assessment in large-enrollment courses: Effectiveness and management. *Journal of Geological Education*, 45(3).
- Berlak, H., Newmann, F. M., Adams, E., Archbald, D. A., Burgess, T., Raven, J., & Romberg, T. A. (1992). *Toward a new science of educational testing and assessment*. New York: Albany State University of New York Press.
- Collins, A. (1993). Performance-based assessment of biology teachers. *Journal of College Science Teaching*, 30(9): 1103-1120.
- Collins, A. (1992). Portfolios for science education: Issues in purpose, structure, and authenticity. *Science Education*, 76(4): 451-463.
- Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Newbury Park, CA: Sage Publications, Inc.
- Kuhs, T. M. (1994). Portfolio assessment: Making it work for the first time. *The Mathematics Teacher*, 87(5): 332-335.
- Rischbieter, M. O., Ryan, J. M., & Carpenter, J. R. (1993). Use of microethnographic strategies to analyze some affective aspects of learning-cycle-based minicourses in paleontology for teachers. *Journal of Geological Education*, 41(3): 208-218.
- Slater, T. F. (1994). Portfolio assessment strategies for introductory physics. *The Physics Teacher*, 32(6): 415-417.
- Slater, T. F. (1997). The effectiveness of portfolio assessments in science. *Journal of College Science Teaching*, 26(5).
- Slater, T. F., & Astwood, P. M. (1995). Strategies for grading and using student assessment portfolios. *Journal of Geological Education*, 45(3), 216-220.
- Slater, T. F., Ryan, J. M., & Samson, S. L. (1997). The impact and dynamics of portfolio assessment and traditional assessment in college physics. *Journal of Research in Science Teaching*, 34(3).
- Tobias, S., & Raphael, J. (1995). In-class examinations in college science – new theory, new practice. *Journal of College Science Teaching*, 24(4): 240-244.
- Wiggins, G. (1989). A true test: Toward more authentic and equitable assessment. *Phi Delta Kappan*, 70(9): 703-713.
- Wolf, D. (1989). Portfolio assessment: Sampling student work. *Educational Leadership*, 46(7): 35-37.

## Scoring Rubrics

Diane Ebert-May  
Department of Botany and Plant Pathology  
Michigan State University

### What is a scoring rubric?

Rubrics are a way of describing evaluation criteria based on the expected outcomes and performances of students. Typically, rubrics are used in scoring or grading written assignments or oral presentations. They may be used, however, to score any form of student performance. Each rubric consists of a set of scoring criteria and point values associated with these criteria. In most rubrics, the criteria are grouped into categories so the instructor and the student can discriminate among the categories by level of performance. In classroom use, the rubric provides an objective external standard against which student performance may be compared.

### Why use scoring rubrics?

Rubrics provide a readily accessible way of communicating and developing our goals with students and the criteria we use to discern how well students have reached them.

### An example

Level of Achievement	General Approach	Comprehension
Exemplary (5 pts)	<ul style="list-style-type: none"><li>- Addressed the question</li><li>- States a relevant, justifiable answer</li><li>- Presents arguments in a logical order</li><li>- Uses acceptable style and grammar (no errors)</li></ul>	<ul style="list-style-type: none"><li>- Demonstrates an accurate and complete understanding of the question</li><li>- Backs conclusions with data and warrants</li><li>- Uses 2 of more ideas, examples, and/or arguments that support the answer</li></ul>
Adequate (4 pts)	<ul style="list-style-type: none"><li>- Does not address the question explicitly, although does so tangentially</li><li>- States a relevant and justifiable answer</li><li>- Presents arguments in a logical order</li><li>- Uses acceptable style and grammar (one error)</li></ul>	<ul style="list-style-type: none"><li>- Demonstrates accurate but only adequate understanding of question because does not back conclusions with warrants and data</li><li>- Uses only one idea to support the answer</li><li>- Less thorough than above</li></ul>
Needs Improvement (3 pts)	<ul style="list-style-type: none"><li>- Does not address the question</li><li>- States no relevant answers</li><li>- Indicates misconceptions</li><li>- Is not clearly or logically organized</li><li>- Fails to use acceptable style and grammar (two or more errors)</li></ul>	<ul style="list-style-type: none"><li>- Does not demonstrate accurate understanding of the question</li><li>- Does not provide evidence to support their answer to the question</li></ul>
No Answer (0 pts)		

### Assessment purposes

- To improve the reliability of scoring written assignments and oral presentations
- To convey goals and performance expectations of students in an unambiguous way
- To convey grading standards or point values and relate them to performance goals
- To engage students in critical evaluation of their own performance

### Teaching goals

#### *Student learning outcomes*

- Communicating about the discipline in a variety of ways
- Improve writing skills
- The quality of reasoning and logic increases

#### *Instructor teaching outcomes*

- Gather a variety of data about students' understanding and performance

### What is involved?

Instructor preparation time	Medium to high.
Preparing your students	Continuous, but students catch on fairly quickly.
Class time	Variable. As students use rubrics, they become better writers and oral presenters, hence the time instructors spend evaluating students' work is reduced.
Disciplines	All.
Class size	All. Rubrics are easy to use in small classes and are particularly useful in large classes to facilitate scoring a large number of written or oral assignments.
Special classroom / technical requirements	None.
Individual or group involvement	Both.
Analyzing results	The level of analysis depends on the instructor's intended goal of the assessment task and the type of data desired about students' performance. For detailed analysis of students' responses, each section of the rubric can be scored independently then totaled. For a holistic analysis of students' responses, all sections of the rubric can be blended and an overall score assigned.
Other things to consider	Rubrics must be readily available to students before they begin an assignment or written test. Posting rubrics on the web and including them in the course materials promotes their usefulness.

### Description

Scoring rubrics are scoring tools that enable instructors to assign points to students' assignments and tests.

### **Limitations**

One challenge in developing and using rubrics is that of describing performance expectations and defining the criteria that differentiate several levels of performance. Quantitative descriptors may be helpful in differentiating among performance levels, whereas variables such as vague or concise must be described clearly so that students see the differences between a statement that is vague and a statement that is concise. Additionally, no assessment tool is effective if it is not used on a regular basis. Developing effective rubrics requires revision based on feedback from students.

### **Sources**

- Ebert-May, D., Brewer, C., & Allred, S. (1997). Innovation in large lectures-teachings for active learning. *Bioscience*, 47: 601-607.
- Freeman, R. H. (1994). *Open-ended questioning: a handbook for educators*. Menlo Park, California: Innovative Learning.
- King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass Publishers.
- MacGregor, J. (1993). *Student self-evaluation: fostering reflective learning*. San Francisco, CA: Jossey-Bass Publishers.
- Magolda, M. B. (1992). *Knowing and reasoning in college: gender-related students' intellectual development*. San Francisco, CA: Jossey-Bass Publishers.
- National Research Council. (1996). *National science education standards*. Washington, D.C.: National Academy Press.
- Novak, J. D., Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.

## Weekly Reports

Eugenia Etkina  
Graduate School of Education  
Rutgers, the State University of New Jersey

### What is a weekly report?

Weekly reports are papers written by students each week that address the following 3 questions:

1. What did I learn this week?
2. What remained unclear to you?
3. If you were the professor, what questions would you ask your students to find out if they understood the material?

### Why use weekly reports?

Weekly reports provide rapid feedback regarding what students believe they are learning and various conceptual difficulties they are experiencing.

### An example

The following example is a student's response to questions 2 and 3.

2. What remained unclear to you? I don't quite understand what defines one ecosystem from another when so many factors are overlapping. I did not fully understand Professor E's reference to squirrels having visual adaptation and yellow lens light. He was speaking rapidly and I don't know if I heard all he said.
3. If you were the professor, what questions would you ask your students to find out if they understood the material? A) What are the three conditions that must be present for evolution by natural selection? B) What is ecology? C) What does an ecosystem consist of? D) What do we mean by saying natural selection is survival of the fittest? E) Why do birds that live on surface water catch fish? F) Name three different types of orientations cues.

### Assessment purposes

- To document students' understanding of their own learning
- To investigate how well students understand the content and logical relationships in the material they are learning
- To document students' questions and select the most typical ones
- To give students feedback concerning the content and the level of difficulty of questions they consider important
- To capture the development of students' reasoning and writing skills over time
- To provide a measure of students' emotional satisfaction with the course and their levels of frustration with its content

## Teaching goals

### *Student learning outcomes*

- Understand the difference between observational facts, concepts, principles, and theories
- Communicate in writing effectively
- Ask important questions
- Reflect on own knowledge and learning

### *Instructor teaching outcomes*

- Answer students' questions on a regular basis
- Bridge gap between learning and assessment
- Communicate desire for student success
- Develop and refine instruction based on student feedback
- Receive regular feedback from students
- Track typical questions

## What is involved?

Instructor preparation time	Minimal. Questions may be written on blackboard or provided in hard copy form.
Preparing your students	Students need explanations on the purpose of the reports and training on structuring the answer to the first question.
Class time	None – done at home.
Disciplines	Appropriate for all ages.
Class size	Any class size. In recitation sections, teaching assistants grade the reports and provide feedback.
Special classroom / technical requirements	None.
Individual or group involvement	Individual.
Analyzing results	Reports need careful grading. The instructor should find a way to answer atypical responses individually and typical responses in class.
Other things to consider	Students must see how reports help them learn – otherwise, the reports will not be taken seriously.

## Description

A weekly report is a paper that students compose each week to analyze and reflect on what they have learned. It consists of three questions aimed at general concepts, uncertainties, and evaluation of comprehension.

## Limitations

When done well, weekly reports may provide a useful and easily accessible way of probing three aspects of students' knowledge.

- Cognitive aspects: To be useful, students must provide a well-structured, in-depth exposition of the concepts, principles, and theories they have studied, trying to explain how they learned what they think they did.
- Affective aspects: Ideally, the response provides evidence of students' feelings, attitudes, and beliefs about the content, the course, and the instructor.
- Metacognitive aspects: Responses to all three questions provide information about students' understanding of their own learning.

Perhaps the most significant limitation of weekly reports is that students need practice with the technique in order to provide useful feedback to the instructor. Normally, however, this limitation can be overcome in a matter of a few weeks.

## Sources

- Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: A cognitive view*. New York: Holt, Rinehart, and Winston.
- Bagley, T., & Gallenberger, C. (1992). Assessing students' dispositions: Using journals to improve students' performance. *Mathematics Teacher*, 85, 660-663.
- Baird, J. R. (1990). Metacognition, purposeful inquiry and conceptual change. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum*. London: Routledge.
- Cizek, G. I. (1997). Learning, achievement, and assessment. In G. D. Phye (Ed.), *Classroom assessment: Learning, achieving and adjustment* (pp. 2-29). San Diego, CA: Academic Press.
- Gunstone, R. F. & Mitchell, I. J. (1998). Metacognition and Conceptual Change. In J. J. Mintzes, J. H. Wandersee, & J. Novak (Eds.), *Teaching science for understanding: A human constructivist view* (pp. 133-163). San Diego, CA: Academic Press.
- Lester, F. K., Lambdin, D. V., & Preston, R. V. (1997). A New Vision of the Nature and Purposes of Assessment in the Mathematics Classroom. In G. D. Phye (Ed.), *Classroom assessment: Learning, achieving and adjustment* (pp. 287-319). San Diego, CA: Academic Press.
- Mintzes, J. J., Wandersee, J. H., & Novak, J. (Eds.). (1998). *Teaching Science for Understanding: A human constructivist view*. San Diego, CA: Academic Press.
- Novak, J. D. & Gowin, D. B. (1984). *Learning how to learn*. Cambridge: Cambridge University Press.
- Redish, E. F. (1994). Implications of cognitive studies for teaching physics. *American Journal of Physics*, 62, 796-803.