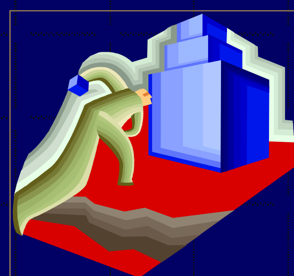
Faculty
Institutes
Reforming
Science
Teaching
II

PROFESSIONAL DEVELOPMENT WORKSHOP II



PROJECT GOALS

a. Receive feedback about plans for implementation of inquiry-based activities in your science course(es);

b. Conduct additional work on improving evaluation and assessment skills; and

c. Begin examination of various forms of scholarship about teaching and learning that includes ideas about design and implementation of research and scholarship.

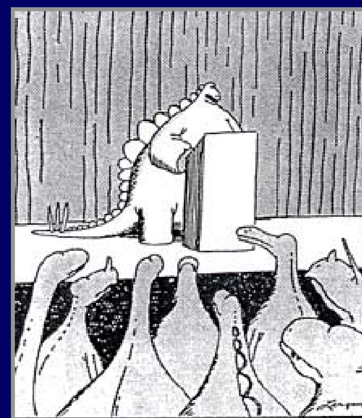
Specific Goals

As a result of your participation in this workshop, you will..

- Share progress and ideas for course/curriculum reforms
- Participate in a learning cycle, cooperative learning
- Align course goals with learning outcomes
- Align assessment instruments with learning goals
- Shift thinking from assessment for accountability to assessment for improvement
- Examine forms of scholarship for teaching/learning

Do We Need To Change the Way We Teach?

Science is important



"The picture's pretty bleak, gentlemen. ... The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

National Science Assessment Shows Stable Scores for 4th- and 8th-Graders, Declines for 12th-Graders

November 20, 2001

A new report released today from the National Center for Education Statistics (NCES), The Nation's Report Card: Science 200 survey by the National Assessment of Educational Progress (NAEP), shows the average scores of fourth- and eight-graders were essentially unchanged from 1996, and the scores for 12th-graders declined by three points; a significant change.

News

"Public Science Literacy Must Be Increased To Stem Tide of Anti-Science Sentiment"

The Scientist

The Honorable Arlen Specter Chairman

Labor, Health & Human Services and Education Appropriation Subcommittee

United States Senate

Dear Senator Specter:

We believe in possibilities and the power of medical research to make them happen. As you know, on April 26th, Christopher Reeve will testify before Congress on a matter that is beyond a personal passion, on a matter upon which his entire future may rely – the vision and promise of stem cell research. Stem cell research has the potential to improve the lives of millions of Americans. Thus, we join our voices with that of Christopher Reeve…

National Association of State Universities and Land-Grant Colleges

State Gov't Support for Higher Education *(Chronicle of Higher Ed.)*

Sector	Gov't Spending over 10 years (1986-96)
Medical	+100%
Prisons	+25%
Higher Education	-14%

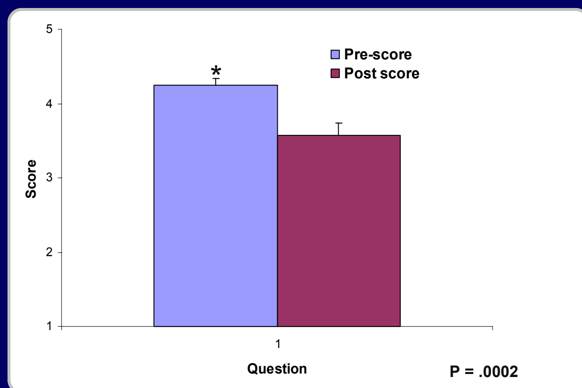
We DO Impact Student Attitudes

- **introductory core course**
- **~ 55 students**
- **pre-post Science Course Attitude Survey (*Workshop Biology)***
- **paired t-test**

It might take some effort for me to understand many unfamiliar scientific concepts, but I would be able to succeed in most cases.

Strongly agree

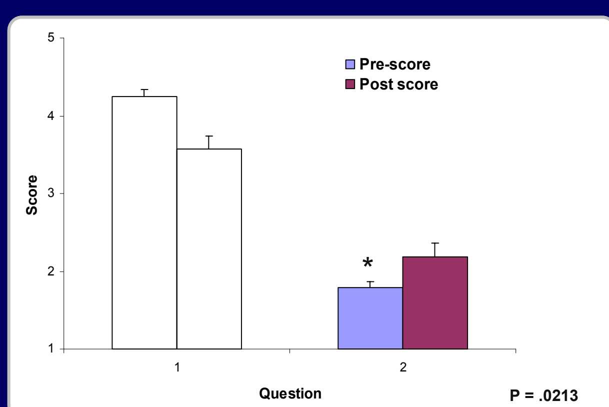
Strongly disagree



Science is too complex a subject for me to learn much about it.

Strongly agree

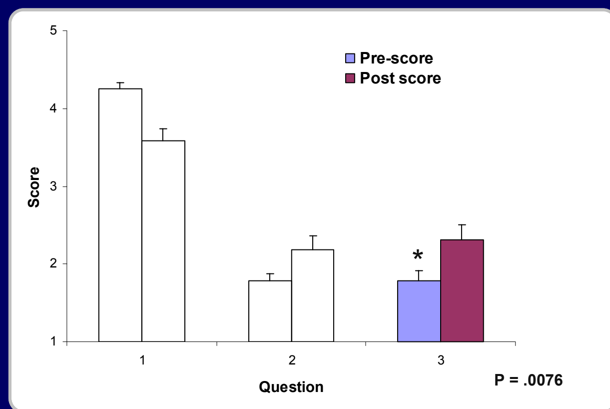
Strongly disagree



I don't think I'll ever be in a position in which I'll be able to use scientific knowledge.

Strongly agree

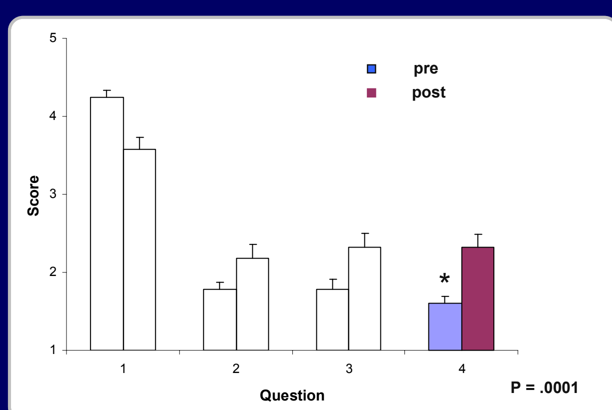
Strongly disagree



It would be a waste of time for me to try to study science.

Strongly agree

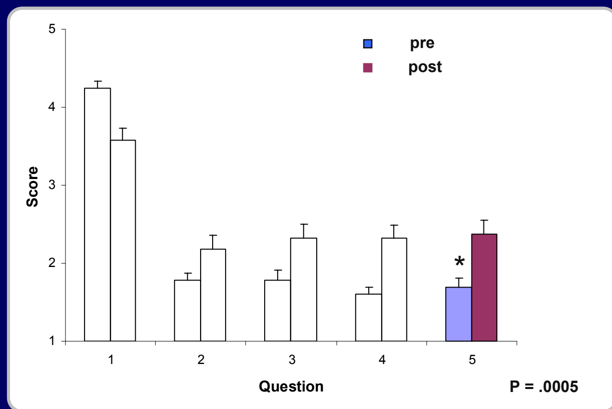
Strongly disagree



If I have children, they will learn about science in school, so I won't need to help them learn about it.

Strongly agree

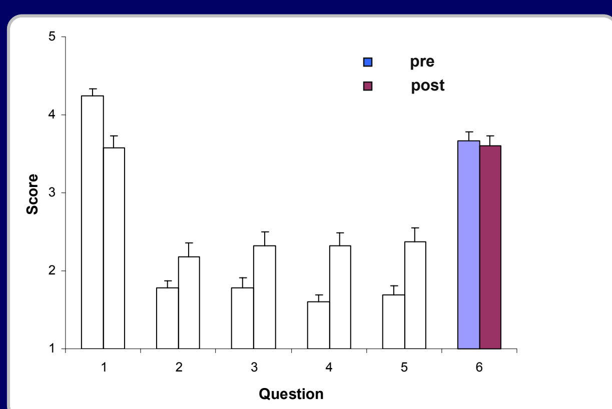
Strongly disagree



I believe that my background in science will allow me to make better decisions for my family and myself.

Strongly agree

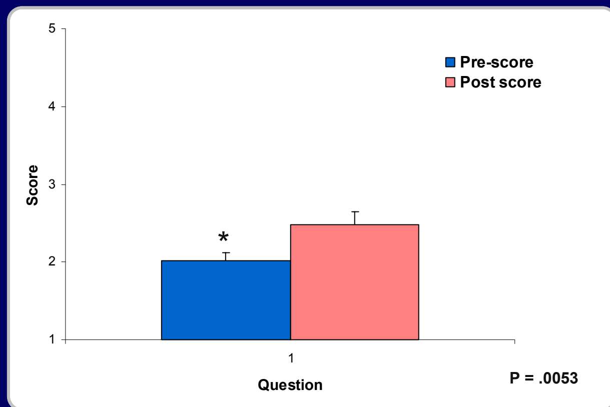
Strongly disagree



Science deals mostly with facts and figures; when language is used, it tends to be complex jargon. Therefore, good writing ability is not necessary in a science class.

Strongly agree

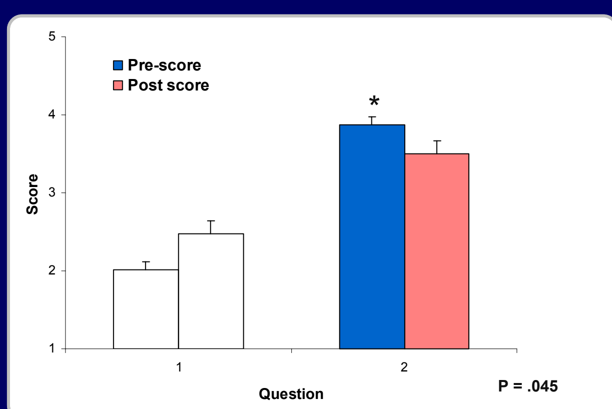
Strongly disagree



Our country would be better off if more people had a basic understanding of science.

Strongly agree

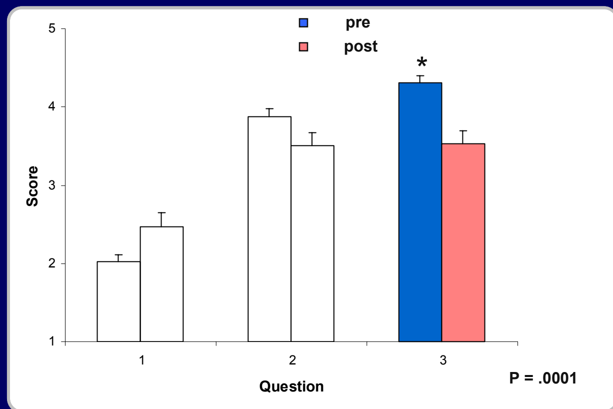
Strongly disagree



Scientific ways of thinking are applicable to many areas of life.

Strongly agree

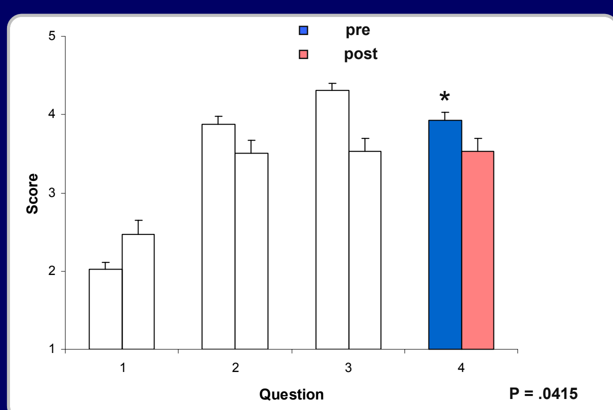
Strongly disagree



People need to understand the nature of science because it has such a great effect upon their lives.

Strongly agree

Strongly disagree

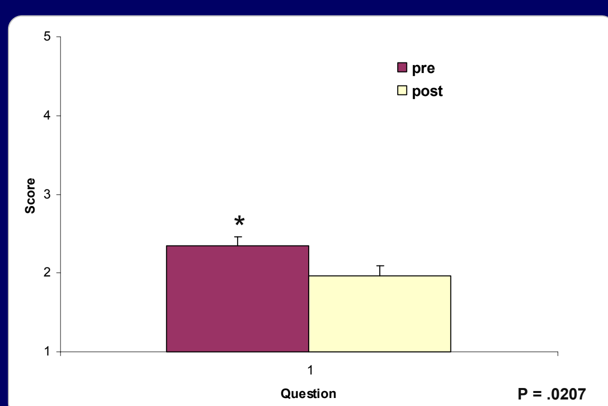


- first-semester introductory course
- ~ 70 students
- pre-post Self-Efficacy Instrument (*Baldwin et al., 1999)*
- paired t-test

How confident are you that after reading an article about a biology experiment that you could write a summary of its main points?

Not At All Confident

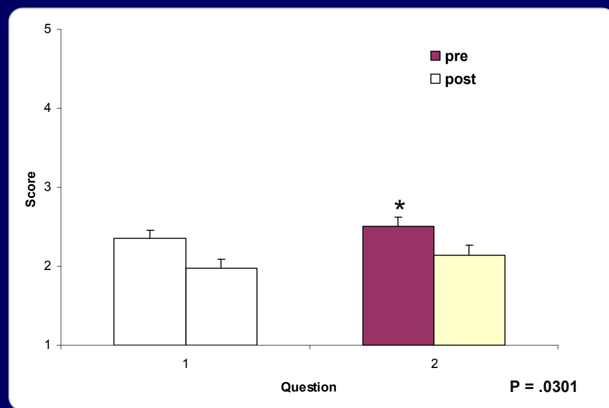
Totally Confident



How confident are you that after reading an article about a biology experiment, you could explain its main ideas to another person?

Not At All Confident

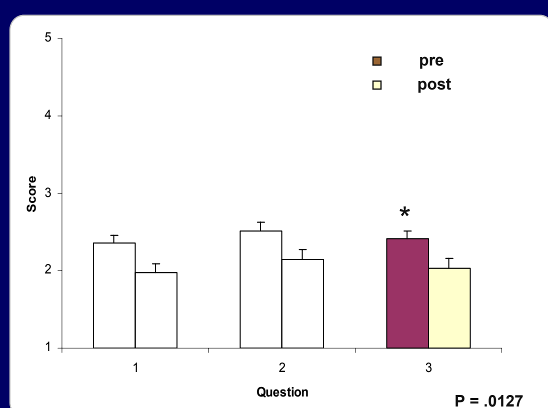
Totally Confident



How confident are you that after watching a television documentary dealing with some aspect of biology, you could write a summary of its main points?

Not At All Confident

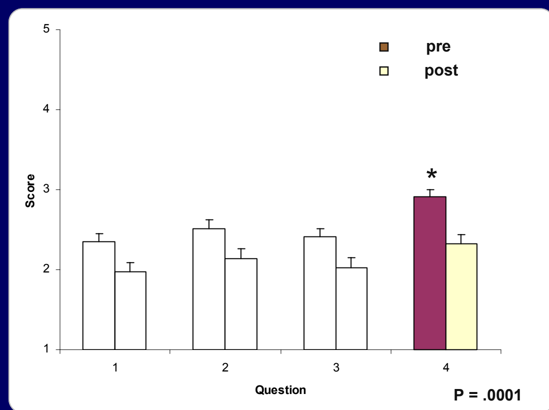
Totally Confident



How confident are you that you could critique an experiment described in a biology textbook (i.e., list the strengths and weaknesses)?

Not At All Confident

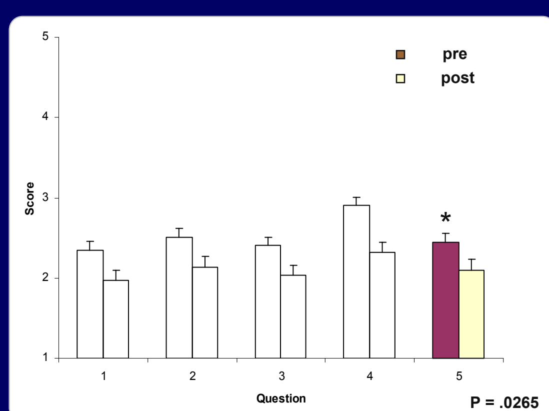
Totally Confident



How confident are you that you could use a scientific approach to solve a problem at home?

Not At All Confident

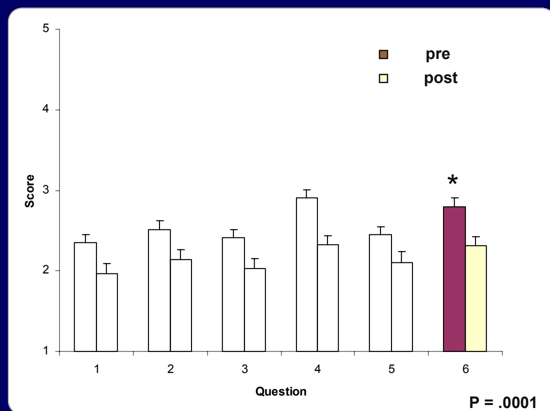
Totally Confident



How confident are you that you would be successful in an ecology course?

Not At All Confident

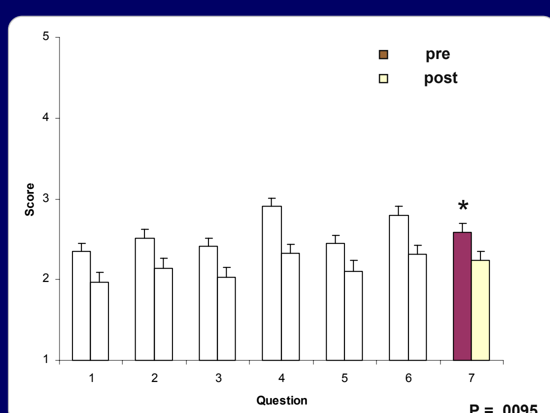
Totally Confident



How confident are you that you would be successful in a human physiology course?

Not At All Confident

Totally Confident



Cooperative Groups

- 4 students per group
- Person A, B, C, D in each group
- First – read problem/ think about task individually
- Discuss A with B
- C with D
- Form group consensus

Engage: What's up with Termites?

1. On a sheet of paper, draw two circles near each other on the center of the page with an ink pen.
2. Release termites onto paper.
3. Keep creatures safe. We will return them to their original habitat.
4. What do you observe about termite behavior?
5. Develop a question your group could explore if you had more time.

How did this inquiry "work?"

How would you assess your students' understanding of scientific inquiry using the termite activity?

- What criteria would you use for assessing student learning?
- What would you have students do?
- How would you "score" student performance?

Types of Inquiry

All focus on the process of scientific investigations.

- **Guided inquiry** – instructors guide students through investigations, ask students focused questions, give suggestions and ideas, supervise
- **Open-ended inquiry** – instructors facilitate independent studies; students design, conduct, modify, and report their own expts.
- **Collaborative inquiry** – students and teachers work together as investigators on authentic questions, e.g., a land use issue

Goals of Termite Activity

1. See "where participants are at" regarding inquiry-based learning/teaching
2. Set atmosphere
3. Model an open-ended inquiry
4. Introduce learning cycles

Learning Cycle

ENGAGE

Initiates learning:

1. Makes connections between past and present learning experiences
2. Organizes students' thinking toward the learning outcomes of current activities.

Modified from Uno, 1999

Learning Cycle

EXPLORE

Provides students with a common base of experience to discover and develop

- Current concepts
- Processes
- Skills

Learning Cycle

EXPLAIN

1. Focuses students' attention on specific aspects of their engagement and exploration experiences.
2. Provides opportunities for students to demonstrate:
   - conceptual understanding
   - process skills
   - behaviors

Learning Cycle

EXPLAIN

3. Provides opportunities for teachers to introduce:
   - Concepts
   - Processes
   - Skills

Learning Cycle

ELABORATE

Provide additional new experiences

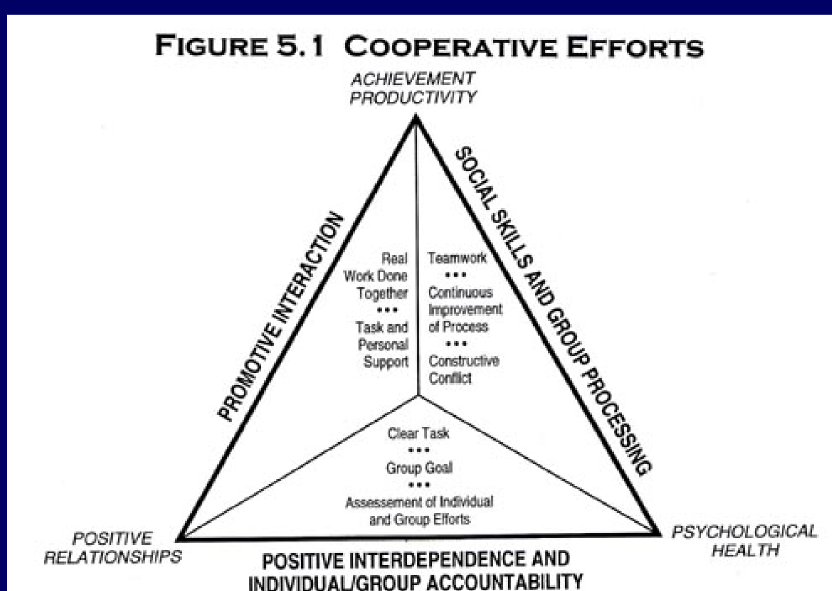
↓

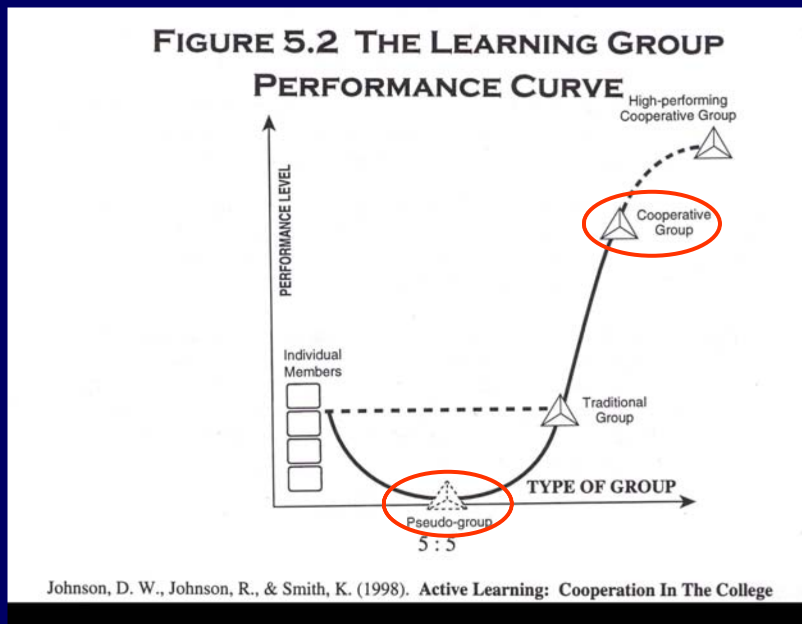
Challenge and extend students' conceptual understanding and skills

Learning Cycle

EVALUATE

1. Encourages students to assess their understanding and abilities.
2. Provides opportunities for teachers to evaluate progress towards learning goals.





Functions of Assessment Data

- **Formative:** diagnostic feedback to students/instructor (during course)
- **Summative:** description of students' level of attainment (end of course)
- **Evaluative:** provides instructors with feedback about the effectiveness of the curricular experience
- **Educative:** students engaged in interesting, challenging experiences to develop further insight and understanding

Hodson 1992

Bloom's Taxonomy for Formative Assessment

- 1-min paper /class period (extended response)
- Determine type of question appropriate to assess goal's of a class period
- Provide rubric before-hand
- Review examples of poor, good, and excellent

What Method or Approach to Use?

What are the qualities you consider most important in your instruments?

1. **Reliability –** a property of the scores or assessment data, not the instrument

   Measurement errors:

   - individuals responding to the instrument
   - administration and scoring of instrument

Characteristics of Reliable Instruments (cont.)

Well-constructed:

worded clearly, unambiguous, appropriate length, standardized approach to rating responses (e.g., clear, articulate scoring rubrics)

Internally consistent:

all items designed to measure particular knowledge or skill must actually measure it

Modified from Palomba and Banta, *Assessment Essentials*

What are the qualities you consider most important in your instruments? (cont.)

2. **Validity –** Is the instrument appropriate for the use to which it will be put?

   "Validity means honesty, that we are measuring what we say we are measuring and that we know and can show what it is we are measuring."

White, 1994. *Portfolios as an Assessment Concept.*

Aspects of Validity to Consider

1. Construct-related validity

- Do results correlate with other instruments examining the same construct?
- Do results differ for groups of individuals expected to exhibit differences?
- Do results change in expected ways as a function of factors that should affect the construct?

Aspects of Validity to Consider

2. Criterion-related reliability

- How dependable is the relationship between the scores or answers on an instrument and a particular future outcome?
- Is the content of the instrument and the content of the course or curriculum matched?
- Does the instrument contain items related to the course being assessed and does it provide evidence that learning successfully occurred?

Aspects of Validity to Consider

3. **Content**
   - Is the instrument thorough in covering the objectives of the course or curriculum?
   - Does it address desired levels of cognitive complexity?
   - To what extent can results be generalized?
   - Are tasks credible to your peers?
   - Will results provide useful information for improving other courses/curricula?

Assessment: Other Factors to Consider

- **timeliness**
- **cost**
- **student motivation**
- **ease of scoring and interpreting**
- **can the results be used for external reporting**

Worthwhile Assignments

(Walvoord and Anderson. 1998. Effective grading: a tool for learning and assessment)

- save time
- make every moment count
- integrate grading, learning, and motivation
- assess the learning you and your students most want to achieve

Course Planning Sequence

Identify what you want your students to learn (i.e., learning goals).

Select tests and assignments that both teach and test the learning you value most.

Construct a course outline that shows the nature and sequence of major tests and assignments.

Course Planning Sequence (cont.)

4. Check that tests and assignments fit your learning goals and are feasible in terms of workload.

↓

5. Collaborate with your students to set and achieve goals.

↓

6. Give students explicit directions for their assignments.

Objectives by Measures Matrix

Objectives	*Measures*		
	Term Paper	Questionnaire	Oral Report
Write at a scholarly level	✓		
Communicate effectively through speech			✓
Value lifelong learning		✓	

Palomba & Banta, 1999. Assessment Essentials.

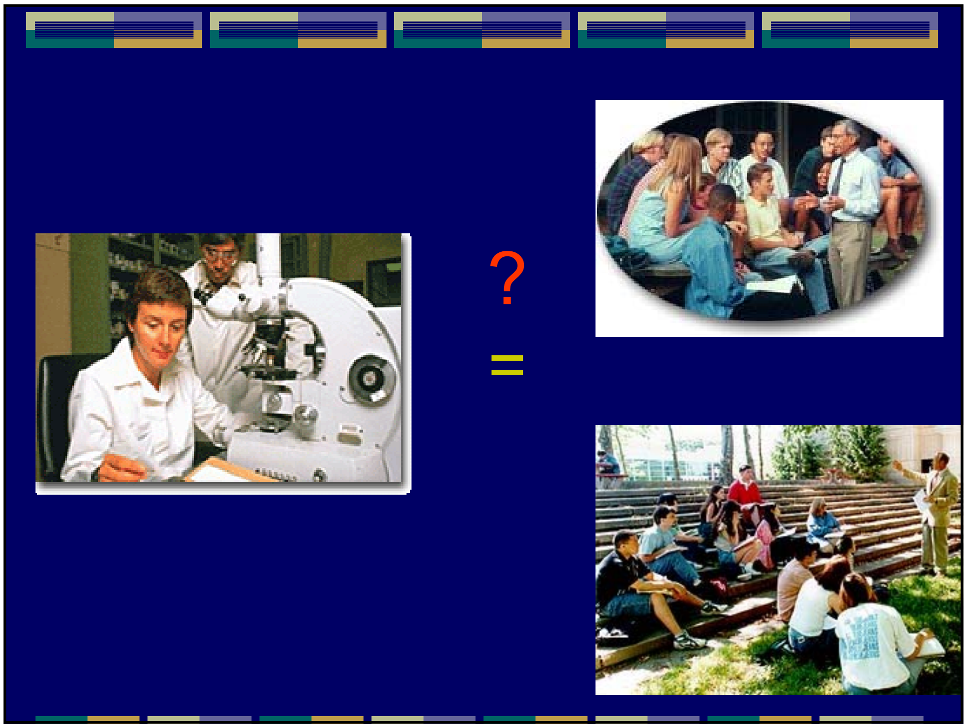
Selection Criteria Matrix

Criteria	*Measures*				
	Objective Tests	Performances	Portfolios	Surveys	Classroom Assignments
Match to curriculum					
Technical quality					
Preparation time					
Value to students					
Programmatic information					

Palomba & Banta, 1999. Assessment Essentials.

The Scholarship of Teaching and Learning

Scholarship in Transition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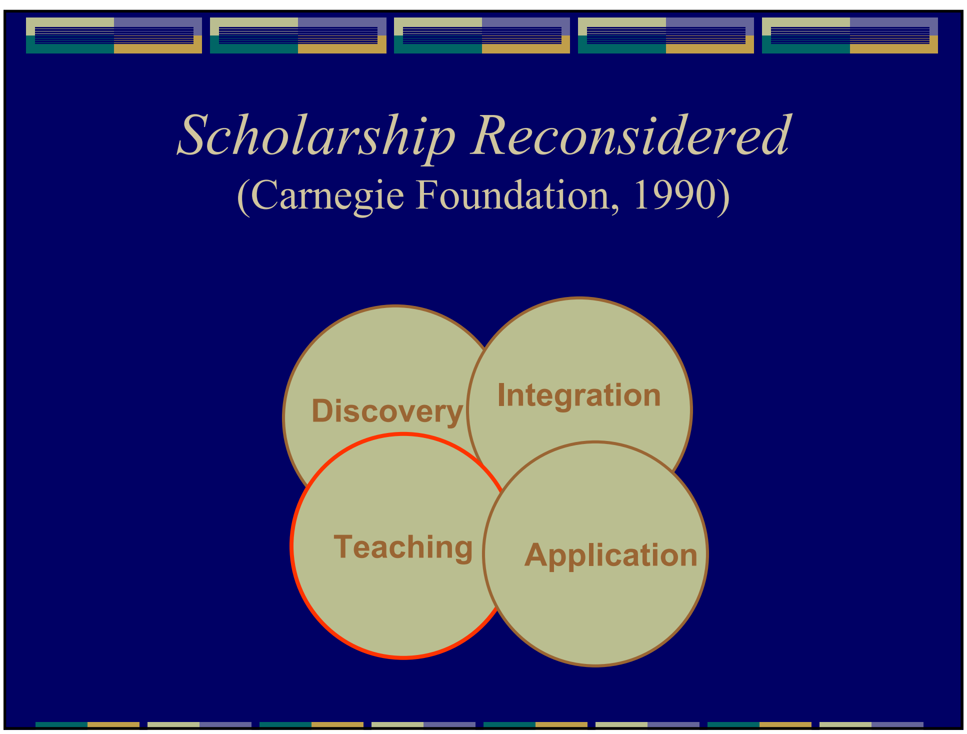

Scholarship Reconsidered
(Carnegie Foundation, 1990)
Discovery
Integration
Teaching
Application

"It is proper to the role of the scientist that he not merely fine new truth… but that he teach, that he try to bring the most honest and intelligible account of new knowledge to all who will try to learn."

Robert Oppenheimer, 200th Anniversary, Columbia University

American Association of University Professors: *The Work of Faculty (1994)*

"The world changes…We now approach the question of balance through definitions of teaching, scholarship, and service that emphasize the great variety of activities so embraced; we urge the integration of *all* the components of academic activity."

In the past five years, has your college or university reexamined faculty roles and rewards?

	Yes- review completed	Yes – review underway	No – plan to soon	No – no plans
All Institutions	21%	45%	17%	18%
Research	25	48	11	16
Ph.D. granting	15	55	15	14
Comprehen sive	20	47	19	15
Liberal Arts	22	39	17	22

The Carnegie Foundation for the Advancement of Teaching, National Survey on the Reexamination of Faculty Roles and Rewards, 1994

Issues Identified as the Focus of Institutional Review

	All	Research	Ph.D. granting	Compre-hensive	Liberal Arts
Clarifying institutional mission	69%	76%	67%	70%	65%
Redefining faculty roles	86	87	96	91	78
Balancing inst. needs and faculty rewards	66	86	80	65	58
Balance of time & effort spent on various tasks	78	76	88	79	76

Changes in Institutional Definitions of Faculty Work (*Percentage responding "Yes"*)

	All	Research	Ph.D. granting	Compre-hensive	Liberal Arts
Scholarship definition broadened	78%	66%	79%	85%	74%
Teaching definition broadened	80	80	89	80	79
Applied scholarship distinguised from citizenship	54	48	55	67	43
Role of faculty as campus citizens clarified	64	47	54	69	67

New practices in place or being considered to reward good teaching

	Now in Place	Under Consideration	Not under Consideration
Travel fund	79%	11%	10%
Awards	78	12	10
Sabbaticals	74	12	14
Grants	68	16	15
Release time	58	18	24
Merit pay	50	25	25
Mentors	37	39	22
Teaching center	28	33	37
Chairs	23	23	53

Criteria for Considering an Activity Scholarly

(Diamond, 2002. *Defining scholarship for the twenty-first century*)

The activity or work…

1. requires a high level of discipline-related expertise.
2. is conducted in a scholarly manner with
   - clear goals
   - adequate preparation
   - appropriate methodology

3. and its results, are appropriately and effectively documented and disseminated.
4. has significance beyond the individual context. It
    - breaks new ground or is innovative
    - can be replicated or elaborated
5. both process and product or result, is reviewed and judged to be meritorious and significant by a panel of one's peers.

Teaching/Learning = Research

- What is your research question?
- What are your hypotheses? (i.e., learning is increased)
- What are the appropriate methods for testing your hypothesis(es)?
- How will you analyze your data?
- What is the significance or consequence(s) of your results (how will they impact your teaching?)
- What are the broader applications of your results? (other courses, grants, publications, etc.)

Pyramid Exam

- 2 copies of exam (white and yellow)
- Each student gets two copies
- Do exam individually
- Do it again as a group

Goal => Assessment

- **Students will be able to demonstrate their understanding of photosynthesis and cellular respiration.**
- **Tools: multiple forms of assessment**

Common Misconceptions: Photosynthesis & Respiration

Photosynthesis as Energy: Photosynthesis provides energy for uptake of nutrients through roots which builds biomass. No biomass built through photosynthesis alone.

Plant Altruism: CO_2 is converted to O_2 in plant leaves so that all organisms can 'breathe'.

All Green: Plants have chloroplasts instead of mitochondria so they can not respire.

Thin Air: CO_2 and O_2 are gases therefore, do not have mass and therefore, can not add or take away mass from an organism.

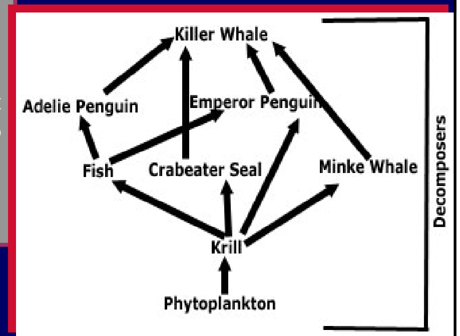
Multiple choice question (pre-post)

Plants gain a tremendous amount of weight (dry biomass) as they grow from seed to adult. Which of the following substances contributes most to that weight gain?

a. compounds dissolved in soil water that are take up by plant roots
b. water
c. molecules in the air that enter through holes in the plant leaves
d. organic material in the soil taken up directly by plant roots
e. solar radiation

Carbon Cycle Problem (post)

Two fundamental concepts in ecology are "energy flows" and "matter cycles". In an Antarctic ecosystem with the food web given above, how could a carbon atom in the blubber of the Minke whale become part of a crabeater seal? Note: crabeater seals do not eat Minke whales. In your response include a drawing with arrows showing the movement of the C atom.



In addition to your drawing, provide a written description of the steps the carbon atom must take through each component of the ecosystem Describe which biological processes are involved in the carbon cycle.

Radish Problem

Experimental Setup:

- **Weighed out 3 batches of radish seeds each weighing 1.5 g.**
- **Experimental treatments:**
  1. Seeds not moistened (dry) placed in LIGHT
  2. Seeds placed on moistened paper towels in LIGHT
  3. Seeds placed on moistened paper towels in DARK

Results: Weight of Radish Seeds

1.46 g 1.63 g 1.20 g

Write an explanation about the results.

(Remember all treatments started as 1.5g).

Problem (cont.)

After 1 week, all plant material was dried in an oven overnight (no water left) and plant biomass was measured in grams.

Predict the biomass of the plant material in the various treatments (use think-pair-share).

- Light, No Water
- Light, Water
- Dark, Water

- What were the learning goals?
- What did students do to attain those goals?
- What types of data were collected to determine whether the students met those goals?