Scientific Teaching

Handelsman, Miller, and Pfund

The Wisconsin Program for Scientific Teaching

Part of the Teaching Mentoring Program

Sponsored by the CVM Teaching Academy

Presented by: John Nilson & Kay Brothers

Active Learning - Helps You Too!

Review and warm-up
Scientific Teaching

Form groups of 3-5 people

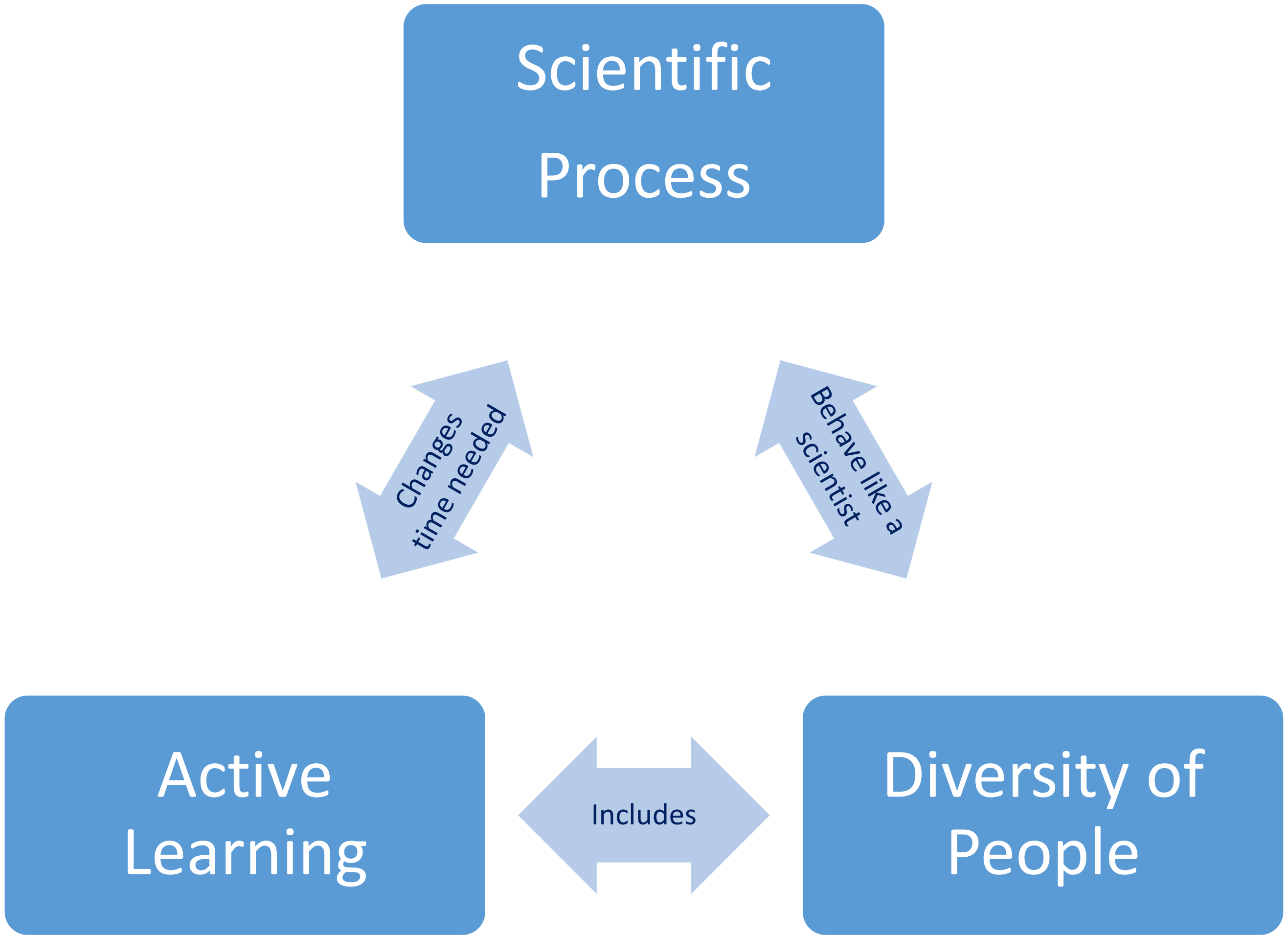
Select 3 of the phrases below

Arrange the phrases and add directional arrows between the word pairs to briefly describe the relationship

Nature of science	Scientific process	Evidence-based
Active learning	Diversity of people	Learning goals

Example


Mini-
Map


Scientific
Process
Changes
time needed
Behave like a
scientist
Active
Learning
Includes
Diversity of
People

Review - Scientific Teaching

“Teaching science in a way that

1. Represents the nature of science as a dynamic, investigative process based on evidence,
2. Engages a diversity of people in a collaborative process and
3. Has clear learning goals in mind, uses methods and instructional materials designed to improve student learning, and evaluates the methods iteratively.”

Review - three pillars of Scientific Teaching

- Active Learning
  - Learn about active learning
  - Explore ‘student learning’
  - Explore ways that active learning can provide a model for how scientists think and behave
- Assessment, both formative and summative
- Diversity, through cooperative/collaborative groups

Active learning defined

- Active learning is a process in which students are actively engaged in learning.
  - Students are doing something in addition to taking notes or following directions
  - Students construct new knowledge and build scientific skills

Active leaning - techniques

- Brainstorming
- Case studies
- “Clicker” question
- Concept map
- Decision making
- Group exam
- Mini-map
- One-minute paper
- Pre/post questions
- Strip sequence
- Think-pair-share

Educational research – presenting evidence

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Article

Teaching More by Lecturing Less

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We carried out an experiment to determine whether student learning gains in a large, traditionally taught, upper-division lecture course in developmental biology could be increased by partially changing to a more interactive classroom format. In two successive semesters, we presented the same course syllabus using different teaching styles: in fall 2003, the traditional lecture format; and in spring 2004, decreased lecturing and addition of student participation and cooperative problem solving during class time, including frequent in-class assessment of understanding. We used performance on pretests and posttests, and on homework problems to estimate and compare student learning gains between the two semesters. Our results indicated significantly higher learning gains and better conceptual understanding in the more interactive course. To assess reproducibility of these effects, we repeated the interactive course in spring 2005 with similar results. Our findings parallel results of similar teaching-style comparisons made in other disciplines. On the basis of this evidence, we propose a general model for teaching large biology courses that incorporates interactive engagement and cooperative work in place of some lecturing, while retaining course content by demanding greater student responsibility for learning outside of class.

Keywords: undergraduate students, developmental biology, peer instruction, just-in-time teaching, concept maps

INTRODUCTION

Thirty years ago, the future success of biology students might have been predictable by the amount of factual knowledge they had accumulated in their college courses. Today, there is much more information to learn, but the increasingly easy accessibility of facts on the Internet is making long-term memorization of details less and less important. Students who go on to biology-related careers after college will be required to apply conceptual knowledge to problem solving rather than simply to know many facts, and they will probably be asked to work as members of a team, rather than individually. Therefore, teaching for conceptual understanding and analytical skills while encouraging collaborative activities makes increasing sense in undergraduate courses.

There is now a great deal of evidence that lecturing is a relatively ineffective pedagogical tool for promoting conceptual understanding. Some of this evidence is general, showing that learners at all levels gain meaningful understanding of concepts primarily through active engagement with and application of new information, not by passive listening to verbal presentations (reviewed in National Research Council, 1999). More specific evidence, primarily from university courses in physics, shows that students learn substantially more from active inquiry–based activities and problem solving than from listening to lectures (Beichner and Saul, 2003; Hake, 1998; discussed further below). Nevertheless, many university faculty who are comfortable with their lecture courses remain unconvinced that more interactive teaching will lead to increased student learning, or that interactive teaching is even feasible in large classes. Colleagues we have talked with are also concerned that the time and effort required for course revision would be prohibitive, that their students would learn less content, that outcomes could not be reliably assessed in any case, and that such changes would take students and faculty alike out of their current comfort zones (see Allen and Tanner, this issue).

To address the validity of these concerns, we carried out an experiment in "scientific teaching" (Handelsman *et al.*, 2004) in a large upper-level Developmental Biology course, in

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- Knight and Wood (2005)

  "Our results indicated significantly higher learning gains and better conceptual understanding in the more interactive course."

Figure 1

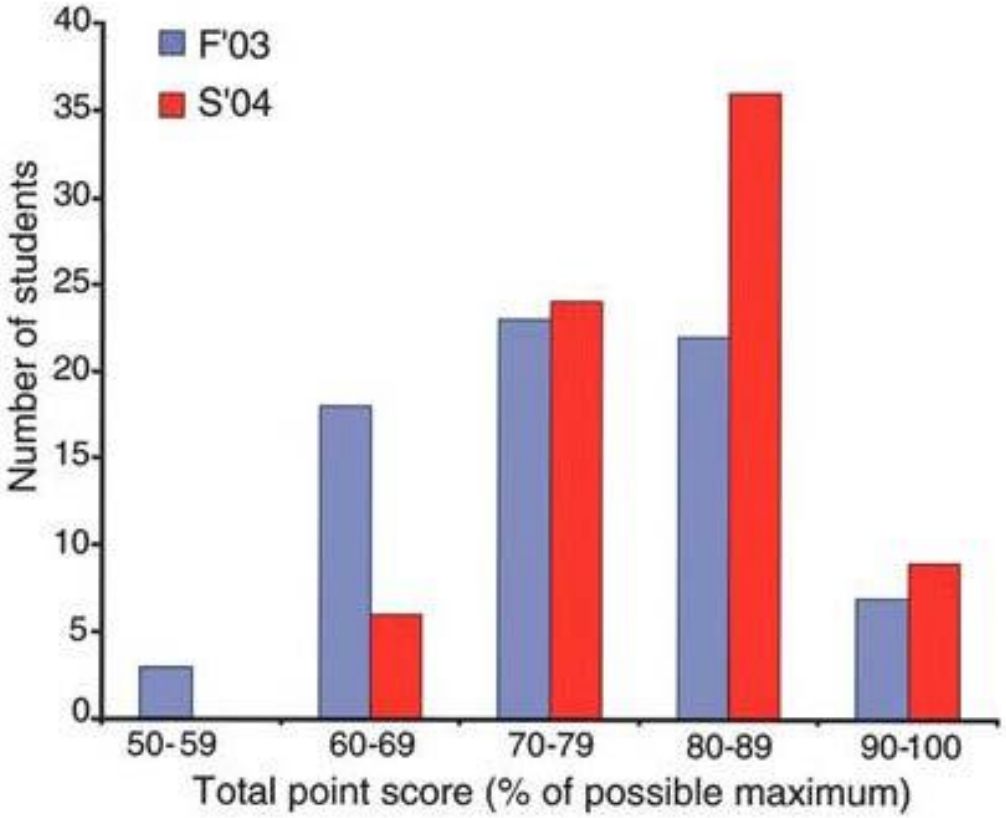


Figure 1. Final course point distributions (% of possible maximum) in traditional (F′03, blue) and interactive (S′04, red) classes. The number of students achieving a final score is shown for five ranges of scores.

Figure 2

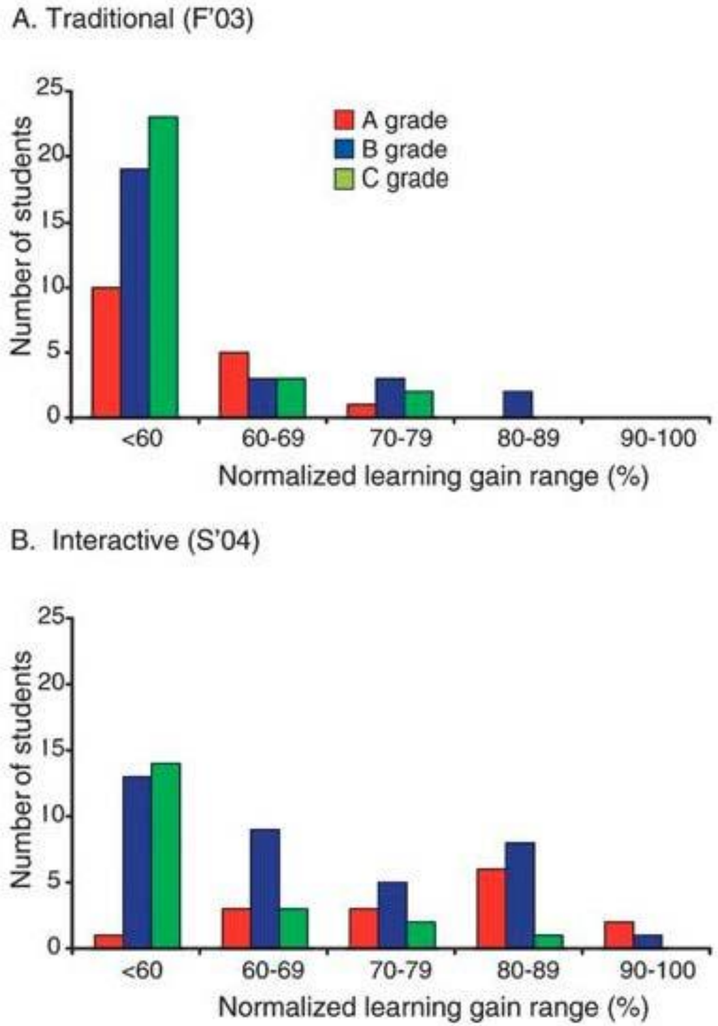


Figure 2. Comparison of normalized learning gain ranges (% of possible maximum) achieved by students in each passing grade range ("A," "B," and "C") in the F'03 and S'04 courses. Normalized learning gains were computed as 100 × (posttest score − pretest score)/(100 − pretest score) (see text). A. F'03 (traditional class). B. S'04 (interactive class).

Explore ‘student learning’

Selected models for thinking about student learning

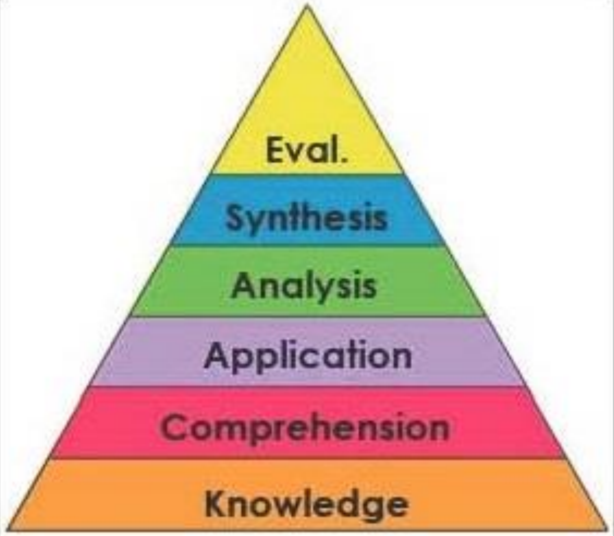
- Scaffold – with regular feedback, students scaffold new information in new contexts
- Constructivism – learning accommodates and builds upon the experiences of the learner who actively integrates new knowledge into his/her existing framework

Bloom's Taxonomy

New Version

In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning. During the 1990's a new group of cognitive psychologists, lead by Lorin Anderson (a former student of Bloom), updated the taxonomy to reflect relevance to 21st century work. The two graphics show the revised and original Taxonomy. Note the change from nouns to verbs associated with each level.

Note that the top two levels are essentially exchanged from the traditional to the new version.



Old Version

Remembering: can the student recall or remember the information?	define, duplicate, list, memorize, recall, repeat, reproduce state
Understanding: can the student explain ideas or concepts?	classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
Applying: can the student use the information in a new way?	choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write.
Analyzing: can the student distinguish between the different parts?	appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
Evaluating: can the student justify a stand or decision?	appraise, argue, defend, judge, select, support, value, evaluate
Creating: can the student create new product or point of view?	assemble, construct, create, design, develop, formulate, write.

Opportunities to help students construct knowledge

Know
Understand
Be Able To Do

Case: Constructing Knowledge

I really struggle to teach evolution. Students seem to get lost in the details and miss the really big concepts like preexisting variation in a population, natural selection, reproduction, and change in gene frequency in a population. How can I make them understand the importance of these concepts? No matter what I say, many of the students' answers are Lamarckian.

<u>Questions to consider:</u>

What issues might be contributing to this situation?
How could active leaning techniques help?
Prior knowledge and misconceptions play what roles in this case?
What suggestions do you have for the professor?
Have you faced a similar challenge?

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Active learning can model how scientists think and behave

Active learning worksheet

- Take 2-3 minutes to work with a partner
- For one or two passive lectures jot down an active lecture compliment
- Think of a few example passive lectures with active lecture compliment of your own

Prelude to Session III: EnGauge Students and Assessment

- Elicits responses from a large group
- Problem-solving in a ‘real-life’ context
- Students evaluate what they know
- Students gauge whether they understand
- Generate creative solutions
- Appreciate processes can be non linear and multidirectional
- Identify most important components of argument
- Evaluate whether and why answers changed
- Recognize cause and effect
- Evaluate critical steps in a process
- Evaluate misrepresented information

Exit Assessment

Address the following question in one minute or less:

- How can active learning techniques engage students in thinking and behaving like a scientist?