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

Scientific Process

Active Learning

Diversity of People

Mini-Map

Includes

Behave like a scientist

Changes time needed
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

Knight and Wood (2005)

“Our results indicated significantly higher learning gains and better conceptual understanding in the more interactive course.”
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. 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 \( 100 \times (\text{posttest score} - \text{pretest score})/(100 - \text{pretest score}) \) (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
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.

**New Version**

<table>
<thead>
<tr>
<th>Level</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remembering</td>
<td>can the student recall or remember the information?</td>
</tr>
<tr>
<td>Understanding</td>
<td>can the student explain ideas or concepts?</td>
</tr>
<tr>
<td>Applying</td>
<td>can the student use the information in a new way?</td>
</tr>
<tr>
<td>Analyzing</td>
<td>can the student distinguish between the different parts?</td>
</tr>
<tr>
<td>Evaluating</td>
<td>can the student justify a stand or decision?</td>
</tr>
<tr>
<td>Creating</td>
<td>can the student create new product or point of view?</td>
</tr>
</tbody>
</table>

**Old Version**

<table>
<thead>
<tr>
<th>Level</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>define, duplicate, list, memorize, recall, repeat, reproduce state</td>
</tr>
<tr>
<td>Comprehension</td>
<td>classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase</td>
</tr>
<tr>
<td>Application</td>
<td>choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write.</td>
</tr>
<tr>
<td>Analysis</td>
<td>appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.</td>
</tr>
<tr>
<td>Synthesis</td>
<td>appraise, argue, defend, judge, select, support, value, evaluate</td>
</tr>
<tr>
<td>Evaluating</td>
<td>assemble, construct, create, design, develop, formulate, write.</td>
</tr>
</tbody>
</table>
Opportunities to help students construct knowledge

Know
Understand
Be Able To Do
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.

Questions to consider:
What issues might be contributing to this situation?
How could active learning 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?