The power of teaching interactively and assessing student learning

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and a panel of other educators
who have developed concept assessments

On each table, there are clickers.

Turn on your clicker. When you vote, you'll see a green light blink by "vote status".

You'll have to reach consensus on the questions and vote together since there aren't enough clickers for everyone.

Let's begin with a few questions about how instructors normally teach

If there are more than ~25 students in my class, the most effective way I can teach them is by lecturing.

A (strongly agree)

B

C

D

E (strongly disagree)

Students will (or should) be able to understand and retain everything that I tell them in lectures

A (strongly agree)

B

C

D

E (strongly disagree)

The best use of class time is for me to present information while students taking notes on what I am showing or telling them.

A (strongly agree)

B

C

D

E (strongly disagree)

The more material I cover in my lectures, the more students will learn and retain from my course.

A (strongly agree)

B

C

D

E (strongly disagree)

Students will be able to effectively learn from my course only what I present and explain to them in my lectures.

A (strongly agree)

B

C

D

E (strongly disagree)

In the classroom, I feel most comfortable when:

a. I am telling students something important

b. I am explaining the answer to a student question

c. I am asking students a question and waiting for someone to volunteer an answer

d. The students are working together on something and I'm listening

e. I am inviting students to share their opinions with the rest of the class

In the classroom, students seem to feel most comfortable when:

a. I am telling them something important
b. I am explaining the answer to one of their questions
c. I am asking them a question and waiting for someone to volunteer an answer
d. They are working together on something and I'm listening
e. I am inviting them to share their opinions with the rest of the class

Most instructors:

- Are most comfortable lecturing
- Believe their students will learn whatever they tell them
- Worry that they can't "cover" the material effectively any other way but lecture

Most students:

- Think they're not learning if the instructor is not lecturing
- Think it's the job of the instructor to teach them, and balk at learning "on their own".
- Are most comfortable when instructor is in content-delivery mode

Many instructors do not focus on scientific reasoning, nor do they teach students to work through questions as a scientist would

As a result, many of our students do not know how to think like scientists because they have not practiced this skill!

How can we change from instructor-centered to learner-centered?

Pedagogies that encourage change

- in class concept questions (clickers)
- peer discussion
- group work
- reflection (knowing what you don't know)
- meaningful assessment

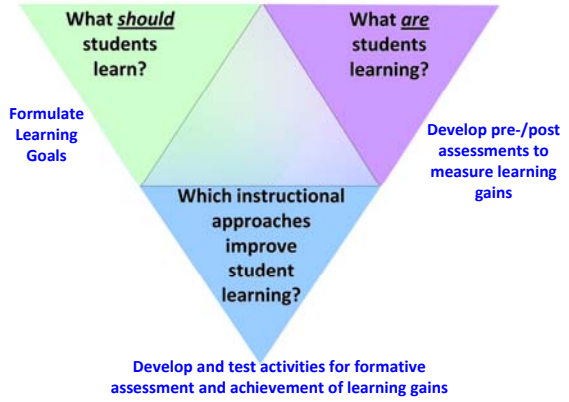
Programs for encouraging change:

The Science Education Initiative

University of Colorado, Boulder: http://www.colorado.edu/sei/

University of British Columbia: http://www.cwsei.ubc.ca/

The Science Education Initiative (SEI)



Resources from the SEI

- Instructor guidance
  - Clicker use
  - Writing learning goals
  - Course archives (including clicker questions, activities, assessment questions)
  - Education research papers
- Student guidance
- Videos to help others gain confidence in using these techniques

An example: Group Work

video produced and directed by
Dr. Stephanie Chasteen, Science Teaching Fellow in Physics, University of Colorado

Other video resources including using clickers:
http://STEMclickers.colorado.edu

What did you see in the video?

Students were invested in their learning

Students knew WHY they were engaged in interactive learning

Students believed this approach helped them learn

Convincing the skeptics: Do these techniques really help students learn?

What if it all sounds and looks good but doesn't result in more student learning?

- **Instructors need to be able to show EVIDENCE that their students are learning (as much, or more!)**

- **Evidence-based changes in teaching require ASSESSMENT TOOLS accepted as valuable by biology educators**

Concept Assessments in Biology

In general, a Concept Assessment or Inventory :

- **Is a set of multiple choice questions that have been validated through extensive student interviews, faculty input, and statistical testing.**
- **Is different from course-based exams: each distracter is in natural language, based on student ideas, and is intended to measure conceptual (not factual) understanding**
- **Allows measurement of learning gain on a set of related topics (pre/post)**
- **Provides a way of comparing student learning in similar classes where the students or the pedagogy is different**

CABs you may find useful

- **Microbiology**
  - Host-Pathogen Interactions: http://www.cbmg.umd.edu/hpi
- **Molecular Biology**
  - Biology Concept Inventory : http://bioliteracy.colorado.edu/
  - Molecular Life Sciences Concept Inventory : http://www.lifescinventory.edu.au/
  - Introductory Molecular and Cell Biology Assessment : jia.shi@colorado.edu
- **Genetics**
  - Genetics Concept Assessment: knight@colorado.edu ; Smith et al. 2008 CBE-Life Sciences
- **Energy and Matter**
  - Diagnostic Question Clusters: http://www.biodqc.org/
- **Natural Selection**
  - Concept Inventory of Natural Selection: Anderson et al. 2002

http://en.wikipedia.org/wiki/Concept_inventory

How can you use data from CABs?

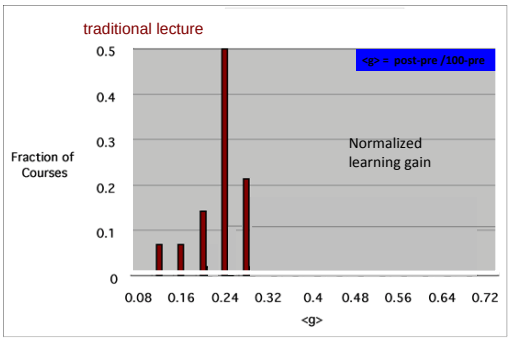
- **Guide your teaching**
  - **Identifying what students don't know at the beginning**
  - **Identifying student misconceptions (most commonly chosen wrong answers)**
- **Refine your teaching**
  - **Identifying what students DON'T UNDERSTAND despite instruction (end of course)**
- **Benchmark change**
  - **Measuring how various interventions affect student learning**

Examples

Interactive teaching promotes higher student learning gains

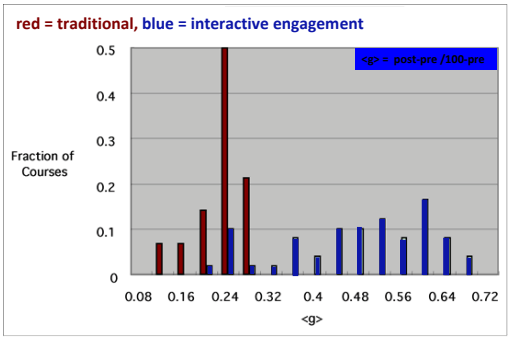
- Give assessment pre, post
- Calculate learning gains
- Compare over several semesters

Force Concept Inventory (Physics)



R. Hake, "…A six-thousand-student survey…" AJP **66**, 64-74 ('98).

Force Concept Inventory



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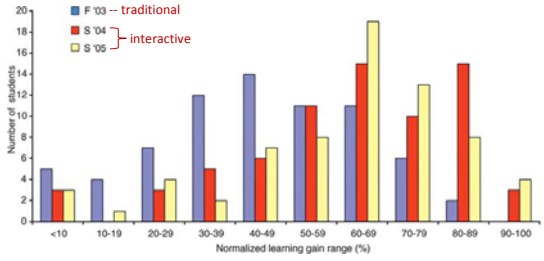
Upper level Biology



Developmental Biology Concept Assessment, Knight and Wood, 2005

Comparison of normalized learning gains (% of possible maximum) in 10% increments on 12 common pretest and posttest questions

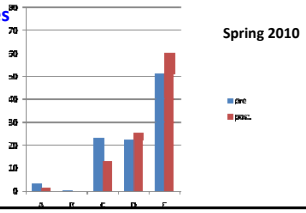
Using CABs to understand what students think pre and post on particular concepts

Which of the following human cells contain a gene that specifies eye color?

A) Cells in the eye.
B) Cells in the heart.
C) Gametes (sperm and egg).
D) Cells in the eye and gametes.
E) All of the above.

(from the Genetics Concept Assessment, Smith et al., 2008)

Even on the post-test, some students still don't understand that all cells contain the same genes



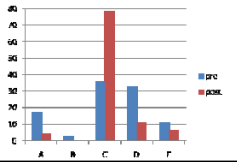
An isolated population of prairie dogs has longer than average teeth. As a result they can eat more grass with less effort and are better able to survive. The mutation(s) that resulted in longer teeth:

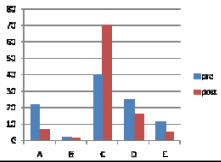
A) allowed the teeth to grow longer over several generations until they reached an optimal length for eating grass.
B) arose in many members of the population at the same time.
C) happened by chance.
D) occurred because the prairie dogs needed to be more efficient at eating grass to survive and reproduce.
E) would only occur in a prairie dog population that eats grass and would not occur in a population that lives on seeds.

(from the Genetics Concept Assessment, Smith et al., 2008)

Students learn that mutations are random rather than directed

Fall 2009





Spring 2010

Free response assessment questions allow additional insight into student misunderstandings

Energy and Matter: Diagnostic Question Clusters: http://www.biodqc.org/

Grandma Johnson had very sentimental feelings toward Johnson Canyon, Utah… when she died she requested to be buried under a creosote bush in the canyon.

Describe below the path of a carbon atom from Grandma Johnson's remains, to inside the leg muscle of a coyote.

Be as detailed as you can be about the various molecular forms that the carbon atom might be in as it travels from Grandma Johnson to the coyote.

NOTE: The coyote does not dig up and consume any part of Grandma Johnson's remains.

Student understanding is measured using a simple rubric that focuses on principled reasoning

Students struggle with this question even after instruction

Ebert-May et al., 2003

In Summary…

- **There are 27 published Concept Assessments in Biology, and more being created**
- **Concept Assesments can help you measure what your students are learning AND demonstrate that interactive techniques are helping your students learn**
- **There are many resources available from the Science Education Initiative that can help you and others adopt best practices: http://www.cwsei.ubc.ca/**

Now, we have several developers of concept assessments here to tell about how you can use their tools, and answer questions

CABs developed by people here at ASM

- **Molecular Biology**
  - Molecular Life Sciences Concept Inventory : http://www.lifescinventory.edu.au/
    - Tony Wright, Susan Hamilton, Mary Rafter, Trevor Anderson
  - Introductory Molecular and Cell Biology Assessment:
    - Jenny knight (knight@colorado.edu)
- **Genetics**
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    - knight@colorado.edu
- **Energy and Matter**
  - Diagnostic Question Clusters: http://www.biodqc.org/
    - Kathy Williams
- **Natural Selection**
  - Concept Inventory of Natural Selection: Anderson et al. 2002
    - Kathleen Fisher

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