Active learning in undergraduate biology classrooms

What, why, and how?

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Learning Objectives

• Explain what active learning is and why it should be used in college science courses

• Design an active learning activity for a biology topic

• Identify a few active learning components that you can incorporate into your courses
After a typical day of class, an instructor overheard this conversation between his students while in line at Subway...

“Man, class was so boring today!”

“It was? I didn’t notice, I was watching the Germany / Argentina match on my phone, missed it this weekend. It usually is boring though.”

“Why do we even bother coming to class? I mean, everything he talks about is in the book.”

“You know what, you’re right. The only reason I come is to get the clicker points.”

“Well, let’s take turns bringing each others clickers from now on so each of us can skip. Way better use of our time.”

“Totally brah. Let’s do it.”

What is this class like?
What is active learning?

Write it on a notecard. Now swap it at least three times.

“A process in which students are actively engaged in learning. It may include inquiry-based learning, cooperative learning, or student-centered learning.”

Scientific Teaching, page 19

“Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work.”

Freeman et al, PNAS, 2014
How do people learn best? Match the labels to the bars

- Audio-visual
- Demonstration
- Discussion
- Lecture
- Practice
- Reading
- Teaching
More activity = more learning

- Audio-visual
- Demonstration
- Discussion
- Lecture
- Practice
- Reading
- Teaching
Why should we use active learning?

Because it works!

Because it’s fun!
First-year calculus based physics (E&M) at the University of British Columbia

Week 1
Week 2
Week 3
Week 4
Week 11
Week 12
Week 13

Section A
Instructor A
Expert lecturer

Section B
Instructor B
Experienced lecturer

Differences in week 12
- Instructor A taught the same way (lecture) as for the first 11 weeks
- The postdocs taught with active learning methods

Verify students are academically equivalent

12 multiple choice questions - both instructors selected

TEST on Electromagnetism

Deslauriers, Schelew & Wieman  Science  2011
Expert instructor
Postdocs

Deslauriers, Schelew & Wieman  Science 2011
Active learning increases student performance in science, engineering, and mathematics

Scott Freeman\textsuperscript{a,1}, Sarah L. Eddy\textsuperscript{a}, Miles McDonough\textsuperscript{a}, Michelle K. Smith\textsuperscript{b}, Nnadozie Okoroafor\textsuperscript{a}, Hannah Jordt\textsuperscript{a}, and Mary Pat Wenderoth\textsuperscript{a}

225 studies were analyzed

“...average exam scores improved by about 6% in active learning sections, and students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning”

Freeman et al, PNAS, 2014

“The impact of these data should be like the Surgeon General’s report on “Smoking and Health” in 1964–they should put to rest any debate about whether active learning is more effective than lecturing.”
How do I do active learning?

- Start small and work big
- Move some material to outside of class
- Hold students accountable for what they do before class
- Sell students on why you are teaching this way
Examples from small to big, with and without technology

• Brainstorm
• Think-pair-share
• Audience response systems (clickers, etc)
• One minute paper
• Drawing exercises
• Data analysis (graphs, figure legends, etc)
• Card swap
• Case studies
• Student role-play
• Peer instruction
• Problem-based learning
Now its your turn!

• You are going to be giving a lesson on a topic in a biology course
• What are some ways that you can use active learning to present this topic?
• You have two minutes to come up with one or more active learning activities you can do to teach this topic
How do you know if it is working?

Think about it on your own for 30 seconds.

Share with your neighbor.

- Formative assessment (no- or low-stakes)
- Summative assessment (exams)
- Student feedback (weekly and midterm!)
  - Can do one minute paper too
It’s not just active learning – you need a structured course too

• Example of a highly structured course
  – Pre-class assignments / quizzes
  – In-class individual or group active learning activities with formative assessment
  – In-class clicker questions
  – Weekly review assignments
  – Practice exams
  – Multiple exams with feedback on exams
What does increased structure do to student performance?

How I teach Human Anatomy

• Spring 2014 quarter (10-weeks), 96 students
  – 1/3 sophomore nursing science majors, 2/3 junior and senior biology majors
• Highly structured components
  – Pre-class online homeworks with textbook reading guides
  – In-class group and individual active learning activities
  – Weekly online review quizzes
  – Three midterms plus a cumulative final

Here are some examples of activities from a single 50-minute lesson on the appendicular skeleton
Appendicular skeleton – Lesson 8

Learning Objectives

8.1 – Identify and describe the major bones and structures of the upper and lower limps
8.2 – Identify and describe the major bones and structures of the pectoral and pelvic girdles
8.3 – Explain how the limbs attach to the girdles to facilitate movement
8.4 – Compare and contrast the pectoral and pelvic girdles
Write down as many appendicular skeleton bones as you can in 30 seconds! Go!

Classify them to what part of the appendicular skeleton they are part of.

Do any of your bones articulate with one another? If so, draw the connections.
Odd bone out – Why?

- Humerus, fibula, metatarsal III, talus
- Femur, metacarpal IV, lunate, ulna
- Clavicle, coxa, patella
Can you label the femur and humerus?

Is this the right or left femur / humerus?

Which side is medial?
Which side is lateral?

Which structure articulates with the proximal end of the ulna?

Where is the patellar surface of the femur?

How can you tell the femur and humerus apart?
What bone is being described?

Description

• Features include glenoid cavity
• Features include greater sciatic notch and crest
• Transmits forces from upper limb to thoracic cage
• Bears weight during sitting
• Most anteroinferior bone of pelvic girdle
• Articulates with sacrum

Bone

• Sacrum
• Ilium
• Ischium
• Scapula
• Pubis
• Clavicle
• Sternum

8.2
8.4
## Compare and contrast the pectoral and pelvic girdles

<table>
<thead>
<tr>
<th></th>
<th>Pectoral</th>
<th>Pelvic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freedom of motion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment to axial skeleton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bones that attach to girdle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A 72 year old woman came to the ER after a fall. She was experiencing severe pain in her right hip and she had bruises on the right side of her face. She had to undergo a hemiarthroplasty (hip replacement). What bones or structures do you think were damaged? Describe what structures of these bones articulate with one another.
How did the students do?

32% As, 54% Bs, 12% Cs, 2% Ds/Fs

How often did you work with your neighbors when asked to do so in class?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
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<tbody>
<tr>
<td>all of the time</td>
<td>(23)</td>
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<tr>
<td>often</td>
<td>(28)</td>
</tr>
<tr>
<td>sometimes</td>
<td>(25)</td>
</tr>
<tr>
<td>rarely</td>
<td>(6)</td>
</tr>
<tr>
<td>never</td>
<td>(3)</td>
</tr>
</tbody>
</table>

Highest of all groups (not significant)
How did the students want to be taught?

This is how I taught the class.
What did the students say?

His lecture style isn't boring. He engages in active learning and keeps us working and talking throughout lecture. Instead of giving us a bunch of facts from the book, he instead does activities that integrates what we read from the book.

Utilizes techniques which are reported efficacious in helping students learn.

This class was the most class I ever interacted in. All the classes I have taken before never pushed me to interact and therefore were hard to pay attention in. His interactive approach of teaching gets the student thinking and keeps them focused unlike other classes.

Classroom activities can be distracting sometimes.

I felt like that we didn't cover everything in class because we were always trying to do so many activities.

He should completely abandon the interactive learning technique and lecture like a normal professor, because that is not working... I really hate that technique.

Overall many, many more positive comments than negative
Potential road blocks / how to make it work

• Stick with it – start on day 1 and keep doing it
  – Students aren’t used to it, especially upper-classmen
• Make small changes and work bigger
• Support what you are doing with research / data
  – Show students that they do better!
• Ask for feedback and respond to it
• Make it fun!
Last thing!

• Take a notecard and write down one thing that you still want to know from me – keep it anonymous if you want, and I’ll answer these questions later (at lunch? by email?)
Thanks!

• UC Irvine
  – Diane O’Dowd
  – Nancy Aguilar-Roca
  – Pavan Kadandale
  – Debra Mauzy-Melitz
  – Andrea Nicholas
  – Brian Sato

• UNC
  – Kelly Hogan
  – Ed Neal
  – SPIRE Program
    http://spire.unc.edu

• NCSU
  – Rich Felder
### Experimental section of Physics
(taught in week 12 by postdocs)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time (min)</th>
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</thead>
<tbody>
<tr>
<td>Pre-class reading assignment</td>
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<tr>
<td>Pre-class quiz (short T/F)</td>
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<tr>
<td>Clicker question #1</td>
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<tr>
<td>Instructor feedback</td>
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<tr>
<td>Clicker question #2</td>
<td>2</td>
</tr>
<tr>
<td>Instructor feedback</td>
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<td>Group Task #1</td>
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<tr>
<td>Instructor feedback</td>
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<tr>
<td>Group Task #1</td>
<td>4</td>
</tr>
<tr>
<td>Instructor feedback</td>
<td>1</td>
</tr>
</tbody>
</table>

Used both active learning methods (clicker questions, group work, etc) as well as pre-class assignments

Deslauriers, Schelew & Wieman *Science* 2011
Students performed higher in an introductory biology course

Data from two semesters of an introductory biology course

Without Active Learning

4-Exam Average Grade (%)

65.1%

A whole grade difference (10%)!!!