9:00 - 9:40 Why Active and Blending Learning?
Studies show that people learn by practice and feedback, not by someone telling them, and that student outcomes are dramatically better when active and blended learning are used. So what are the key elements of active and blended learning, and why are they effective?

Why active and blending learning?
(Is it ethical to lecture in 2019?)

John L. Falconer
Department of Chemical and Biological Engineering
University of Colorado Boulder

Consider this scenario
You are starting a new research project that involves separating a mixture of organic isomers
How do you decide the best technique to use?
Consider this scenario
You are scheduled to teach a new course.
How do you decide what teaching approach to use?

"Why do outstanding scientists who demand rigorous proof for scientific
assertions in their research, continue to use and, indeed, defend on the basis of their intuition alone, teaching methods that are not the most effective?


"I know what works. I can tell when students get it."

Undergraduate course at Johns Hopkins
"What routinely goes on in most college classes is not teaching and learning, but stenography."

Rich Felder

"If a professor can be replaced by a computer than they should be"

Candace Thille at Stanford

Problem with lectures

- almost impossible to learn much from a bad lecturer
- everything seems clear with a good lecturer; hard parts and easy parts look the same
- students have no clue about the hard thinking required to work out the solution

When student confront the need to do something similar on an assignment, they realize how much they completely missed.

Brent and Felder CEE 46, 29 (2012)
People learn by practice and feedback, *not* by someone telling them

**Student feedback at end of semester**

"I became accustomed to the traditional lecture format that most professors utilize. It is very hard to pay attention and stay motivated in these type of class settings where we just sit for an hour and take notes while the professor rambles on about subjects we know little about."
Active learning: “involves students in doing things and thinking (and reasoning) about the things they are doing”

When you were a student, how many courses used active learning?
A. 0
B. 1
C. 3
D. 5 or greater
Some views on lecturing

A Nobel laureate thought traditional lecture courses were simply unethical.

*Learn Better* by Boser

Are College Lectures Unfair?

Does the college lecture discriminate?

Is it biased against undergraduates who are not white, male and affluent?


Teaching is not an art

McDermott, 2001
Does active learning work?

The data are so conclusive that Freeman and his colleagues refuse to even conduct studies comparing lecture courses against more mental-engaged types of classes.

"If you are a professor and refuse to do active learning, it raises an ethical question". "It's like a doctor giving you a less effective drug. You think it's an issue of malpractice."


225 studies were analyzed

compared active learning and traditional lecturing in STEM courses

active learning: students’ performance on exams and the concept inventory increased by 0.47 standard deviation (STD)

*traditional lecture: students were 1.5 times more likely to fail*

Is it ethical to fail students who would pass if active learning was used?

Failure rate 3 times higher with traditional instruction
Learning gains **double** for introductory physics (9 instructors)

Dramatic increase in quiz performance with interactive instruction
Difference is 2.5 standard deviations
Only top 1% of students in standard instruction scored above average of interactive instruction

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<tr>
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<th>Trad</th>
<th>Transformed</th>
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<tbody>
<tr>
<td>Attendance</td>
<td>58%</td>
<td>81%</td>
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<tr>
<td>Engagement</td>
<td>50%</td>
<td>85%</td>
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<tr>
<td>Learning (test)</td>
<td>41%</td>
<td>74%</td>
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<tr>
<td>above guessing (23%)</td>
<td>18%</td>
<td>51%</td>
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Studies of student note taking show:

Only students who already know the material well are able to take notes that follow the organizational framework and are accurate. Others do not have the framework, so cognitive load too high: their notes (and lecture) are not of much use.

Michigan State University: changed Introductory Chemistry to active learning

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<tr>
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<th>2012–13</th>
<th>2015–16</th>
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<tbody>
<tr>
<td>Mean course grade&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.2</td>
<td>2.9</td>
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<tr>
<td>D or F grades and withdrawals, %</td>
<td>33</td>
<td>17</td>
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Core biochemistry course at Stanford Medical School.

<table>
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<tr>
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<th>Before adopting</th>
<th>After adopting</th>
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<td>Attendance (optional)</td>
<td>30%</td>
<td>80%</td>
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Positive student reviews increased substantially
Why waste precious class time on a lecture?
Teachers can then teach instead of making speeches.


In my UG thermo course with 76 students: 96% attendance

In Introductory Physics courses, few students develop a functional understanding of the material they studied

Question: Students were told light of wavelength $\lambda$ is incident on a slit of width $a = 4\lambda$. They were asked whether minima would appear on a distant screen and, if so, to find the angle to the first minimum.
<table>
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<th>Percent correct</th>
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<tr>
<td>Undergraduates</td>
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<tr>
<td>Quantitative</td>
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<td>70%</td>
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**Question:** Students were told the pattern above results when a mask with a narrow slit is placed between a laser and a screen. They were asked whether the slit width is greater than, less than, or equal to the wavelength and to explain their reasoning.
"The ability to obtain correct answers for numerical problems often depends on memorized algorithms"

L.C. McDermott, J. Phys. 69, 1127 (2001)
The better you know something, the more difficult it becomes to teach it.

Another student knows best what a fellow student is struggling with.

on qualitative questions, student performance is essentially the same

○ before and after standard instruction by lecture and textbook,
○ with or without demonstrations,
○ with or without a standard laboratory
○ in large and small classes
○ regardless of the popularity of the instructor
Reasons for active learning:

- More effective for learning: students perform better
- Higher-order thinking and reasoning skills are better
- Students like it
- Attendance higher
- More enjoyable for instructor
- More student-instructor interaction
- Encourages cooperation

Types of active learning that have demonstrated to enhance learning

- Small group discussion and peer instruction
- Testing
- Clickers
- Problem-based learning
- Problem sets and groups
- Computer simulations

President's Council Report 2012
Active learning works best when combined with blended learning

Most information delivery is outside of class

Blended learning
- a blend of different learning modes and materials
- combines online and instructor-led learning
- learners can access content on their own time/work, on their own pace

Learners can focus on content while using self-paced, online material
Class time not wasted covering material learners already know or that they can practice on their own.
Frees class time for active learning