End of Lecture?

The Future of Evidence-Based Teaching

Mary Pat Wenderoth—SALTISE June-2015

Discussion Question:

Why do instructors lecture?

We think that our objective of teaching the students to think was well-accomplished.
(Miller & Cheetham 1990)

I just know that students .... (UW professor, 3/09)

... we feel that our junior-senior cell biology course ... works extraordinarily well ..." (Lodish et al. 2005)

We strongly believe that lecture leads to deeper understanding.... (Rosenthal 1995)

We think that our objective of teaching the students to think was well-accomplished.
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I just know that students .... (UW professor, 3/09)

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We strongly believe that lecture leads to deeper understanding.... (Rosenthal 1995)

Discussion Question:

What is active learning?
(aka Evidence-Based Teaching)

Characteristics of active learning strategies

1. Students **involved** in learning.
2. Students **engaged** in activities
3. **Less information transmission** and
   greater focus on cognitive skills
4. Student **motivated** to learn.
5. Students have **immediate feedback** from instructor
6. Students use **higher order thinking**
   (analysis, synthesis, evaluation)

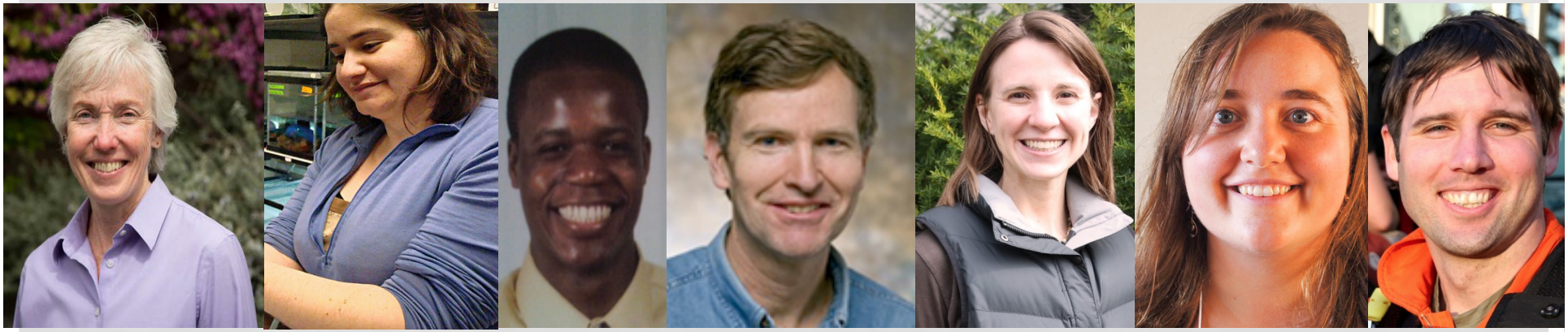
Bonwell, C.; Eison, J. (1991). *Active Learning: Creating Excitement in the Classroom AEHE ERIC Higher Education Report No. 1*. Washington, D.C.: Jossey-Bass. ISBN 1-878380-08-7.

Does active learning really work?

Is there DATA ?

Started project: 2 January 2008

"Ended" project: 12 May 2014



Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, & Mary Pat Wenderoth. 2014 PNAS 1111(23): 8410-8415 www.pnas.org/cgi/doi/10.1073/pnas.1319030111

A meta-analysis:

Five criteria for admission

1. Contrast any **active learning** intervention with **traditional lecturing** (same class and institution);
   cooperative group activities in class, worksheets/tutorials, clickers, PBL, studios …
2. Occurred in a **regularly scheduled course** for undergrads;
3. Limited to changes in the conduct of **class sessions**;
4. Involved a course in **STEM**: Astronomy, Bio, Chem, CompSci, Engineering, Geo, Math, Physics, Psych, Stats;
5. Included **data** on some aspect of **academic performance**—exam/concept inventory scores or failure rates (DFW).

Which of the following studies meet the criteria for admission into the meta-analysis?

1. A physics study which compares student learning gains on the Force Concept Inventory in two classes
   Class A: uses clickers
   Class B: uses colored cards

2. A geology study which compares student learning
   Class A: students had weekly graded online homework
   Class B: no weekly homework

3. A biology study which examines students performance on clicker questions after they engage in discussion with peers

4. A math study which compares student learning
   Class A: students use worksheet activities
   Class B: instructor shows students how to work problems

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Literature Searching

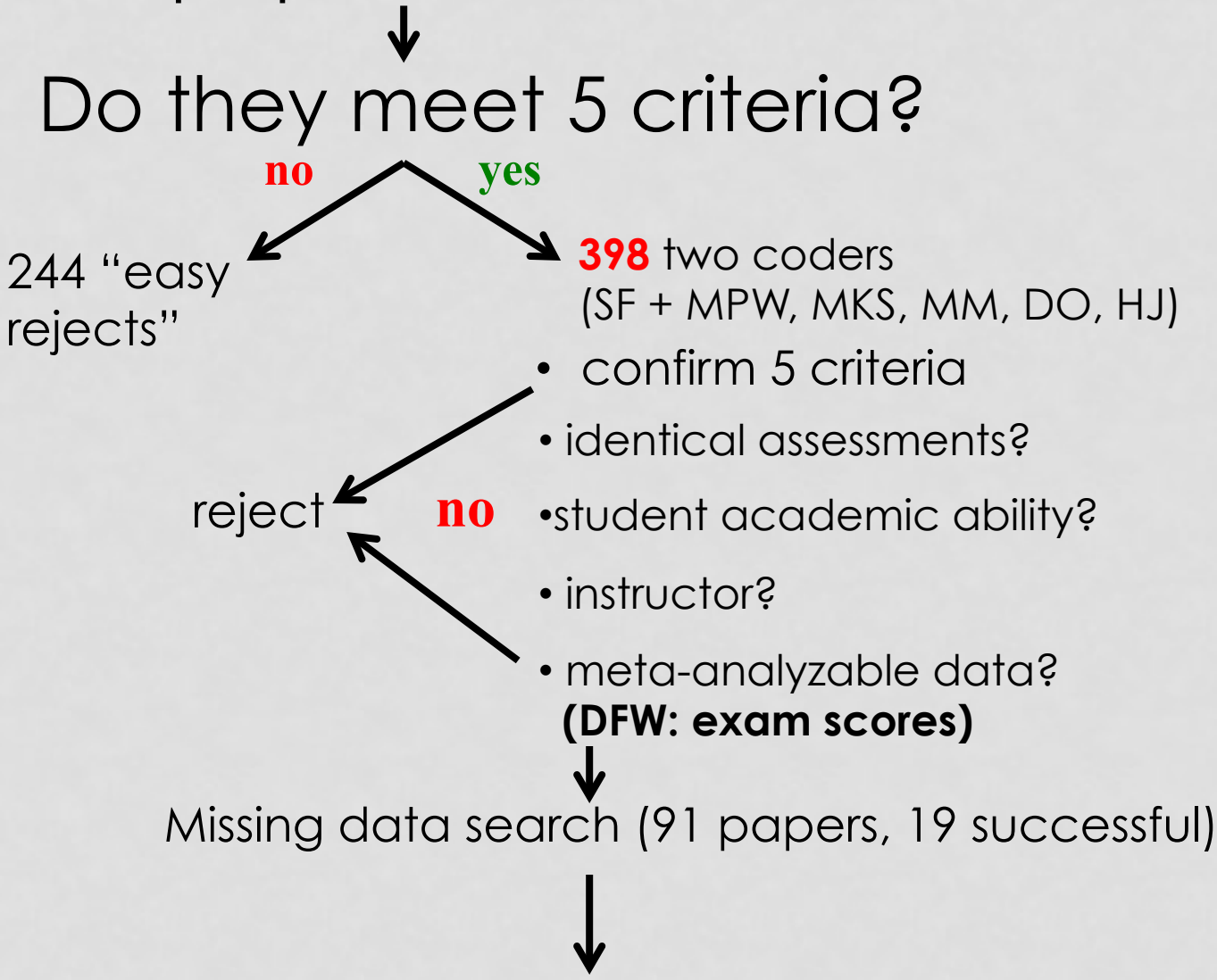
1. Hand-search every issue **55 STEM education journals** from 6/1/1998 to 1/1/2010; (read titles/abstracts)

2. Query seven online **databases** using 16 terms;

3. Mine 42 **bibliographies** and qualitative or quantitative reviews;

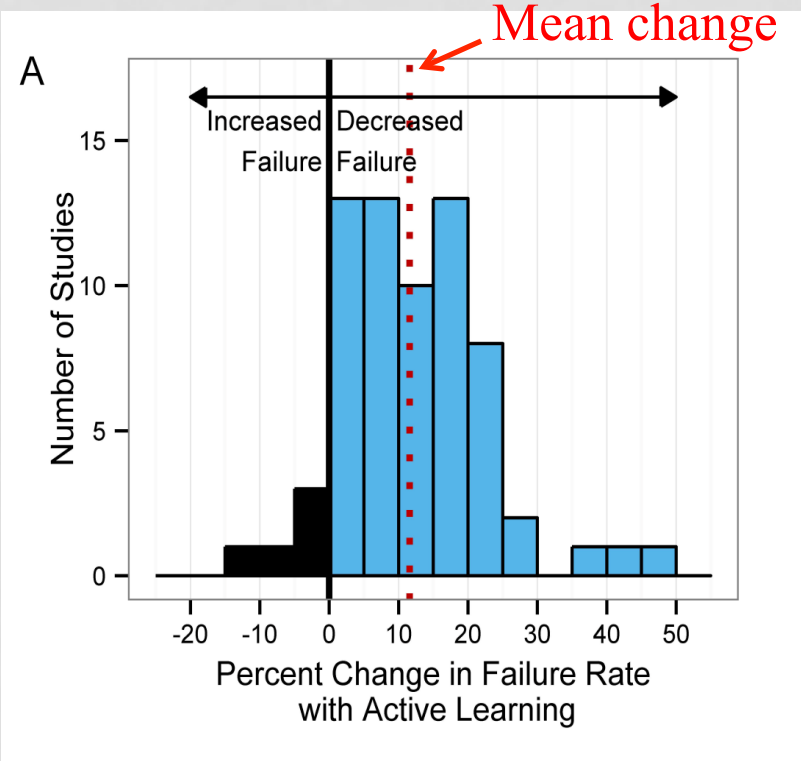
4. **"Snowballing"**

Coding: **642** papers-one researcher reads



Results: Failure Rate

67 studies reported failure rate data

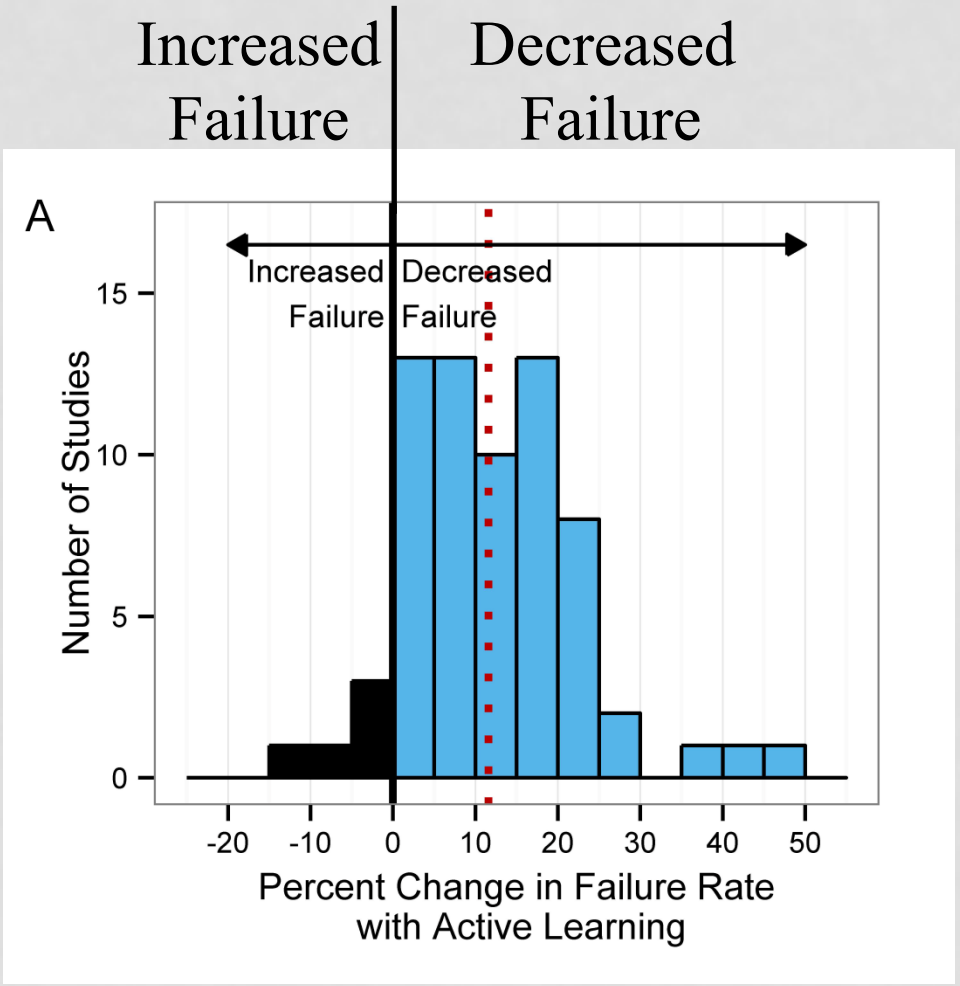


- Risk ratio = 1.5;
  students in lecture are 1.5x more likely to fail
- Average failure rate
  active learning 21.8% vs. 33.8% for traditional lecture
  a 55% increase in fail rate with traditional lecture

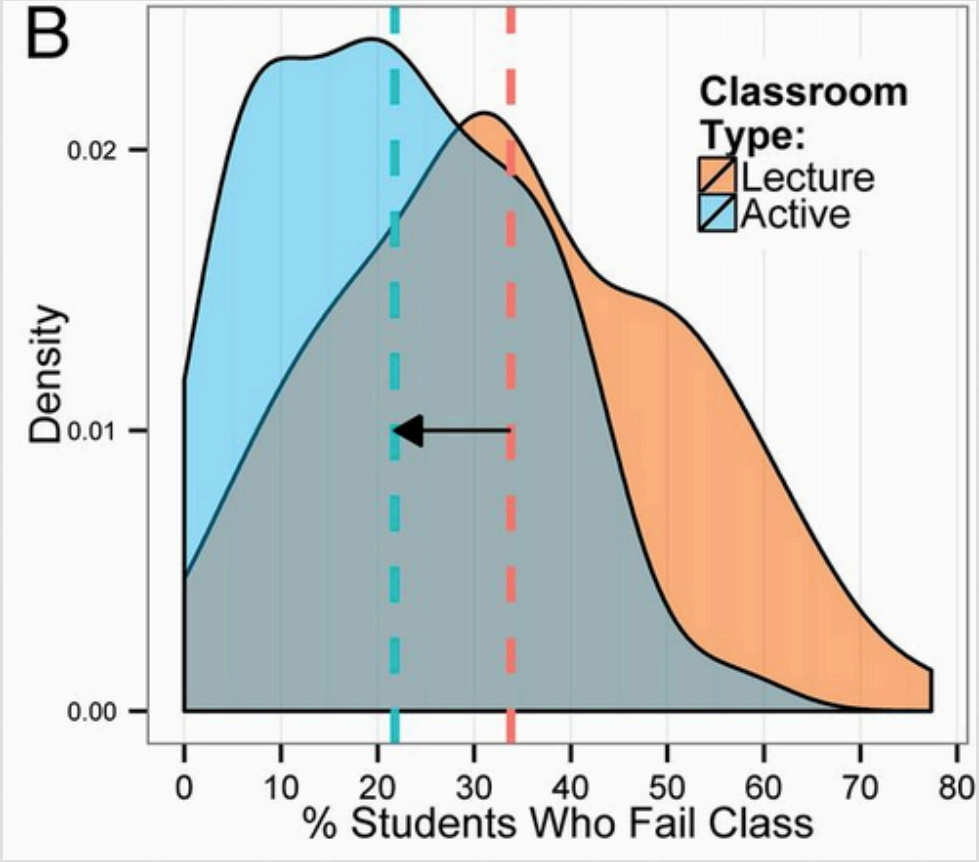
You do a study where you compare 2 classes
Class A: with clickers
Class B: without clickers.

Students in class A (+clickers) have lower failure rate.
This data would be included in the:

1. Black bars
2. Blue bars



Results:
Failure Rate



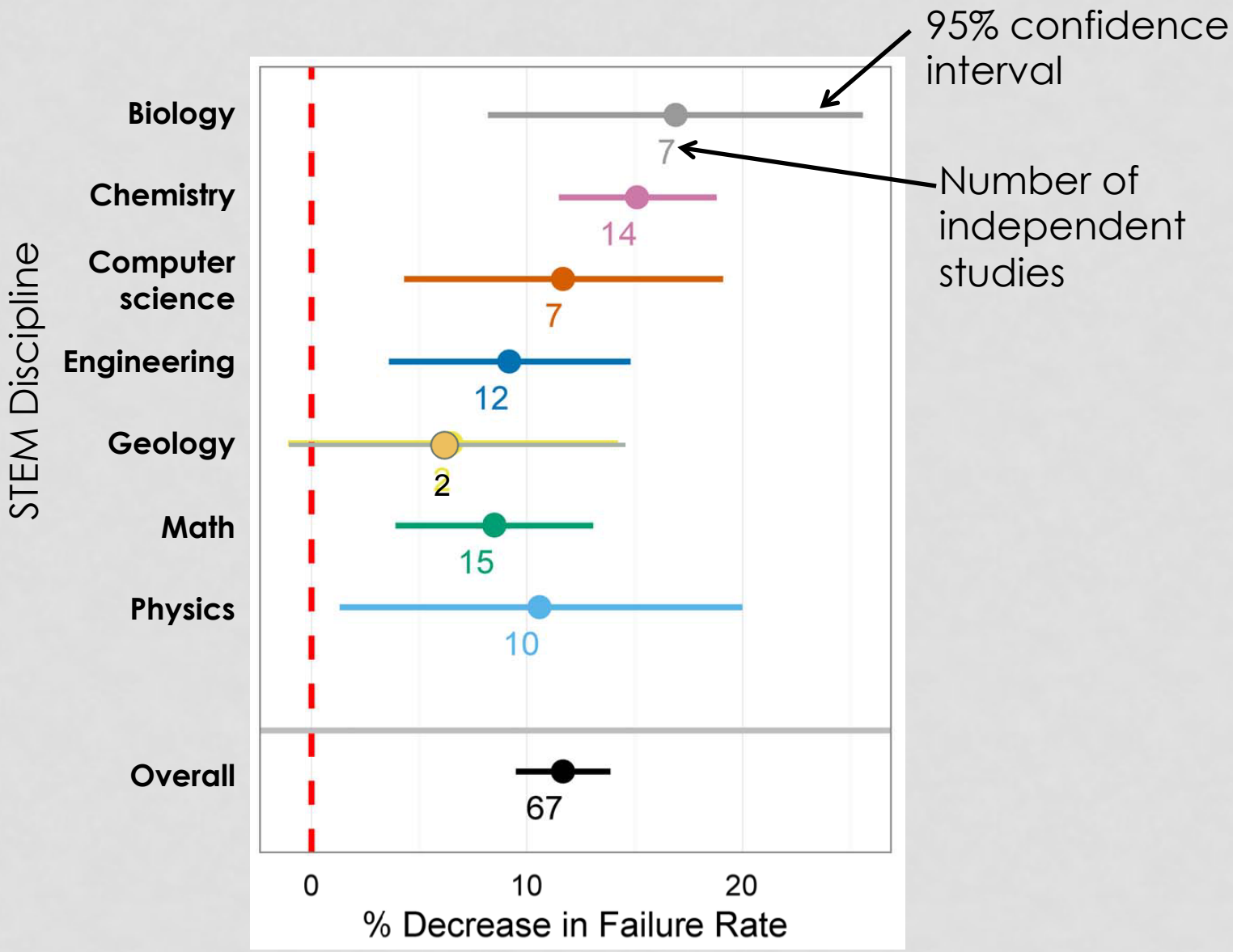
If this was a biomedical randomized control trial, it would be stopped

In our sample:

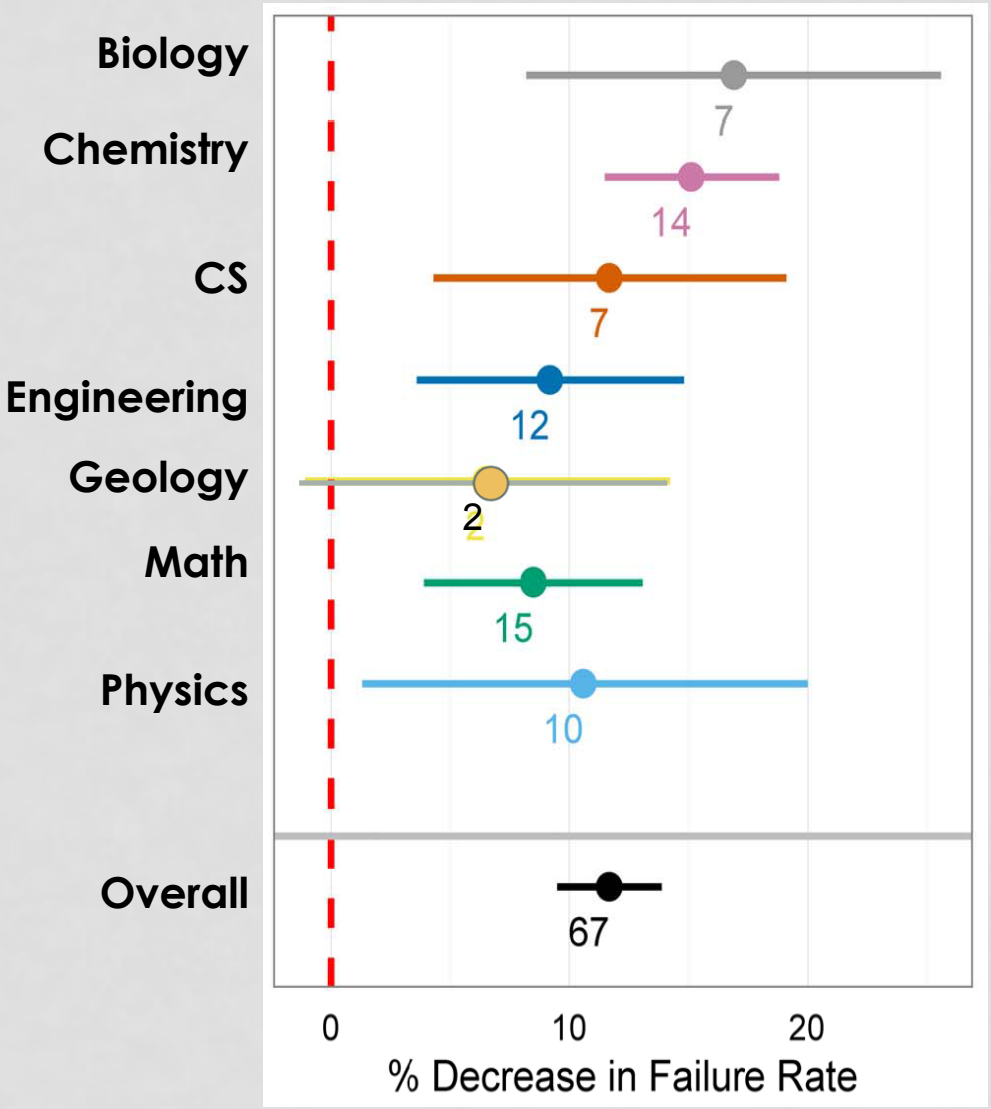
3,516 fewer students would fail;

~$3.5M in saved tuition.

Failure Rate by Discipline



What is conclusion from this data?

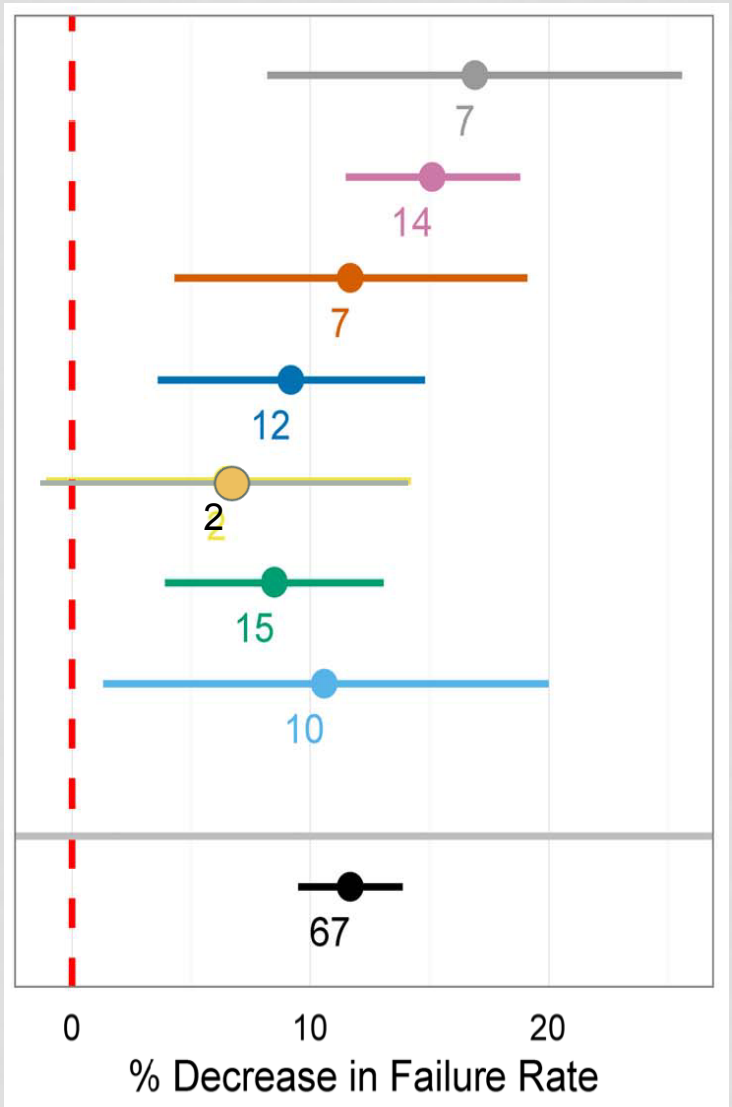


There is a statistically significant decrease in failure rate in

1. every STEM discipline ≥ 7 studies

2. biology but not other STEM disciplines

What is conclusion from this data?



There is a statistically significant decrease in failure rate in

1. every STEM discipline ≥ 7 studies

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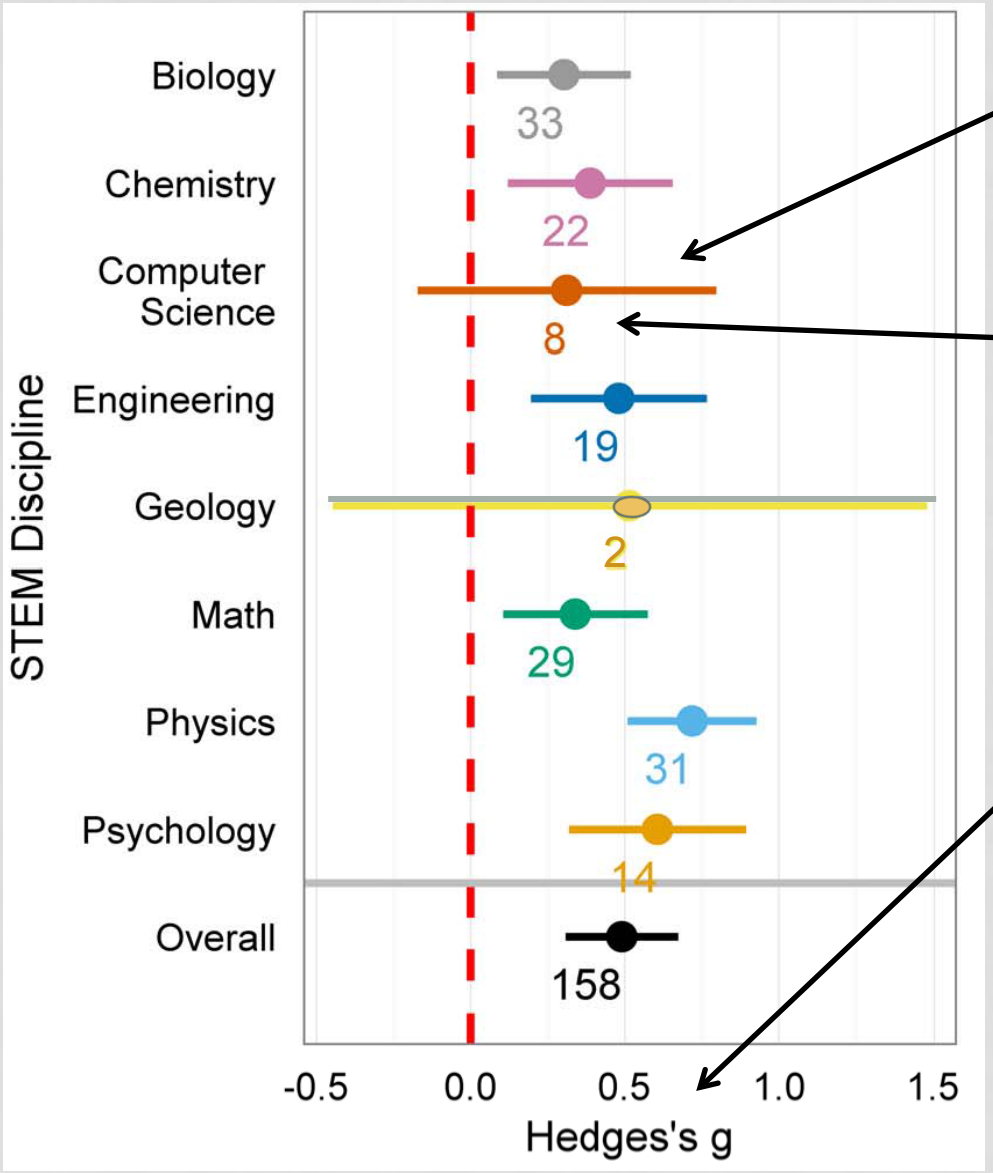
Student Performance on **Exams**



95% confidence interval

Number of independent studies

Used to determine small, med, large effect size

In K-12,
0.2 is large effect size

Results: **Exam Data**

Overall effect size = 0.47

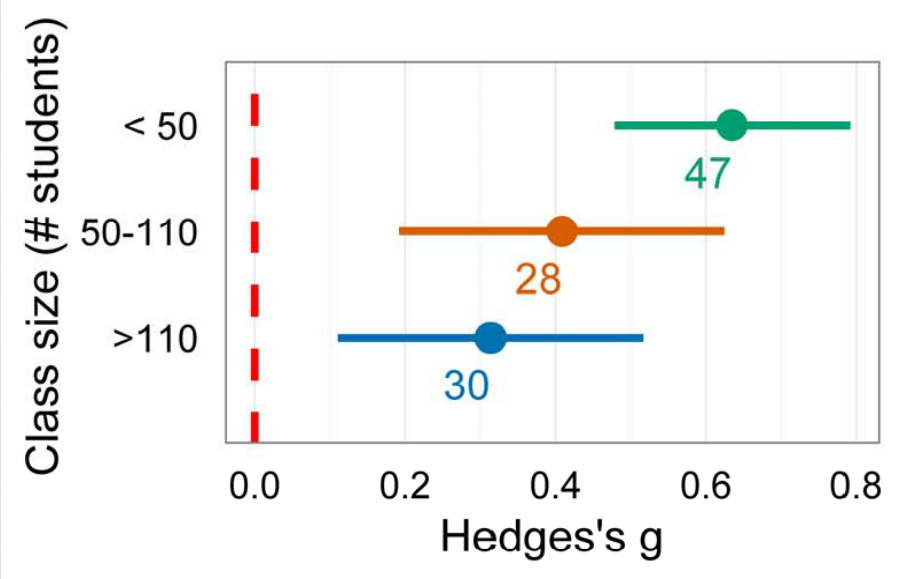
Student performance with active learning **increased** by just under half a standard deviation

- In intro STEM classes at the University of Washington

  6% increase in exam scores;
  0.3 increase in average grade

  Students in 50th percentile under lecturing would improve to 68th percentile.

Exam Data by Class Size



Which of the following can you conclude from this graph?

Active learning works

1. **only in small classes**
2. **only in large classes**
3. **across a variety of class sizes**

Other results

Drop in failure rates- no difference between

- **CLASS SIZE: small, medium, vs. large classes**
- **COURSE LELVEL: intro vs. upper-division courses**

Effect sizes for exam performance same for

- **majors vs. non-majors courses**
- **Intro vs upper division courses**

Two fundamental results

- **DFW**

  Students in lecture sections are 1.5 times more likely to fail, compared to students in active learning classes

- **Exams**

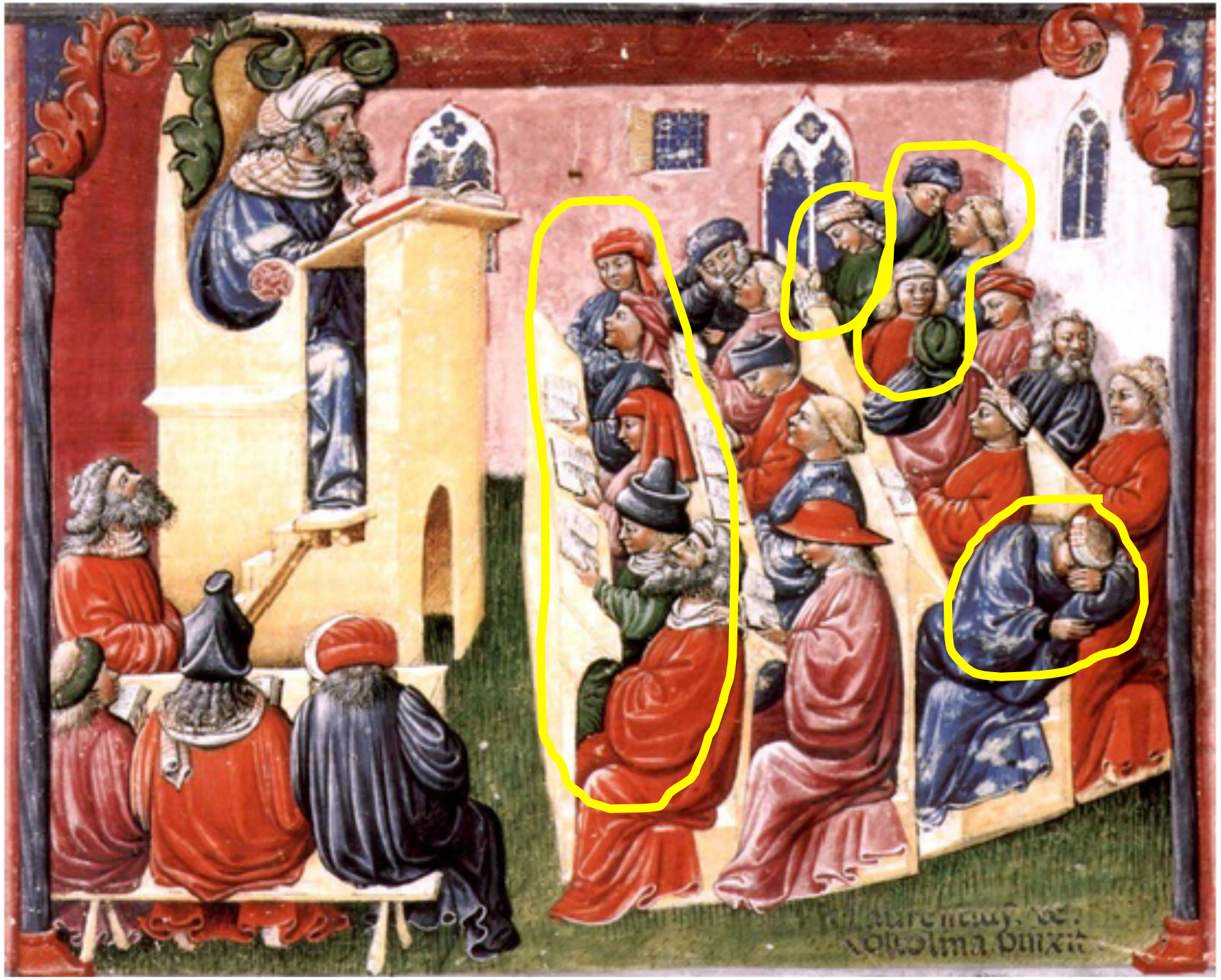
  Students in active learning classes earn higher grades compared to students in traditional lecture sections -enough to raise grades by half a letter.

Note: students who leave STEM bachelor's or associate's degree programs have GPA's 0.5 and 0.4 lower than persisters.

Which class do you want to take?

1	2
Active Learning course lower fail rate higher grades	Traditional lecture course higher fail rate lower grades

What does traditional lecturing look like in a classroom?



What does active learning look like in a classroom?

Instructor posing questions

Students discussing clicker questions

Instructor discussing worksheets with students

What would you do?

A job candidate presents his/her research seminar

While listening to their talk you realize that

- They have ignored the research literature of the past 40 years
- They are using methods that are 700 years old
- These methods are known to be ineffective

Would you hire them?

PNAS

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

[a]Department of Biology, University of Washington, Seattle, WA 98195; and [b]School of Biology and Ecology, University of Maine, Orono, ME 04469

Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

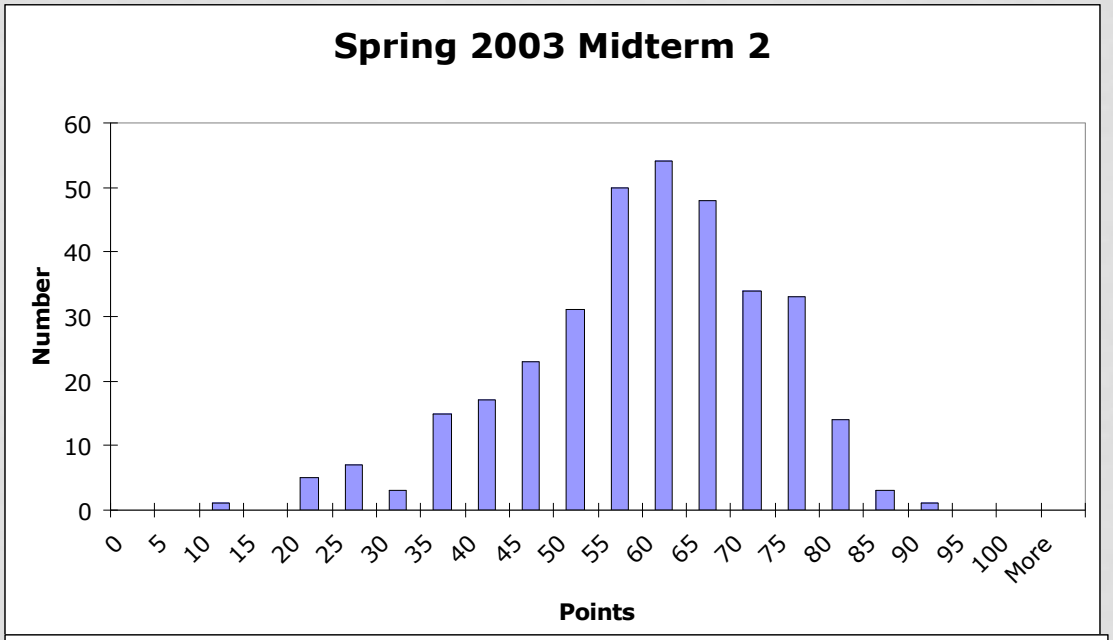
As of June 1, 2015

Downloads

abstract	**86,000**
full text	**17,000**
PDF	**50,000**

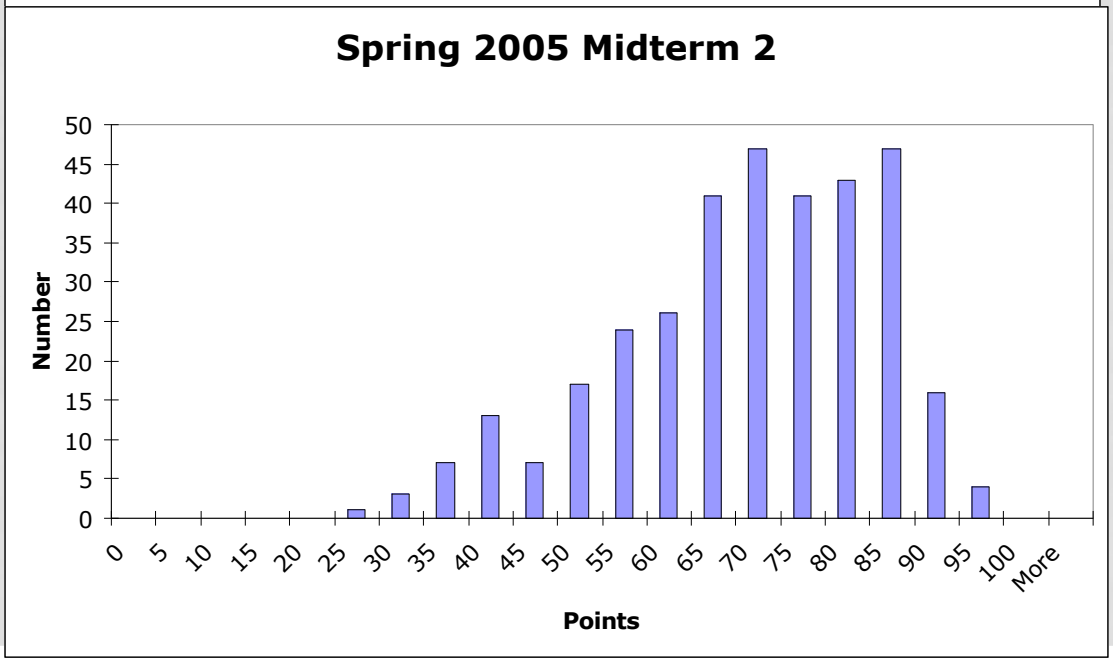
Does Active Learning only help the bottom of the class?

2003



2005

+ Clicker Q
+ reading quiz



Freeman et al. 2007

Impact on the Achievement Gap

UNC - Intro Biology course

3yr traditional vs 2 yr Active Learning

Regression model ---- PREDICTED **EXAM performance**

Compare 4 students with same SAT math & reading score

Black vs White

First gen. vs Continuing

Eddy and Hogan 2014 *CBE-LSE*

Take home message

Active Learning (a.k.a Evidence-Based Teaching)
Increases student performance for **ALL** students

Disproportionate increase for
- African-American students
- First-Generation students

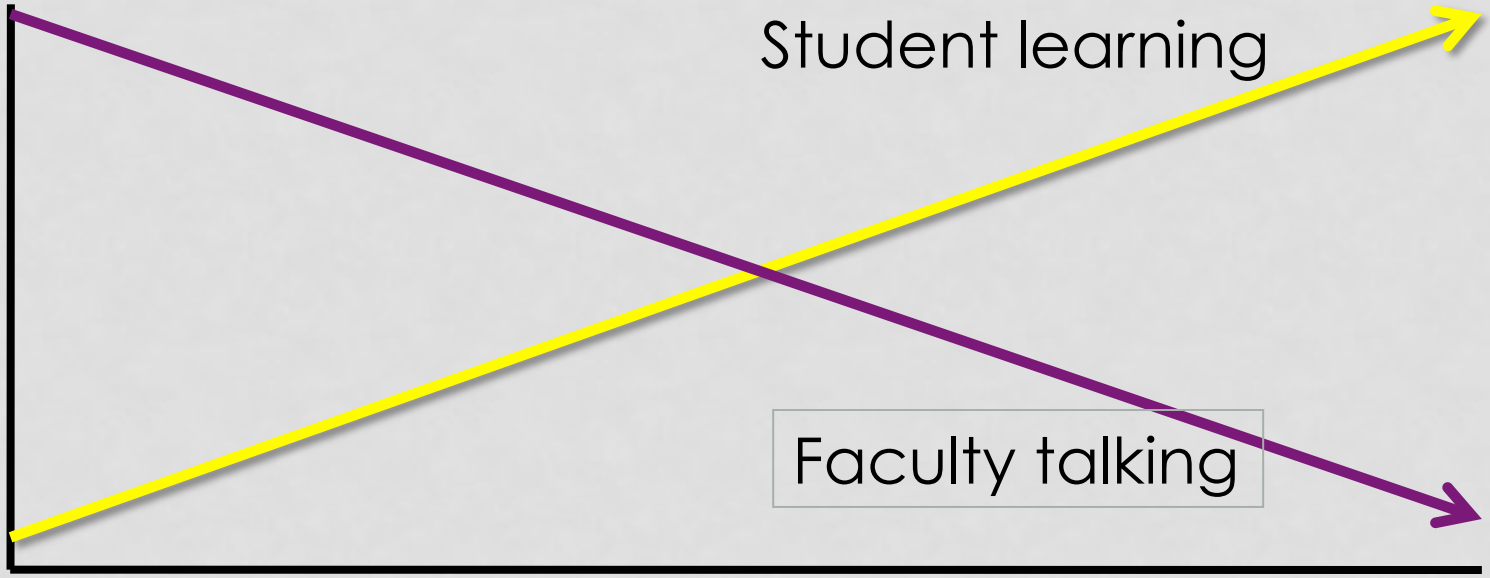
Increased Course Structure Improves Performance in Introductory Biology

LOW	MEDIUM	HIGH
Fall 2002	Spring 2005	Fall 2009
lecturing Socratic method	lecturing clicker Q reading Q	No lecturing (at all) 6+ clicker Q weekly practice exam daily reading Q 15 random calls

Bloom ALL exam questions from Fall 2002 - 2009
Bloom level increased from 2.7 to 3.1

Freeman, Hake, & Wenderoth (2011)*CBE—LSE* 10, 175–186

	LOW		MEDIUM		HIGH	
	Spr '02	Spr '03	Spr '05	Fall '05	Fall '07	Fall '09
< 1.5	18.2%	15.8%				



“Ask, Don’t Tell”

The person doing the talking
is doing the learning.

Guide learning by questioning.

Why is active learning more effective?

Cognitive Science Research

McDaniel @ Wash U.
Roediger @ Wash U
Bjork @ UCLA
Karpicke @ Purdue
Schwartz @ Stanford
Chi @ ASU
Dweck @ Stanford
Beilock @ U. Chicago

12 word pairs
Swahili-- English

					immediate
Group 1--	S	S	S	S	Test
Group 2--	S	S	S	**T**	Test
Group 3--	S	S	**T**	**T**	Test
Group 4--	S	**T**	**T**	**T**	Test

S= study word pairs for 5 sec each
T= Swahili word only- you fill in English word- No feedback

12 word pairs
Swahili-- English

Who thought they would do best?

Who did best?

					immediate
Group 1--	S	S	S	S	Test
Group 2--	S	S	S	**T**	Test
Group 3--	S	S	**T**	**T**	Test
Group 4--	S	**T**	**T**	**T**	Test

S= study word pairs for 5 sec each
T= Swahili word only- you fill in English word

12 word pairs Swahili-- English

Who thought they would do best?

Who did best?

					1st week		2nd
Group 1	S	S	S	S	Test	----	Test
Group 2	S	S	S	T	Test	----	Test
Group 3	S	S	T	T	Test	----	Test
Group 4	S	T	T	T	Test	----	Test

Learners poor judges of their learning

"Testing Effect"-- Retrieval

	Retention Interval		
Condition	5 min	1 week	Forgetting
SSSS	.83	.40	.43
SSST	.78	.56	.22
STTT	.71	.61	.10

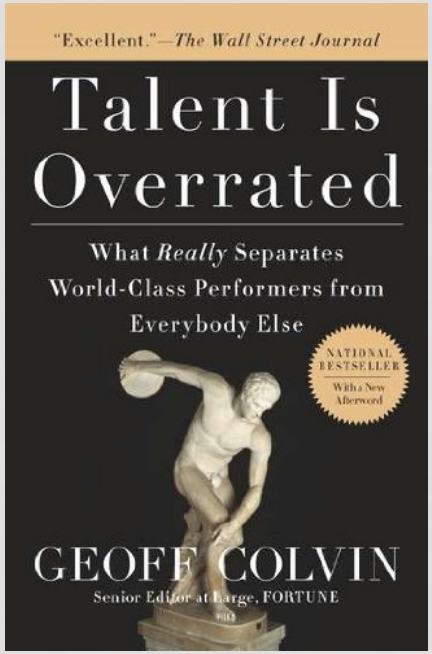
Testing enhances learning

Roediger and Karpicke 2004

"Deliberate Practice"

K. A. Ericsson

1. Activity **designed specifically** to improve performance
2. It can be **repeated** a lot
3. Continuous **feedback**
4. Mentally **demanding**
5. **Isn't fun**

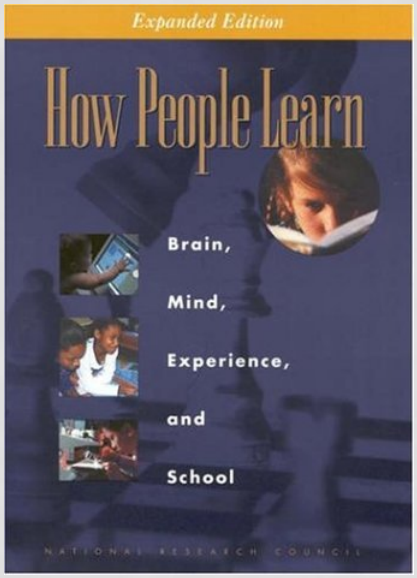


"Ask, Don't Tell"

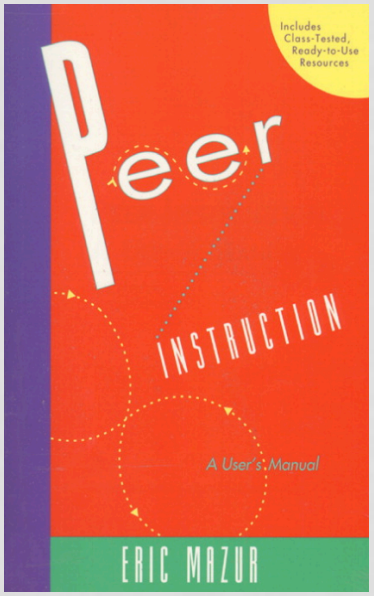
Questioning is form of **testing**.

Challenging students to solve problems is **deliberate practice**.

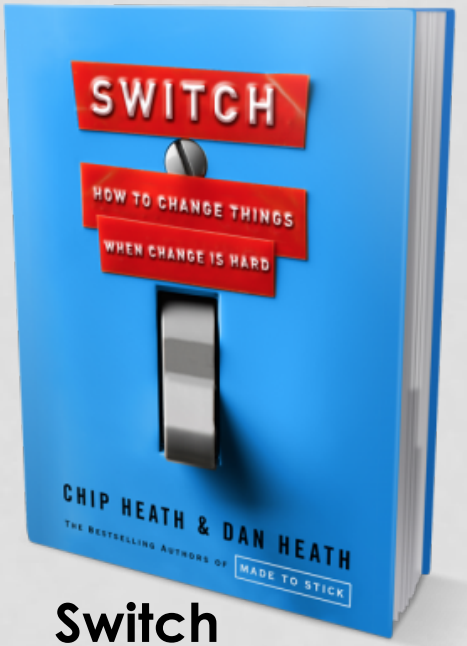
Questions



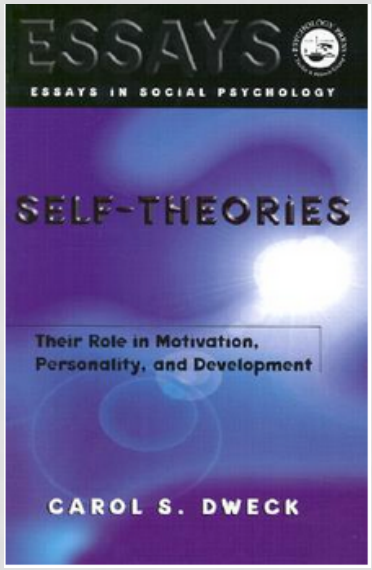
How People Learn



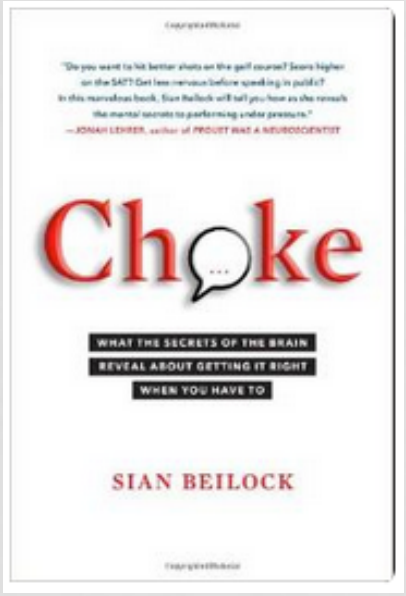
Peer Instruction



Switch

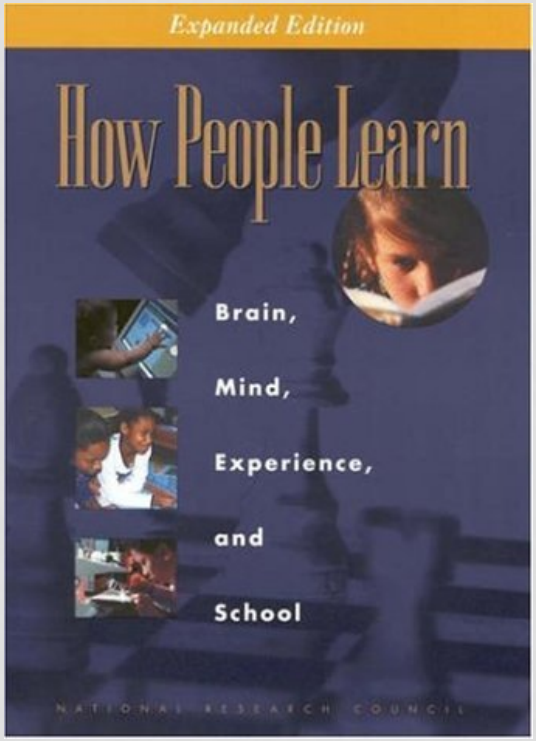


Self-Theories



Choke

How People Learn



Build BOTH factual knowledge
AND conceptual framework.

Resources

1. UW Biology Education Research Group
   https://sites.google.com/site/uwbioedresgroup/

2. Carl Weiman Science Education Initiative
   http://www.cwsei.ubc.ca/resources/index.html

4. Sit in on classes
   using evidence-based teaching

Thanks to

Education researchers for producing the evidence that will make our faculty better teachers and our students better learners.

Effective use of clickers

1. Pose a challenging higher order question
   (< 60% correct)

2. Students answer alone

3. Do not show results

4. Peer discussion

5. Revote

6. Instructor led student debrief
   using Random Call

Smith et al. *Science* 2009
Smith et al. *CBE- Life Science Education* 2011
Mazur Peer- Instruction

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Eddy, S. L., & Hogan, K. A. (2014). Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?. *CBE-Life Sciences Education*,*13*(3), 453-468.

NY Times article on closing achievement gap in Intro Biology.
http://www.nytimes.com/2014/09/03/education/active-learning-study.html?_r=0