Introduction to peer instruction

James M. Fraser
Visiting scholar

Julie Schell
Postdoctoral fellow

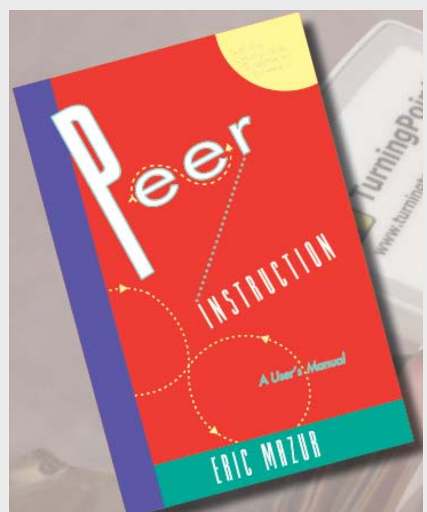
2011 New Faculty Workshop
June 27, 2011 - Hilton Garden Inn, Greenbelt
Presentation will be posted online.

You need to know your peers!

Learn the first names of (at least) two colleagues sitting near you.

Intro to us

- not Eric Mazur
- Eric's research: black silicon, fs 3D writing, single cell surgery…
- creator of Peer Instruction



Intro to Julie

- Senior PD fellow in Mazur group
- Design, implementation, assessment of research-based pedagogies
- Peer Instruction, Just-in-Time Teaching

Intro to James

Queen's UNIVERSITY

DEPARTMENT OF Physics & Engineering Physics Astronomy

Research: optics, nanoscience

646 OPTICS LETTERS / Vol. 35, No. 5 / March 1, 2010

In situ 24 kHz coherent imaging of morphology change in laser percussion drilling

Paul J. L. Webster,[1,*] Joe X. Z. Yu,[1] Ben Y. C. Leung,[1] Mitchell D. Anderson,[1] Victor X. D. Yang,[2,3,4] and James M. Fraser[1]

PRL **104,** 017401 (2010) PHYSICAL REVIEW LETTERS week ending 8 JANUARY 2010

Saturation of the Photoluminescence at Few-Exciton Levels in a Single-Walled Carbon Nanotube under Ultrafast Excitation

Y.-F. Xiao, T. Q. Nhan, M. W. B. Wilson,* and James M. Fraser†
Department of Physics, Engineering Physics & Astronomy, Queen's University, Kingston, Ontario, K7L 3N6

…but also a **teacher**!

“Frankly, applying a radically new approach to teaching a large undergraduate class is a "high-risk" activity a for non-tenured faculty. Students may not appreciate it (for a variety of reasons) which will result in poor ratings for the instructor.”

Intro to me

Appraisal of performance of faculty member by head of department
Faculty member: James Fraser
Calendar year 2010
CONFIDENTIAL

“...his evaluations in PHYS104 were among the best in the Department, an outstanding accomplishment in a course once seen as an almost impenetrable gateway… . In this year’s submission, James does not discuss any of the pedagogic reforms he has gradually introduced but .. evaluations .. confirm the clear benefits of his imaginative approaches to teaching.”

Introduction

1. Transfer of information

2. Assimilation of information

Introduction

1. Transfer of information

Easy - done in lecture.

2. Assimilation of information

Hard - left to the student.

Solution: **move information transfer out of the lecture hall so we can help students assimilate it in class!**

Outline

1. What is “peer instruction”?
2. Why does it work?
3. Let’s try it.
4. Quantitative improvements due to PI.
5. Overcoming the major obstacles.

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- no ON/OFF button
- only last "click" counts
- display shows recorded answer

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Workshop preparation

Did you review Eric's video or article on Peer Instruction?

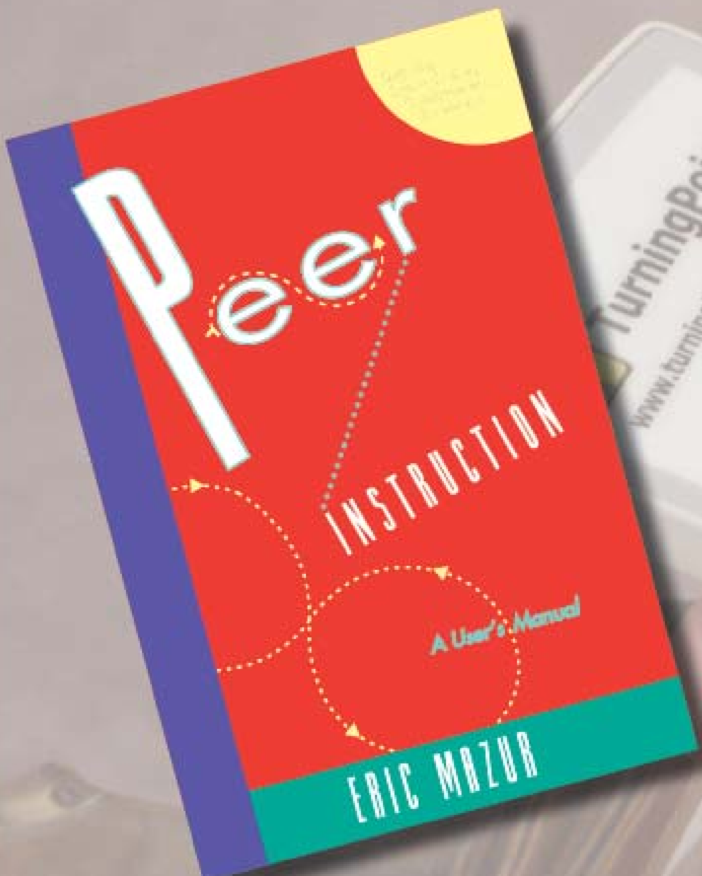
1) Yes
2) Somewhat
3) No and I do not know much about it.
4) No but I had already encountered PI before.

Workshop preparation

Comments in *blue* were submitted by you.

I will answer all the questions you raised online and send you the link.

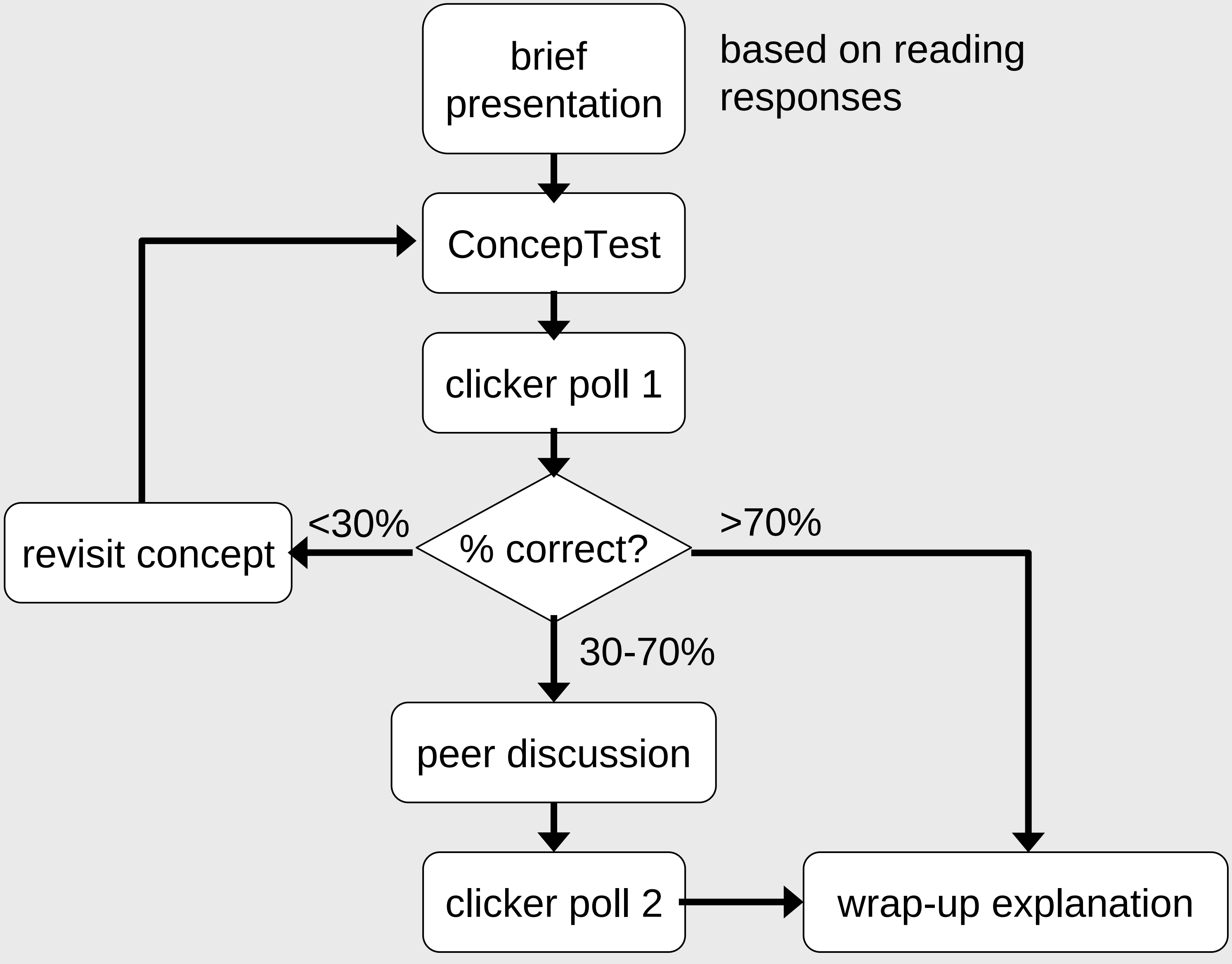
Peer Instruction



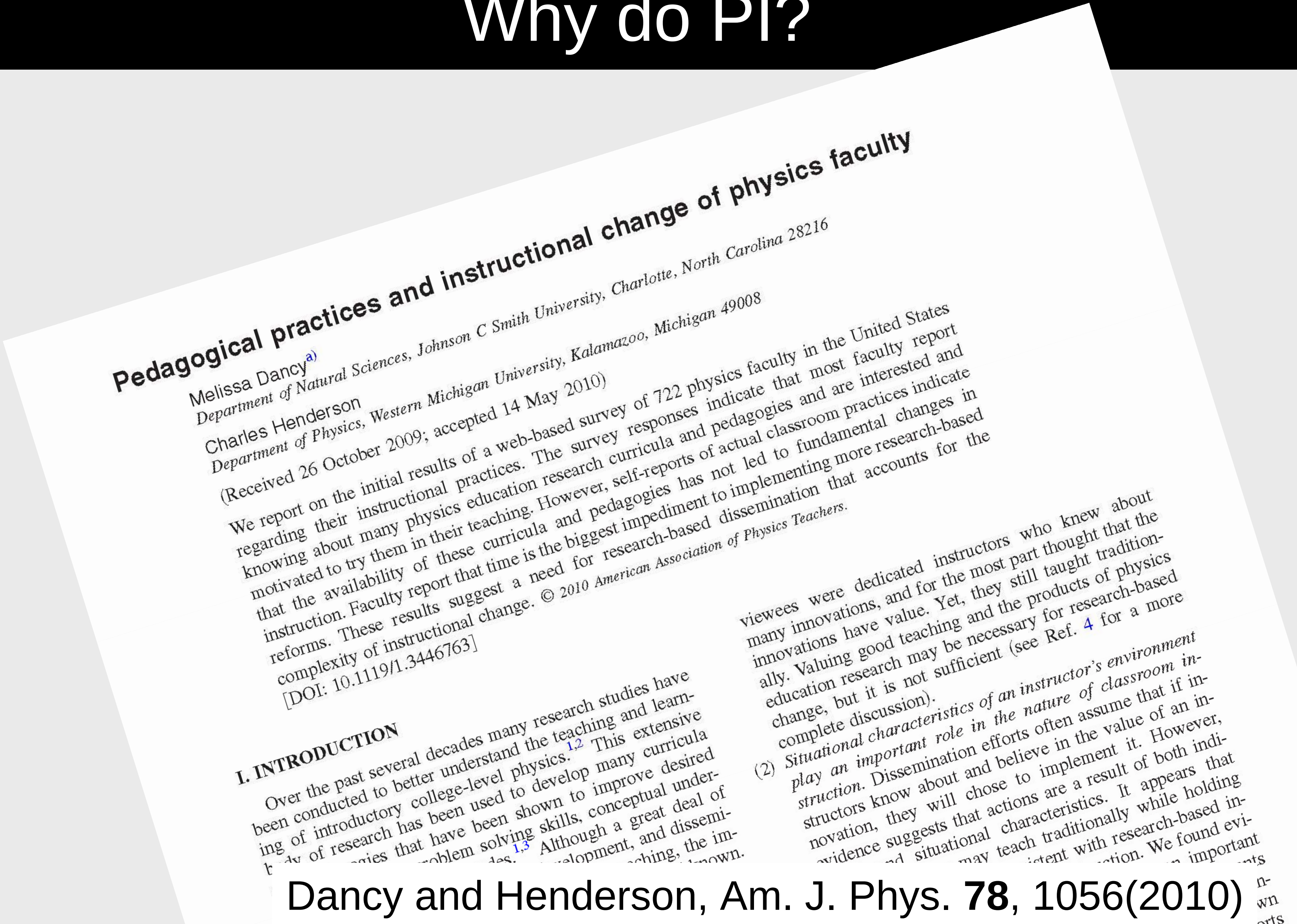
move information transfer
out of classroom

- assign reading
- teach by questioning

ConcepTest


brief presentation
based on reading responses
ConcepTest
clicker poll 1
% correct?
<30%
revisit concept
>70%
30-70%
peer discussion
clicker poll 2
wrap-up explanation

Why do PI?



Pedagogical practices and instructional change of physics faculty

Melissa Dancy[a)]
Department of Natural Sciences, Johnson C Smith University, Charlotte, North Carolina 28216

Charles Henderson
Department of Physics, Western Michigan University, Kalamazoo, Michigan 49008

(Received 26 October 2009; accepted 14 May 2010)

We report on the initial results of a web-based survey of 722 physics faculty in the United States regarding their instructional practices. The survey responses indicate that most faculty report knowing about many physics education research curricula and pedagogies and are interested and motivated to try them in their teaching. However, self-reports of actual classroom practices indicate that the availability of these curricula and pedagogies has not led to fundamental changes in instruction. Faculty report that time is the biggest impediment to implementing more research-based reforms. These results suggest a need for research-based dissemination that accounts for the complexity of instructional change.
[DOI: 10.1119/1.3446763]

I. INTRODUCTION

Over the past several decades many research studies have been conducted to better understand the teaching and learning of introductory college-level physics.[1,2] This extensive body of research has been used to develop many curricula ... that have been shown to improve desired ... problem solving skills, conceptual under... Although a great deal of ... development, and dissemi... teaching, the im... known.

viewees were dedicated instructors who knew about many innovations, and for the most part thought that the innovations have value. Yet, they still taught traditionally. Valuing good teaching and the products of physics education research may be necessary for research-based change, but it is not sufficient (see Ref. 4 for a more complete discussion).

(2) *Situational characteristics of an instructor's environment play an important role in the nature of classroom instruction.* Dissemination efforts often assume that if instructors know about and believe in the value of an innovation, they will chose to implement it. However, evidence suggests that actions are a result of both individual and situational characteristics. It appears that ... may teach traditionally while holding ... consistent with research-based in... instruction. We found evi... important

Dancy and Henderson, Am. J. Phys. **78**, 1056(2010)

Why do PI?

- The strategy that was the best known was Peer Instruction,[8] with 64% of the faculty reporting familiarity.

Table II. Percentage of respondents who indicated that they used Peer Instruction who also self-report using specific classroom practices consistent with Peer Instruction.

	Percentage of respondents
Students discuss ideas in small groups (multiple times every class)	27
Students solve/discuss qualitative/conceptual problem (multiple times every class)	27
Whole class voting (multiple times every class)	38
Conceptual questions (used on all tests)	64

Dancy and Henderson, Am. J. Phys. **78**, 1056(2010)

Why do PI?

- helps develop conceptual models
- solidifies understanding
- provides immediate feedback
- empowers students

PI: What do you think?

Of the following, which is the **LEAST** important part of Peer Instruction:

1) Student pre-class preparation
2) Clicker polling technology
3) Student voting before discussion
4) Peer discussion
5) Wrap-up explanation

Why do PI?

Why Peer Discussion Improves Student Performance on In-Class Concept Questions

M. K. Smith,[1]* W. B. Wood,[1] W. K. Adams,[2] C. Wieman,[2,3] J. K. Knight,[1] N. Guild,[1] T. T. Su[1]

When students answer an in-class conceptual question individually using clickers, discuss it with their neighbors, and then revote on the same question, the percentage of correct answers typically increases. This outcome could result from gains in understanding during discussion, or simply from peer influence of knowledgeable students on their neighbors. To distinguish between these alternatives in an undergraduate genetics course, we followed the above exercise with a second, similar (isomorphic) question on the same concept that students answered individually. Our results indicate that peer discussion enhances understanding, even when none of the students in a discussion group originally knows the correct answer.

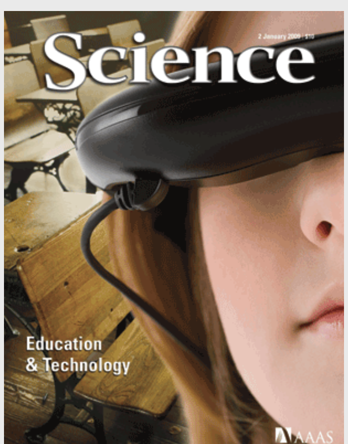
In undergraduate science courses, conceptual questions that students answer using personal response systems or "clickers" are promoted as a means to increase student learning [e.g. (*1*, *2*)], often through peer instruction (PI) (*3*). Instructors using this approach break up their lectures with multiple-choice questions to test understanding of the concepts being presented. When PI is used, students are first asked to answer a question individually, and then a histogram of their responses may be displayed to the class. If there is substantial disagreement among responses, students are invited to discuss questions briefly with their neighbors and then revote before the correct answer is revealed. The instructor then displays the new histogram and explains the reasoning behind the correct answer. Most instructors report that the percentage of correct answers, as well as students' confidence in their answers, almost always increases after peer discussion (*2*–*4*).

It is generally assumed that active engagement of students during discussion with peers, some of whom know the correct answer, leads to increased conceptual understanding, resulting in improved performance after PI. However, there is an alternative explanation: that students do not in fact learn from the discussion, but simply choose the answer most strongly supported by neighbors they perceive to be knowledgeable. We sought to distinguish between these alternatives, using an additional, similar clicker question that students answered individually to test for gains in understanding. Our results indicate that peer discussion enhances understanding, even when none of the students in a discussion group originally knows the correct answer.

In an undergraduate introductory genetics course for biology majors at the University of Colorado Boulder (additional demographic in-

[1]Department of Molecular, Cellular, and Developmental Biology, University of Colorado, Boulder, CO 80309, USA. [2]Department of Physics, University of Colorado, Boulder, CO 80309, USA. [3]Department of Physics, University of British Columbia, Vancouver, BC V6T 1Z3, Canada.

*To whom correspondence should be addressed. E-mail: michelle.k.smith@colorado.edu



Smith *et al.*, Science **323**, 122 (2010)

Why do PI?

"…these students are arriving at conceptual understanding on their own, through the process of group discussion and debate."

Why Pe… Student Perform… Concept Questions

M. K. Smith,[1*] W. B. Wood,[1] W. K. Adams,[2] C. Wieman,[2,3] J. K. Knight,[1] N. …

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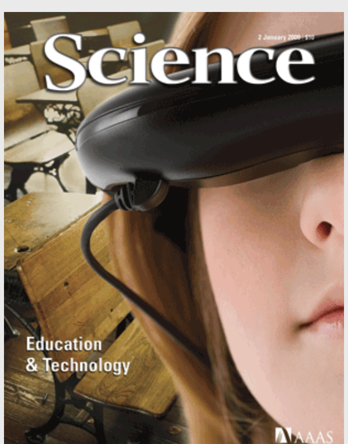


Smith *et al.*, Science **323**, 122 (2010)

Why do PI?

Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping

Jeffrey D. Karpicke* and Janell R. Blunt

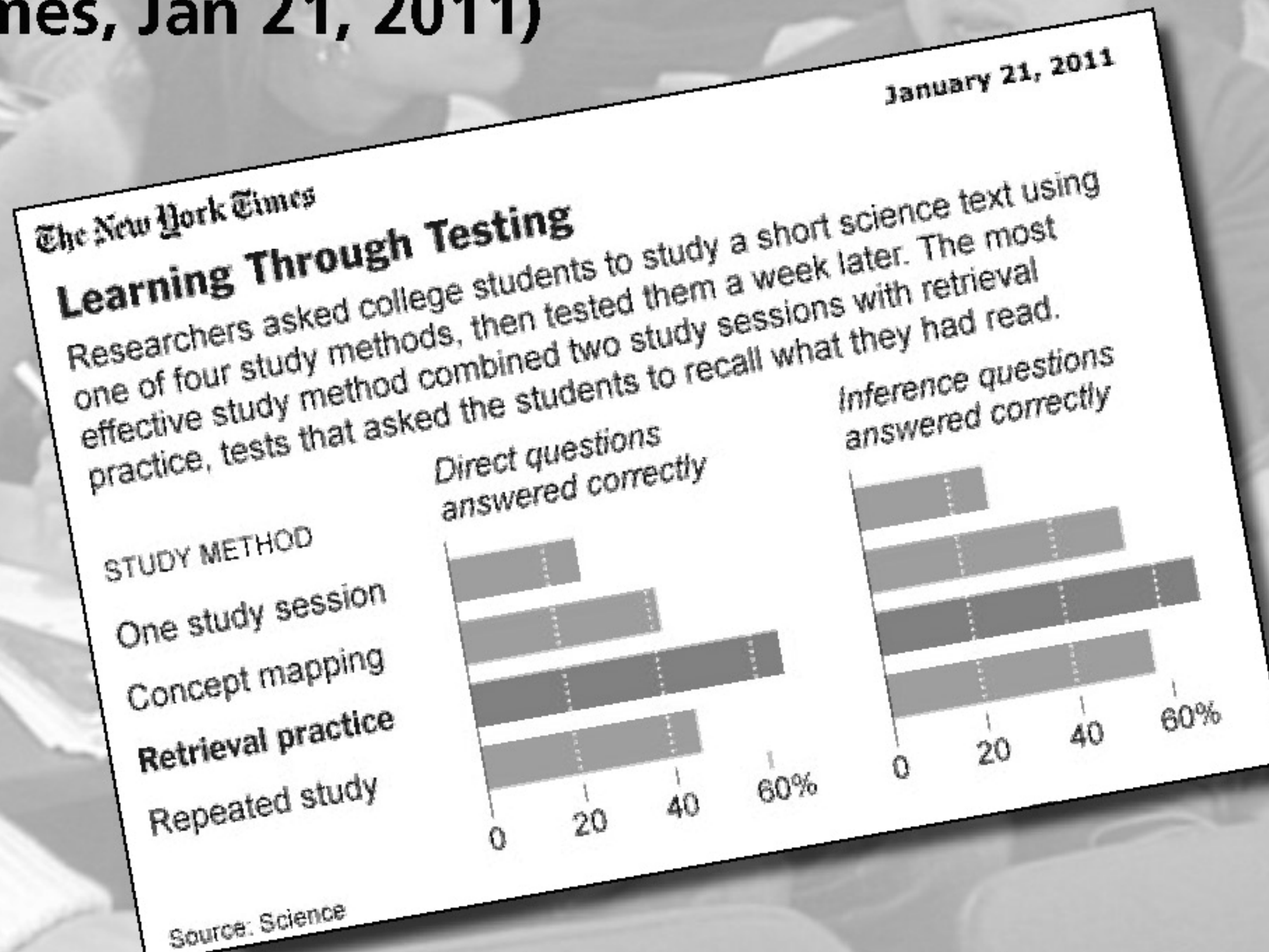
Educators rely heavily on learning activities that encourage elaborative studying, whereas activities that require students to practice retrieving and reconstructing knowledge are used less frequently. Here, we show that practicing retrieval produces greater gains in meaningful learning than elaborative studying with concept mapping. The advantage of retrieval practice generalized across texts identical to those commonly found in science education. The advantage of retrieval practice was observed with test questions that assessed comprehension and required students to make inferences. The advantage of retrieval practice occurred even when the criterial test involved creating concept maps. Our findings support the theory that retrieval practice enhances learning by retrieval-specific mechanisms rather than by elaborative study processes. Retrieval practice is an effective tool to promote conceptual learning about science.

J.D. Karpicke, *et al.* Science **331**, 772 (2011)

Why do PI?

To Really Learn, Quit Studying and Take a Test

(New York Times, Jan 21, 2011)



Let’s try it: kinematics example

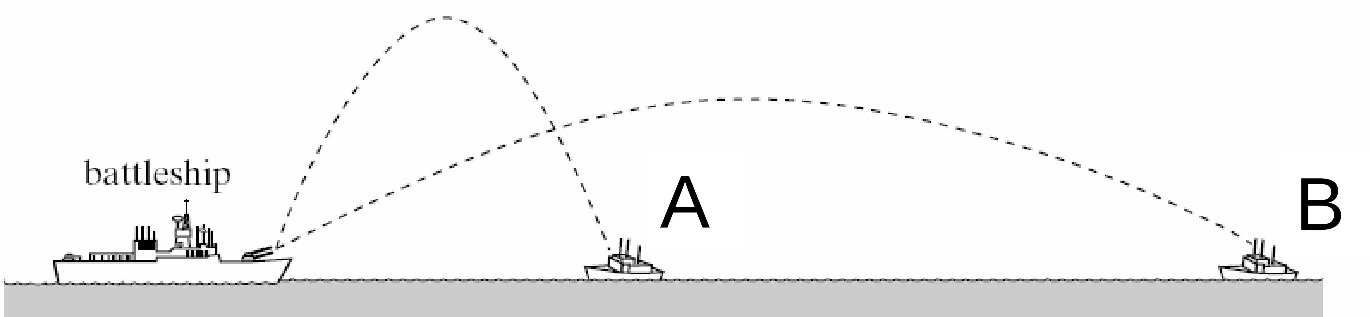
Background on projectile motion:

horizontal/vertical motion decoupled

trajectory is a parabola

Let’s try it!

A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first?



1) A
2) B
3) both get hit at (nearly) the same time
4) not enough information to answer

[redacted]

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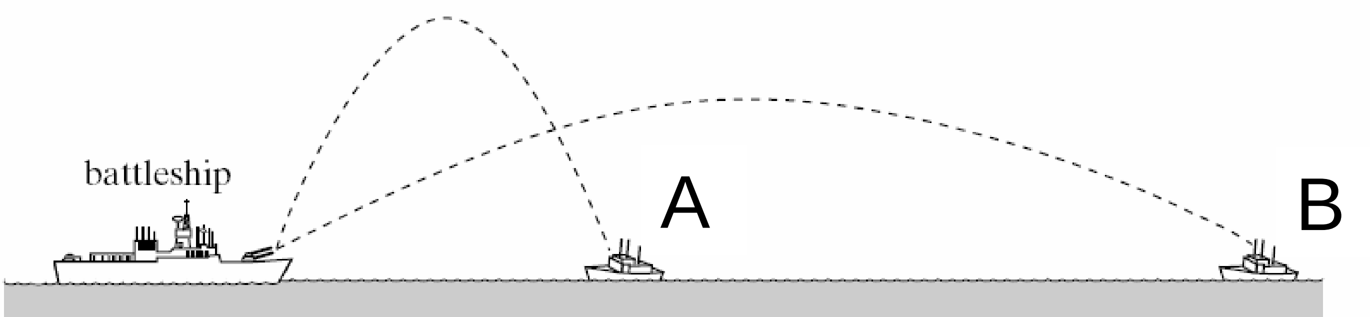
A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first?



1) A
2) B
3) both get hit at (nearly) the same time
4) not enough information to answer

Alternate ConcepTest

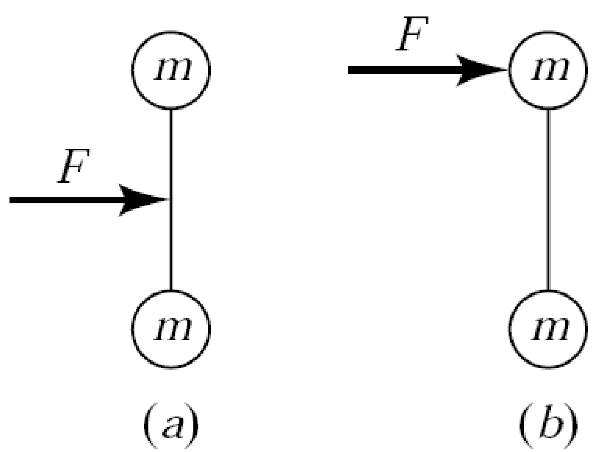
Background:

External force causes CM acceleration.

External torques cause angular acceleration.

Alternate ConcepTest

A force F is applied to a dumbbell for a time interval Δt, first as in (a) and then as in (b). In which case does the dumbbell acquire the greater energy?



1) a
2) b
3) no difference
4) it depends on rotational inertia of dumbbell

[redacted]

Alternate ConcepTest

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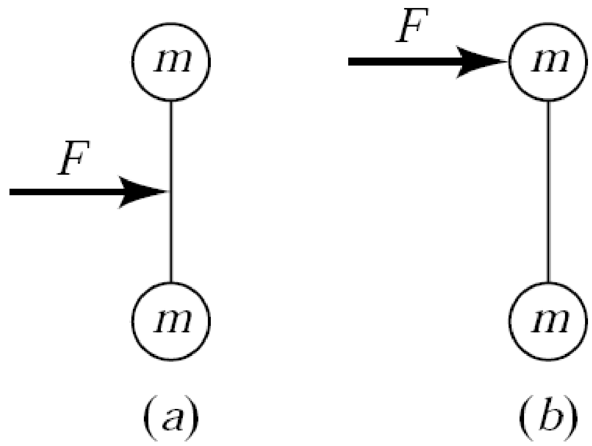


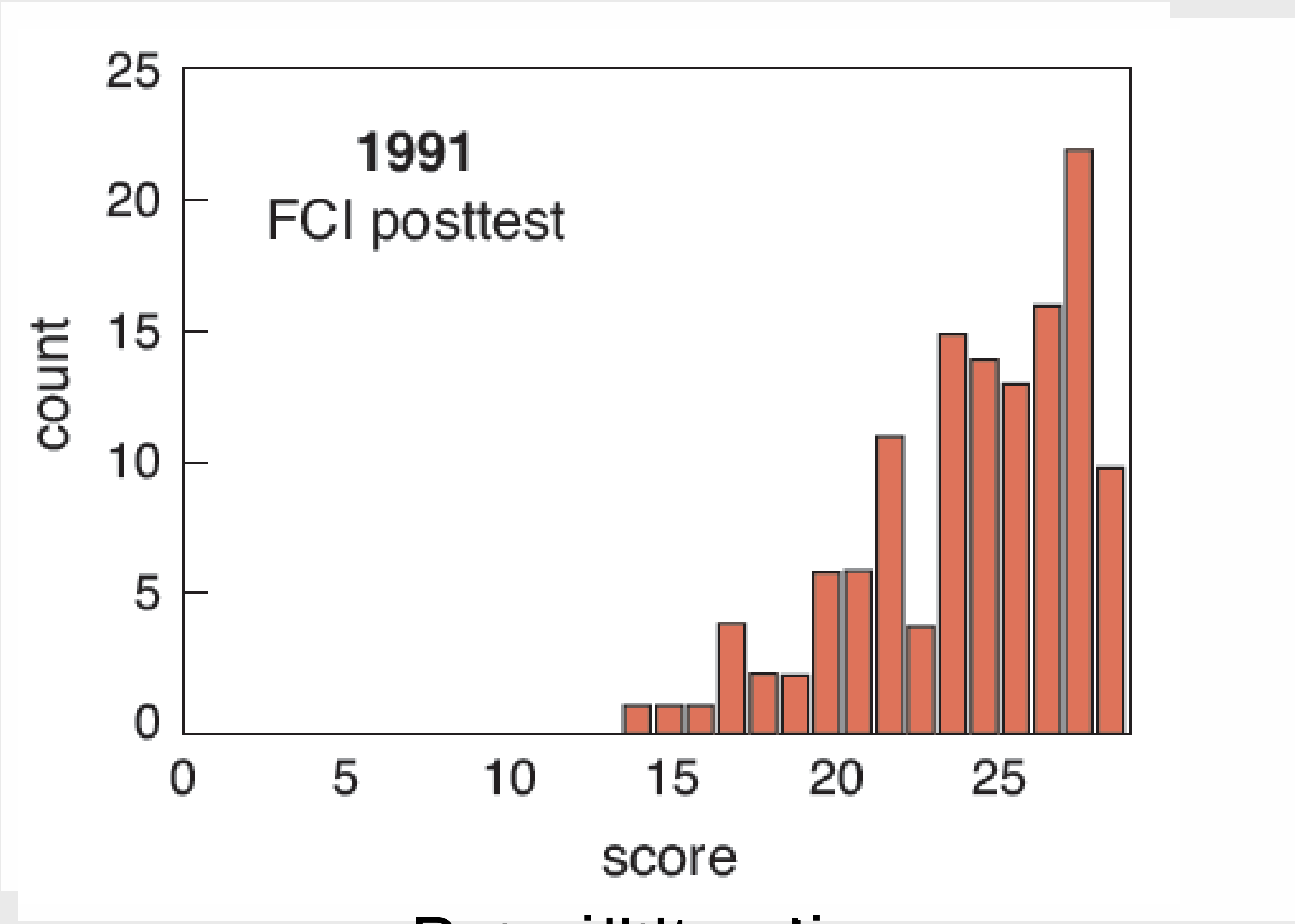
1) a
2) b
3) no difference
4) it depends on rotational inertia of dumbbell

Quantitative results

“..how to assess effectively whether students learned?”

And do we get any other benefits?

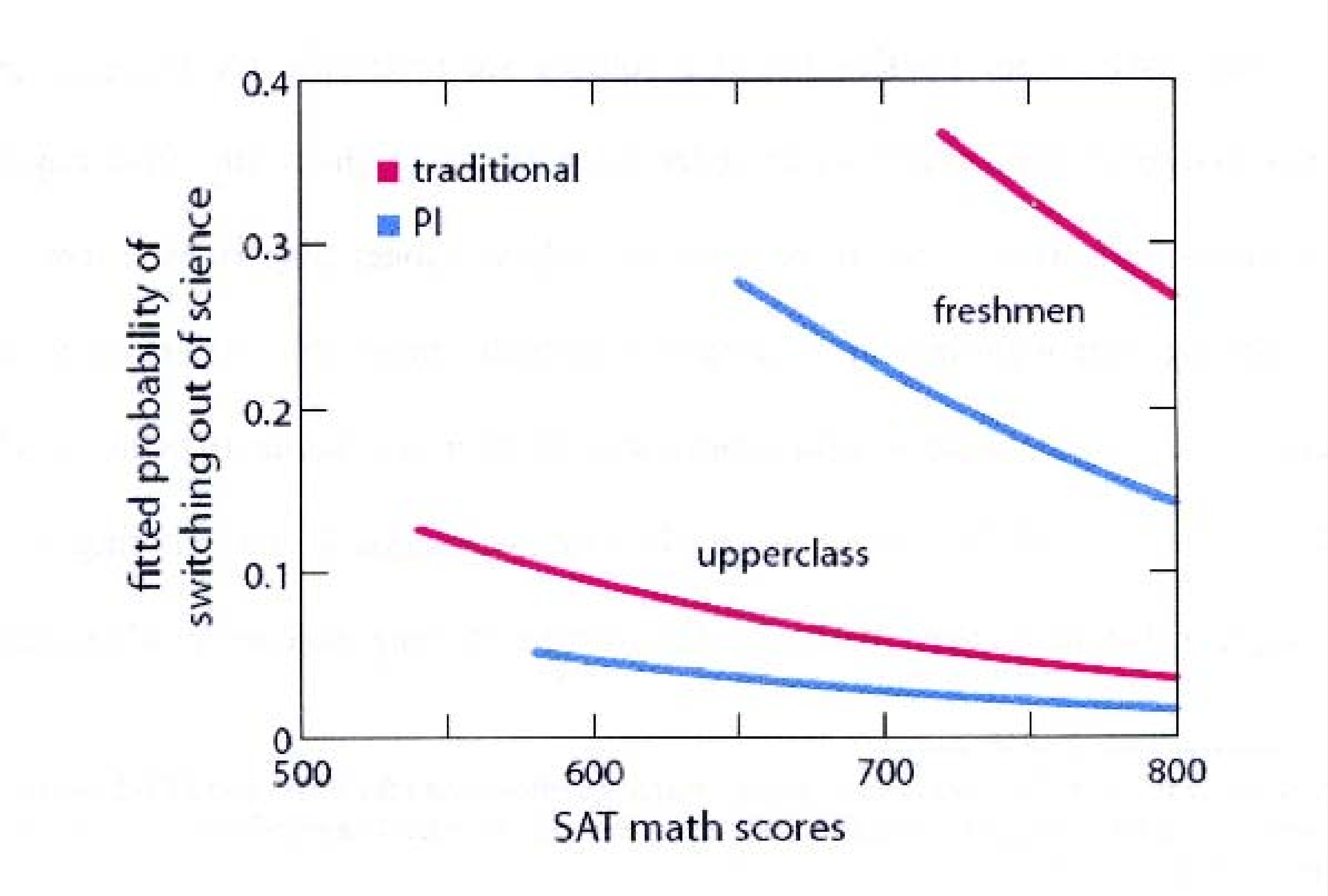
Quantitative results



Peer instruction

traditional

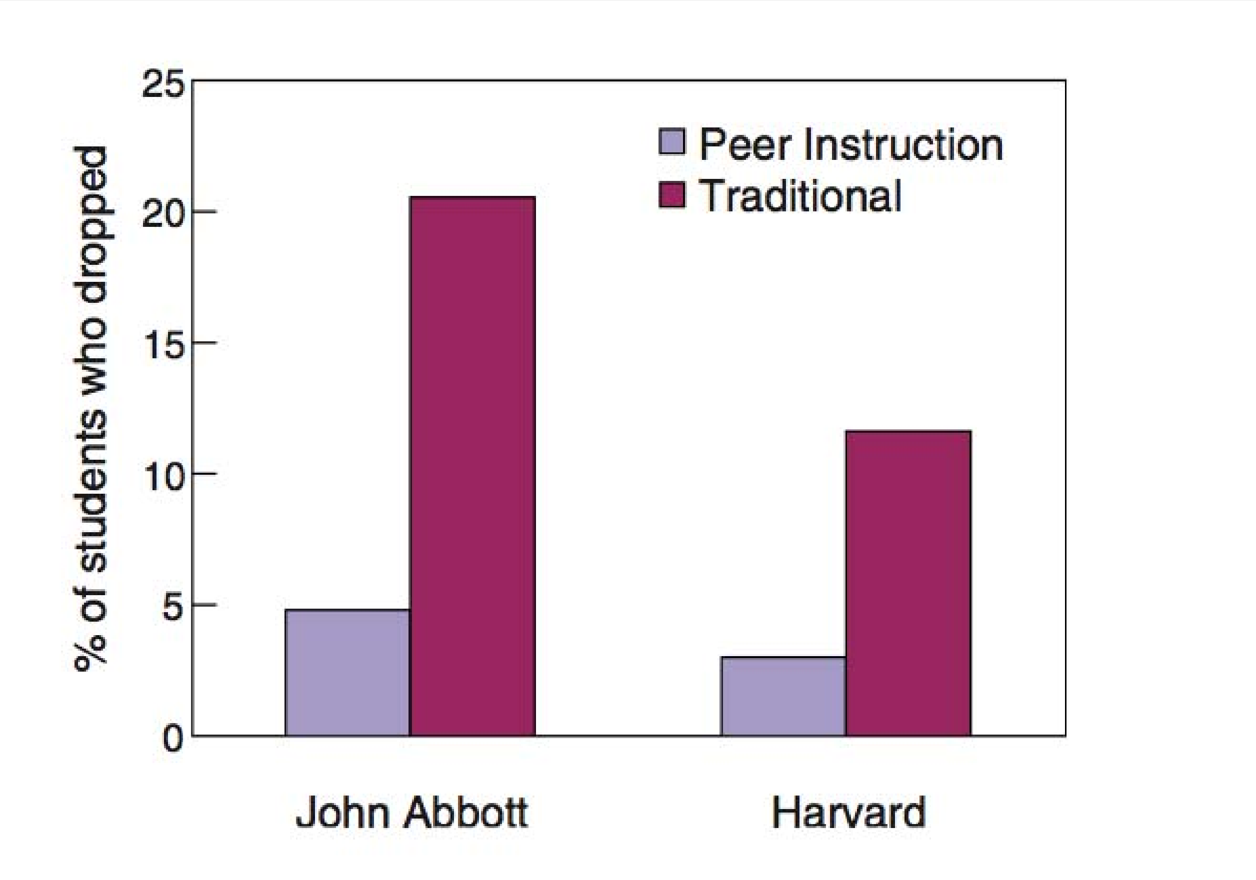
Quantitative results: PI and Retention



Watkins, 2010, Harvard University

Quantitative results: PI and Retention

".. how does peer instruction alter if the students you have are not Harvard students."



Lasry *et al.*, Am. J. Phys. **76,**11, November 2008

What do you think?

What is the biggest obstacle to effective PI?

1) student inertia
2) technology (cost and hassle)
3) loss of coverage
4) reduced problem solving skills
5) limited prep time

SKIP

What about problem solving?

"If interactive lectures do not discuss problem-solving with students, how do students learn how to solve them?"

"How is problem solving incorporated into the course to prepare students for future classes that involve more advanced problems?"

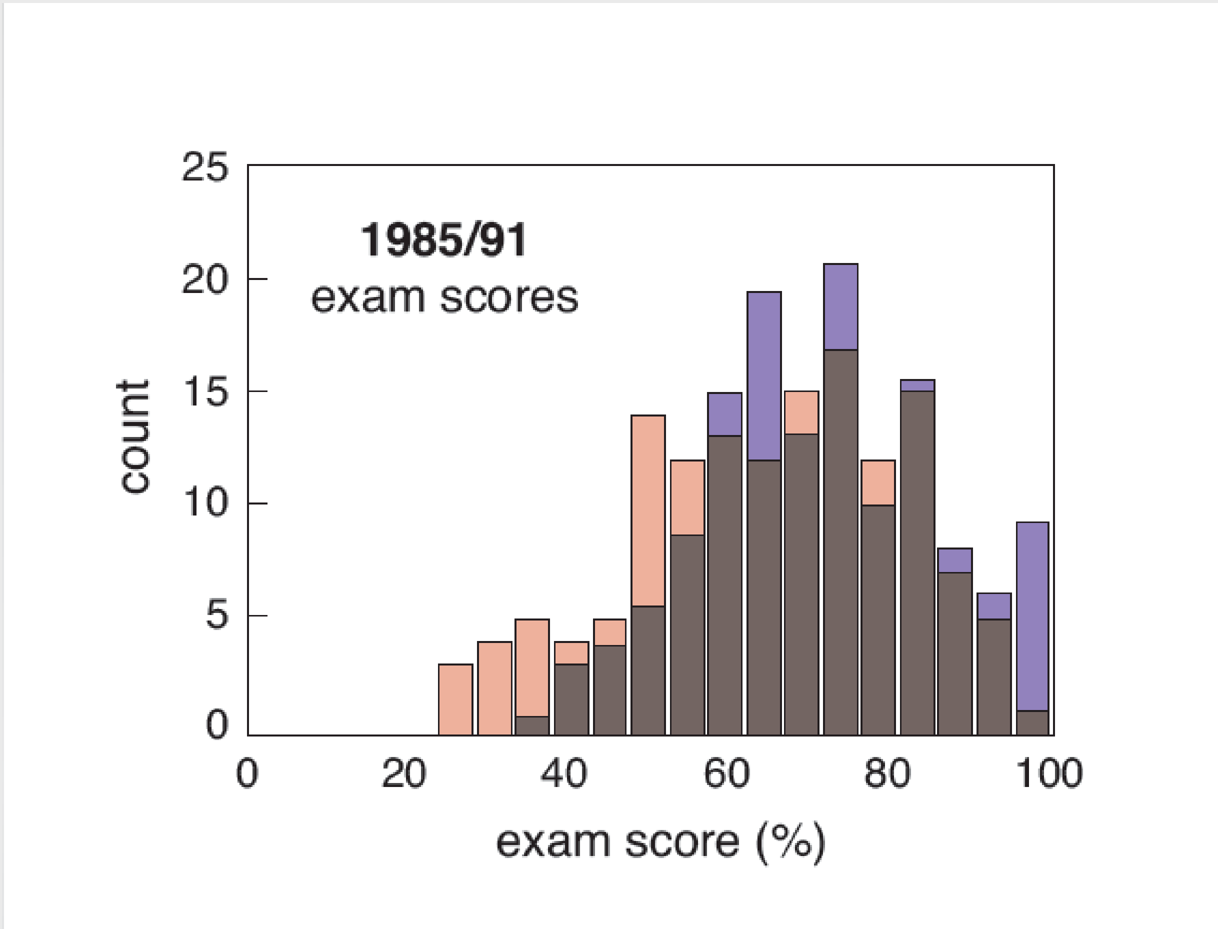
Am. J. Phys. **76,**11, November 2008

What about problem solving?

Help students learn problem solving by practicing problem solving! (NOT working through examples on the board)

BACK

What about problem solving?



BACK

Am. J. Phys. **76,**11, November 2008

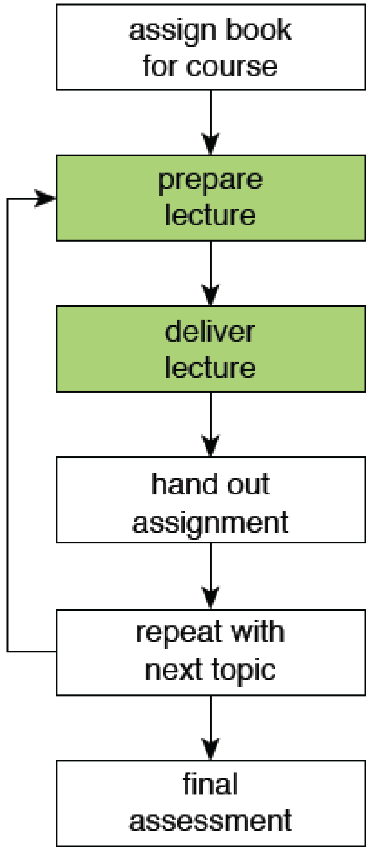
What about time?

“Relatively speaking, I think this will require more time.”

“In a large class, I feel like the time required to carefully read through all the free responses given on the JiTT quizzes, correctly identify weaknesses, and adjust what content will be emphasized in class the next morning, is extremely demanding.”

“Are there any specific tools available to create such a web based feedback system?”

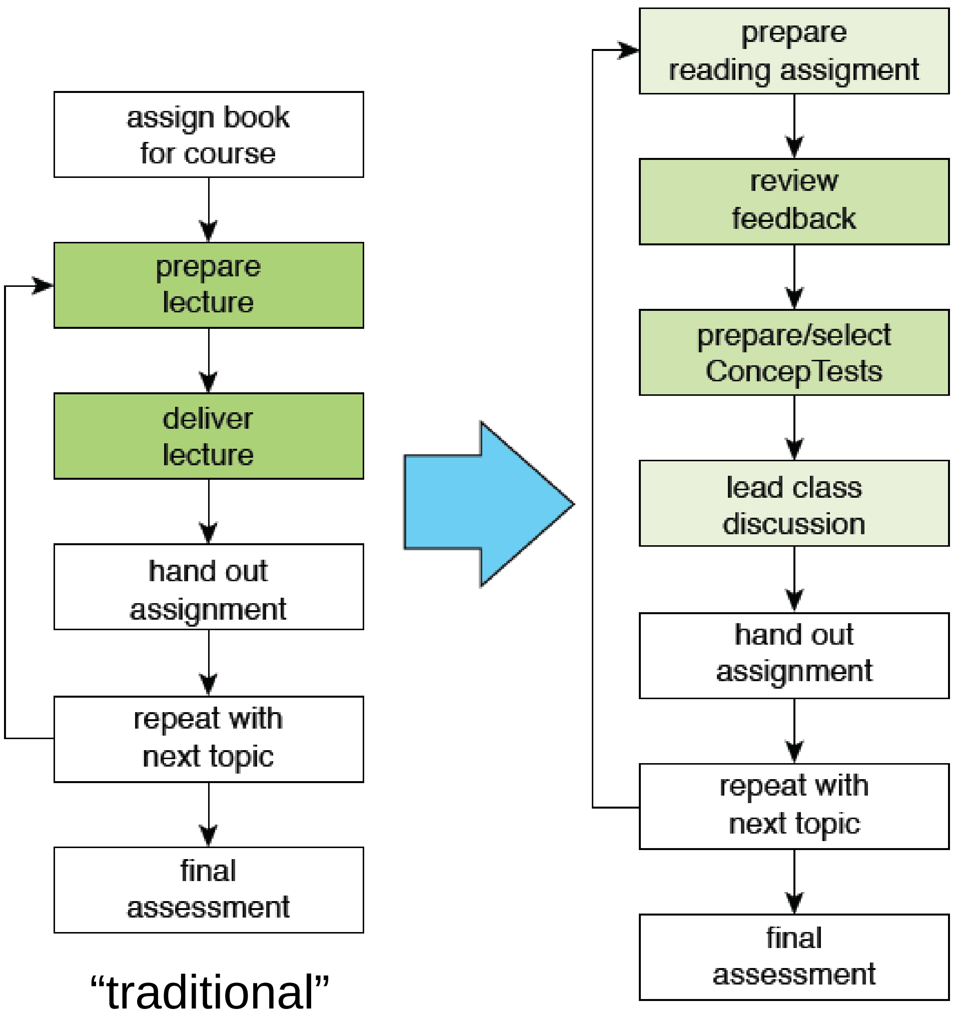
What about time?



“traditional”

BACK

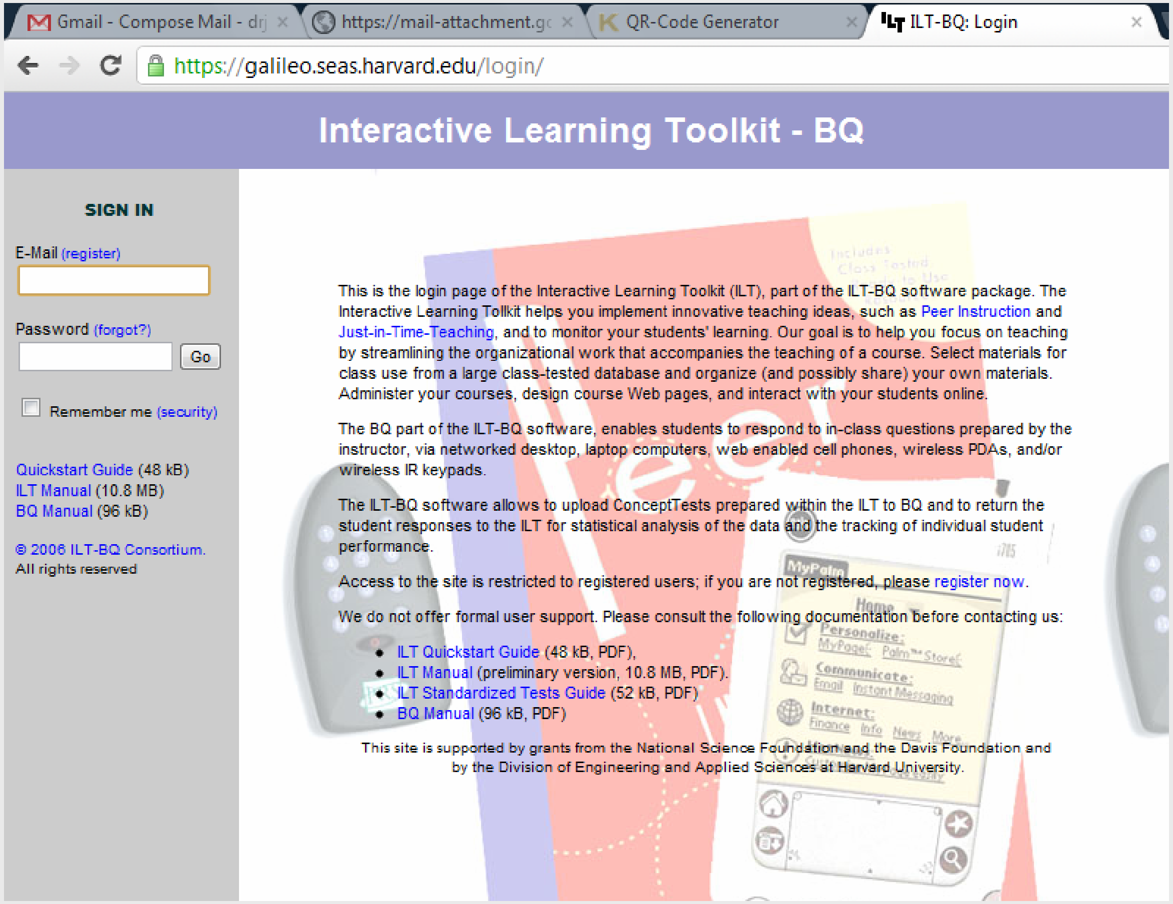
What about time?



“traditional”

BACK

Free access to ILT



https://galileo.seas.harvard.edu

BACK

What about student inertia?

Biggest obstacle: *“the pre-class reading assignments, although my hope would be that students would get used to doing this after trying it few times at the beginning of the course.”*

“Motivating students.”

“From the college where I am from, it is very likely that most of the students in my class will not do the pre-class reading, this will make the pedagogies not that effective for my students.”

“Student inertia. Students are used to the standard lecture model - it's what they're used to and it's comfortable.”

Overcoming student inertia

- Present quantitative results

- Take the time to get student buy-in.

"Write down something that you can do really well. Now write down how you learned how to do it."

- Match assessment to course goals!
  - first midterm early and mostly conceptual
  - even split between conceptual and problem solving

BACK

What about coverage?

"How do I organize a class/lecture so that there is as little material coverage loss as possible, compared to traditional lectures?"

"Is there a risk of losing coverage of material using the methods discussed by Professor Mazur?"

"Within a class that has a set of topics that the instructor is required to cover (prescribed and monitored by a dean, provost, etc), how can these techniques be implemented with minimal loss of coverage?"

The unpredictable nature of the individual lectures (and by extension the material that will be covered in the course) might be an obstacle. "

What about coverage?

IN-CLASS	"lectures"
coverage	complete
material learned	little

Material covered by reading assignments - goes beyond what is covered in class!

BACK

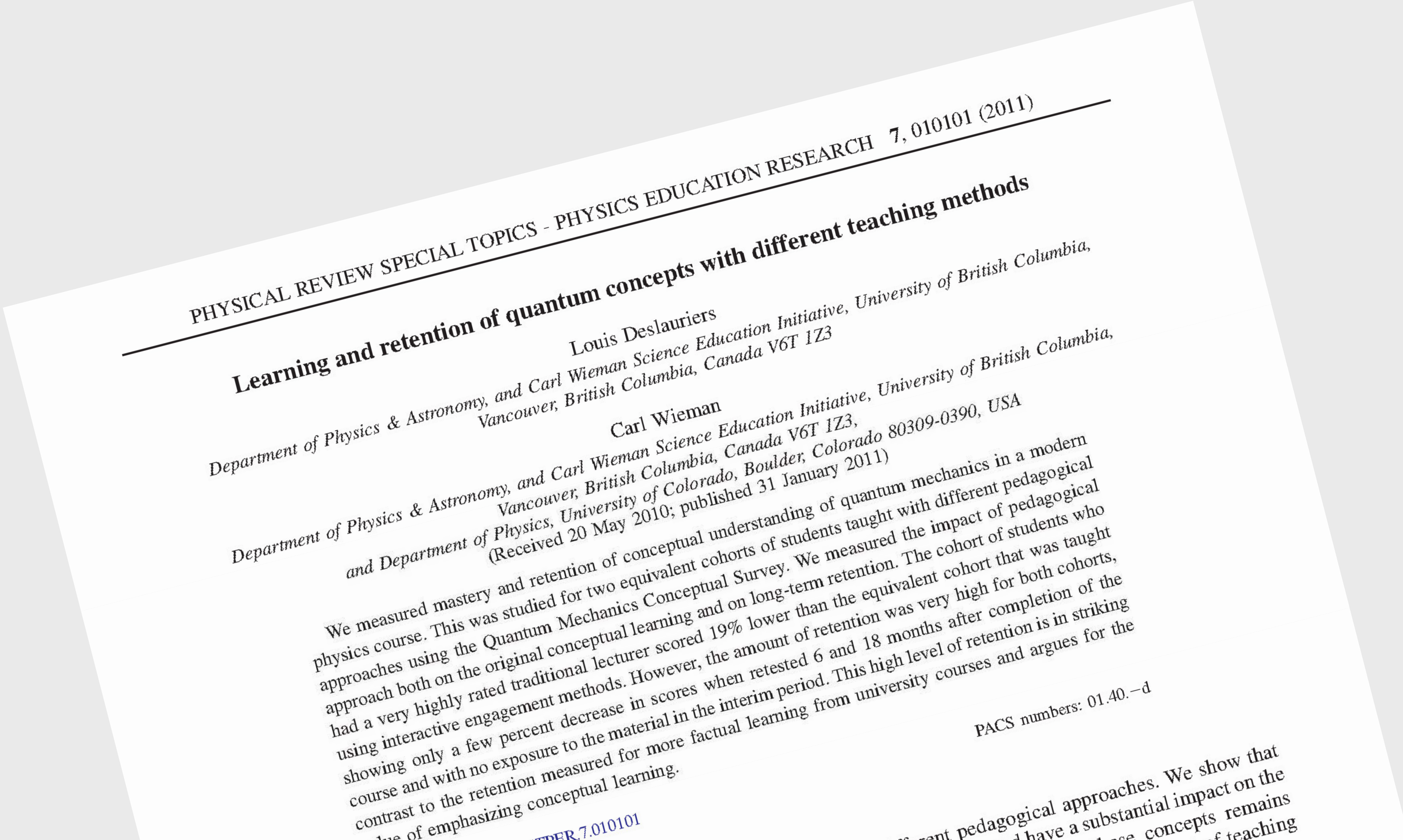
Beyond freshmen?

“I can see how these techniques can be applied to introductory courses, but what about upper-division classes?”

“You talk a lot about using your methods in the intro physics classroom. Do you have any pointers for upper level undergraduate physics classes?”

“Can “Peer instruction” be used for introductory course of Modern Physics, which contains of relativity and quantum physics?”

Upper-yr quantum mechanics:


PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH **7**, 010101 (2011)

Learning and retention of quantum concepts with different teaching methods

Louis Deslauriers

Department of Physics & Astronomy, and Carl Wieman Science Education Initiative, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z3

Carl Wieman

Department of Physics & Astronomy, and Carl Wieman Science Education Initiative, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z3,
and Department of Physics, University of Colorado, Boulder, Colorado 80309-0390, USA

(Received 20 May 2010; published 31 January 2011)

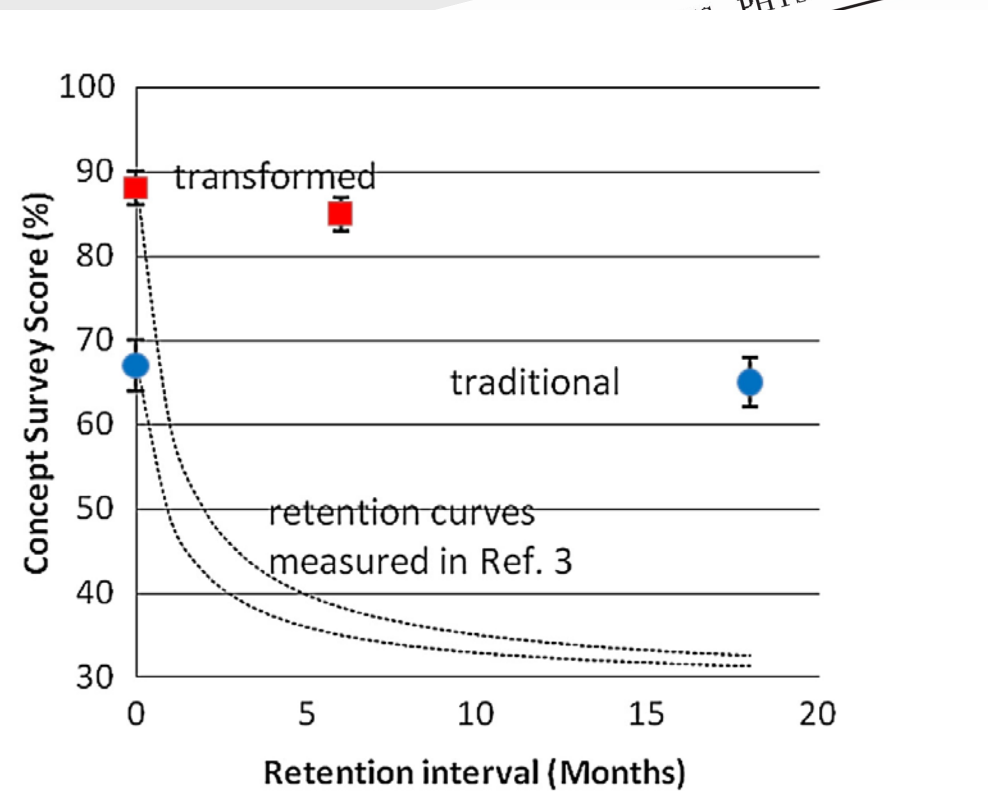
We measured mastery and retention of conceptual understanding of quantum mechanics in a modern physics course. This was studied for two equivalent cohorts of students taught with different pedagogical approaches using the Quantum Mechanics Conceptual Survey. We measured the impact of pedagogical approach both on the original conceptual learning and on long-term retention. The cohort of students who had a very highly rated traditional lecturer scored 19% lower than the equivalent cohort that was taught using interactive engagement methods. However, the amount of retention was very high for both cohorts, showing only a few percent decrease in scores when retested 6 and 18 months after completion of the course and with no exposure to the material in the interim period. This high level of retention is in striking contrast to the retention measured for more factual learning from university courses and argues for the value of emphasizing conceptual learning.

PACS numbers: 01.40.−d

Deslauriers and Wieman, PRST-PER **7**, 010101 (2011)

Upper-yr quantum mechanics:

"There were preclass reading assignments with quizzes on the reading, and class time was highly interactive and largely taken up with clicker questions with peer discussion and small group activities such as completing worksheets or concept maps, with follow up ''minilectures….''



"…these ideas about effective instruction apply both to advanced material for which students have had not previous exposure and to very high level students who are pursuing degrees in physics."

Deslauriers and Wieman, PRST-PER **7**, 010101 (2011)

What about creating ConcepTests?

Biggest obstacle: “Choosing appropriate questions! I've been doing this for while in astronomy and have figured out which concepts need to be tested and how to phrase questions, but I have not done this in physics yet.”

I would imagine that coming up with the right set of questions that really illuminates the (mis)understanding of students would be very difficult. It's great to see that there are sets of questions and databases one can access to help in this process.

Julie!

Summary

Active engagement through PI greatly improves learning gains.

Suggested dinner topic: what might help you implement PI at your institution?

Research funding

Pew Charitable Trust, Pearson/Prentice Hall, Davis Foundation, Engineering Information Foundation, Derek Bok Center for Teaching and Learning, National Science Foundation

Follow Eric: eric_mazur