

Understanding Educational Reforms: Impacts of Physics Education Research

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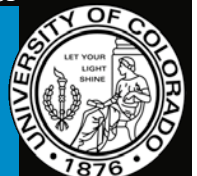
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Outline / Framing

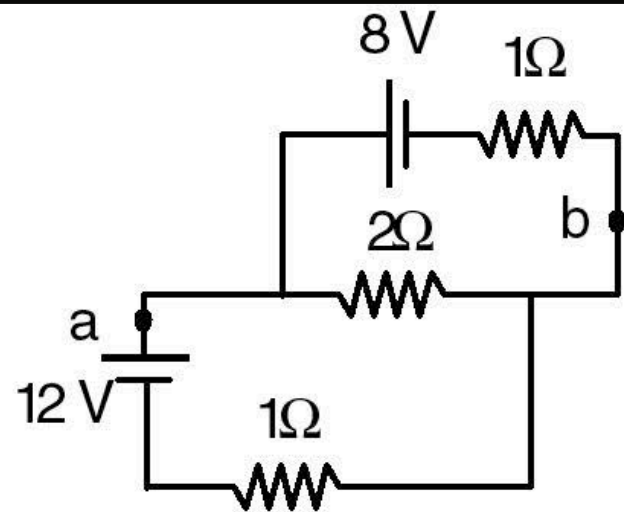
- Brief overview of why, what, and how of PER
 - Building on a base
 - Theoretical models & educational practices
- Impacts
 - Introductory physics (results, replicability)
 - Longitudinal study
 - K12 teacher recruitment and prep
 - Upper division and gender issues (if time!)

How are we doing: Harvard

From Mazur 1997

How are we doing: Harvard

Find the current through the 2 Ohm resistor and the potential difference between points a and b

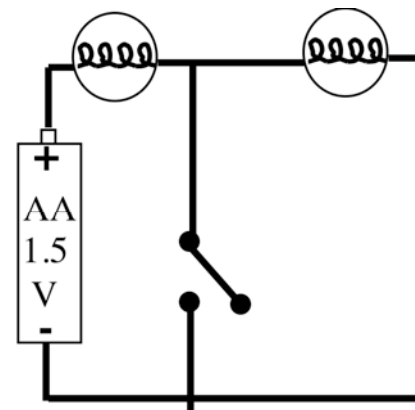


~75%

In the circuit shown, explain what happens when the switch is closed...

- a) To the current through the battery
- b) To the brightness of the bulbs

...



~40%

From Mazur 1997

Overview of PER

- Investigating education scientifically
 - Far more to our classes than what is traditionally evaluated
 - Physics education research has something to say about this
 - Models of student learning
 - Tools for measurements
 - evidence of impact
 - curricula / approaches
-
- The diagram consists of three yellow arrows pointing left towards the list items. The top arrow points to 'Models of student learning' and is labeled 'Theory'. The middle and bottom arrows both point to 'Tools for measurements' and are collectively labeled 'Experiment'. The bottom arrow also points to 'evidence of impact' and is labeled 'Application'.

PER: the field

Rapidly growing

- **Journals (Physical Review, AJP, ...)**
- **APS, PERC**
- **NSF funding**
- **>50 institutions with PER groups or faculty**

Building on a base: Studying Science Education Scientifically

Classroom practice

Curricular reforms

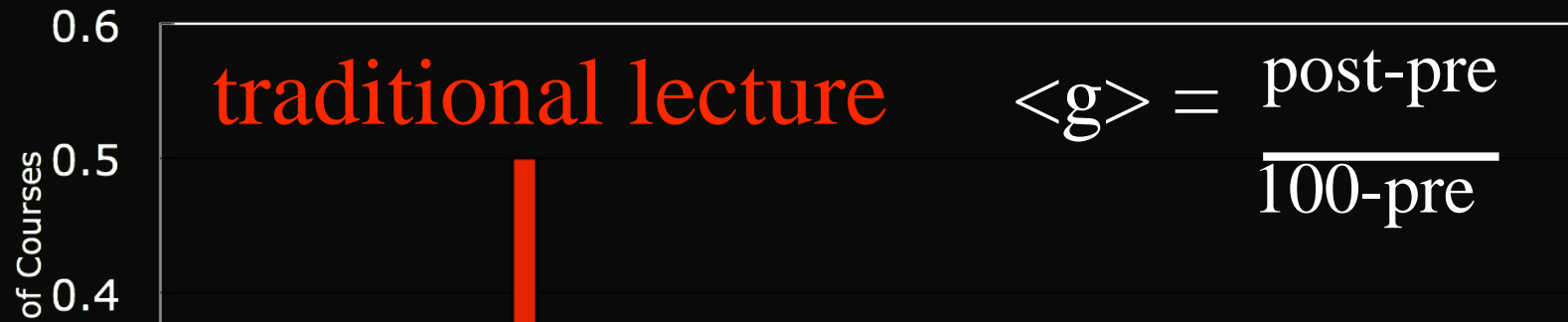
Data



Student concepts and engagement

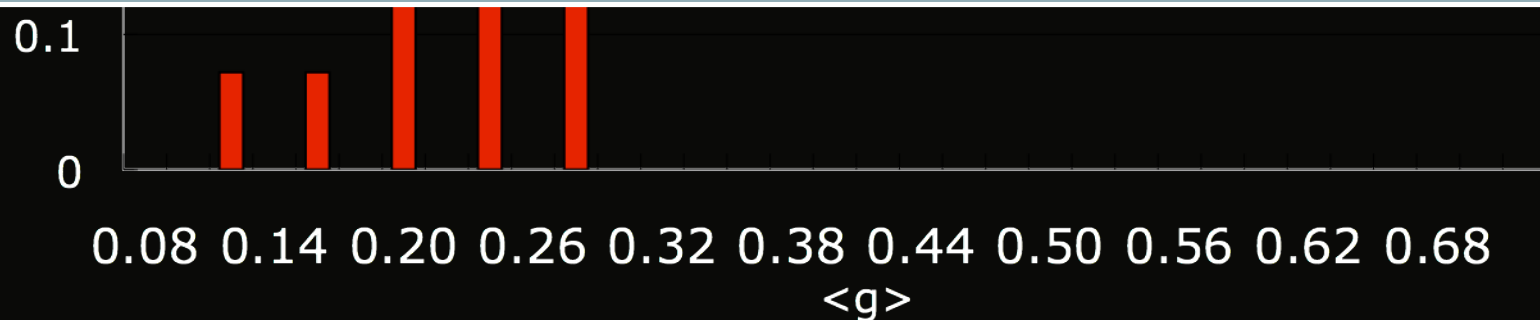
Theoretical frames

Force Concept Inventory



Take home message:

*Students learn less than 25% of the most basic concepts
(that they don't already know).*



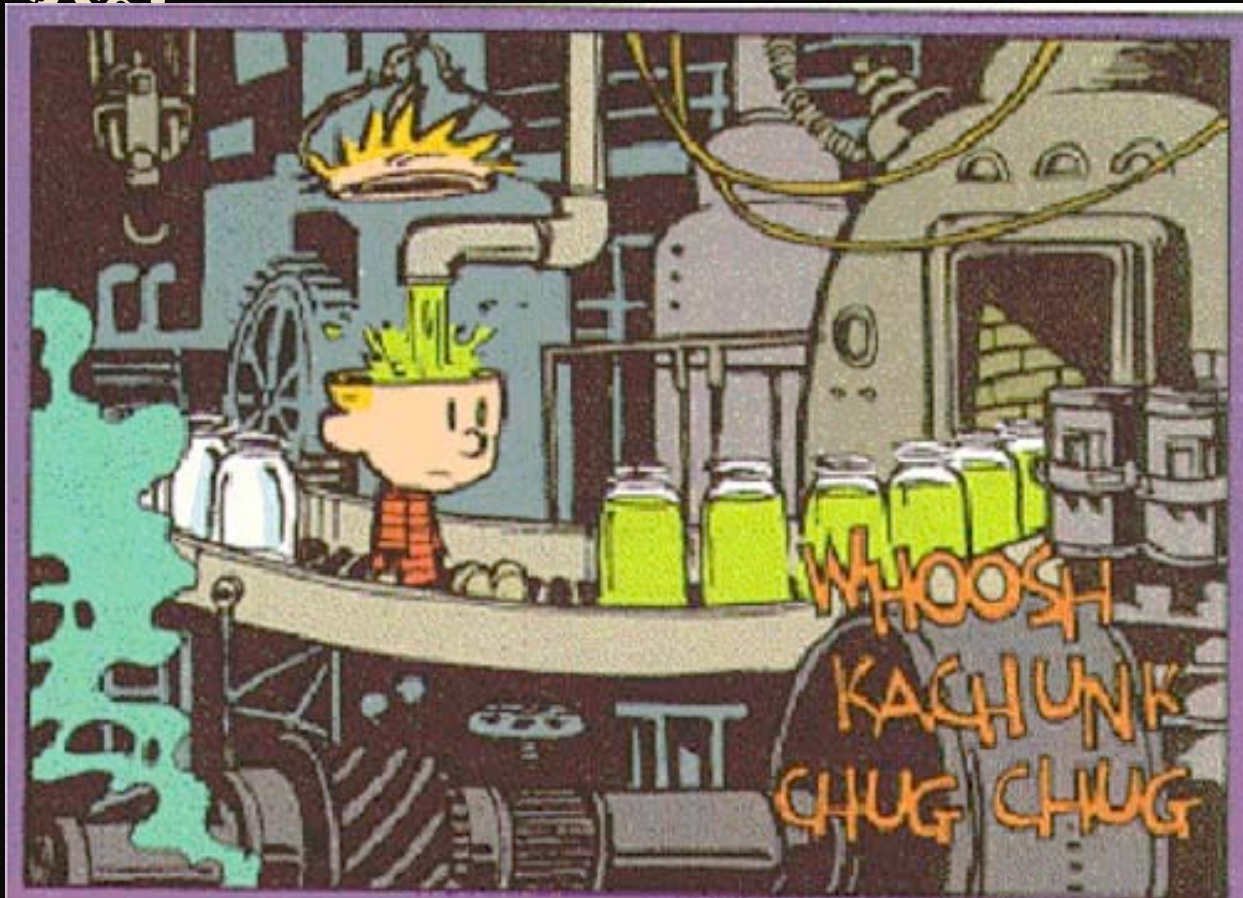
Hestenes, Wells, Swackhamer, Phys Teacher 30 (1992) p. 141

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

why does this happen?

Trad'l Model of Education

Individual ← **Instruction via transmission** Content (e.g. circuits)



Built in to our classes?

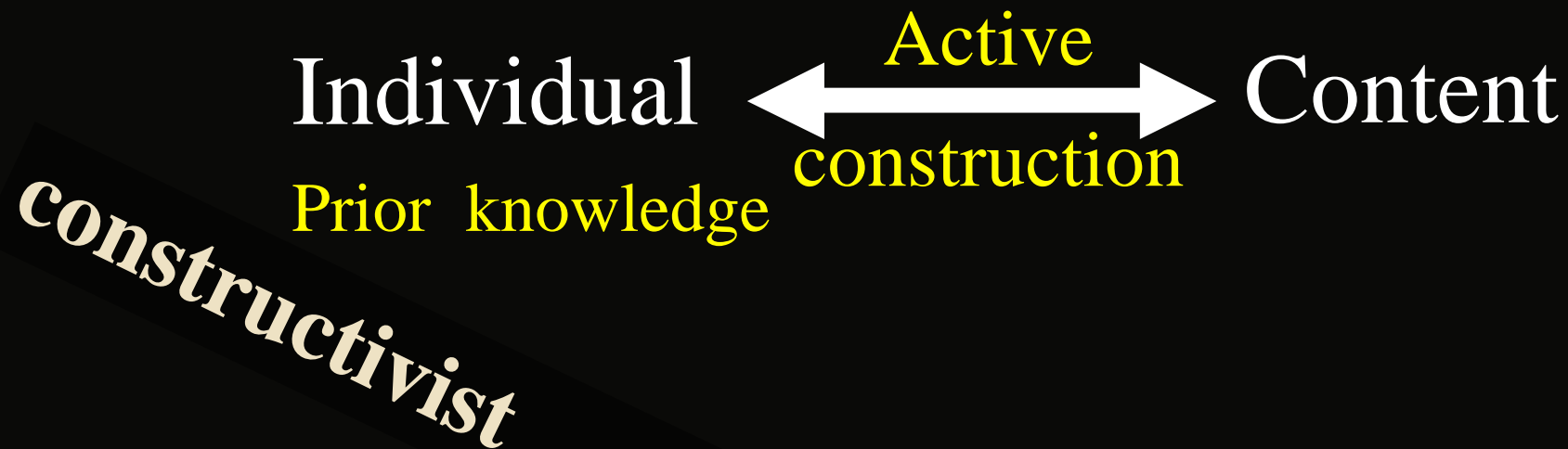
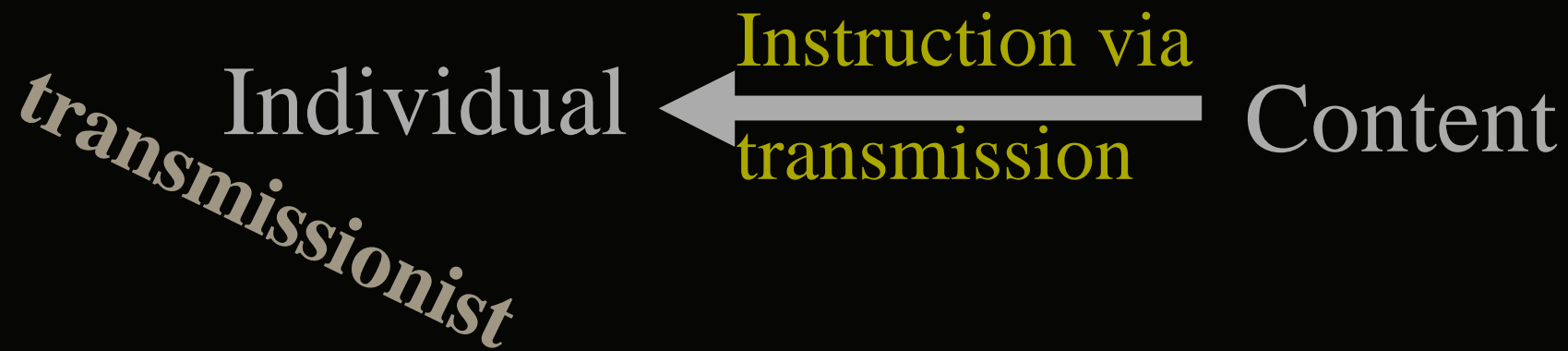
2000 years ago



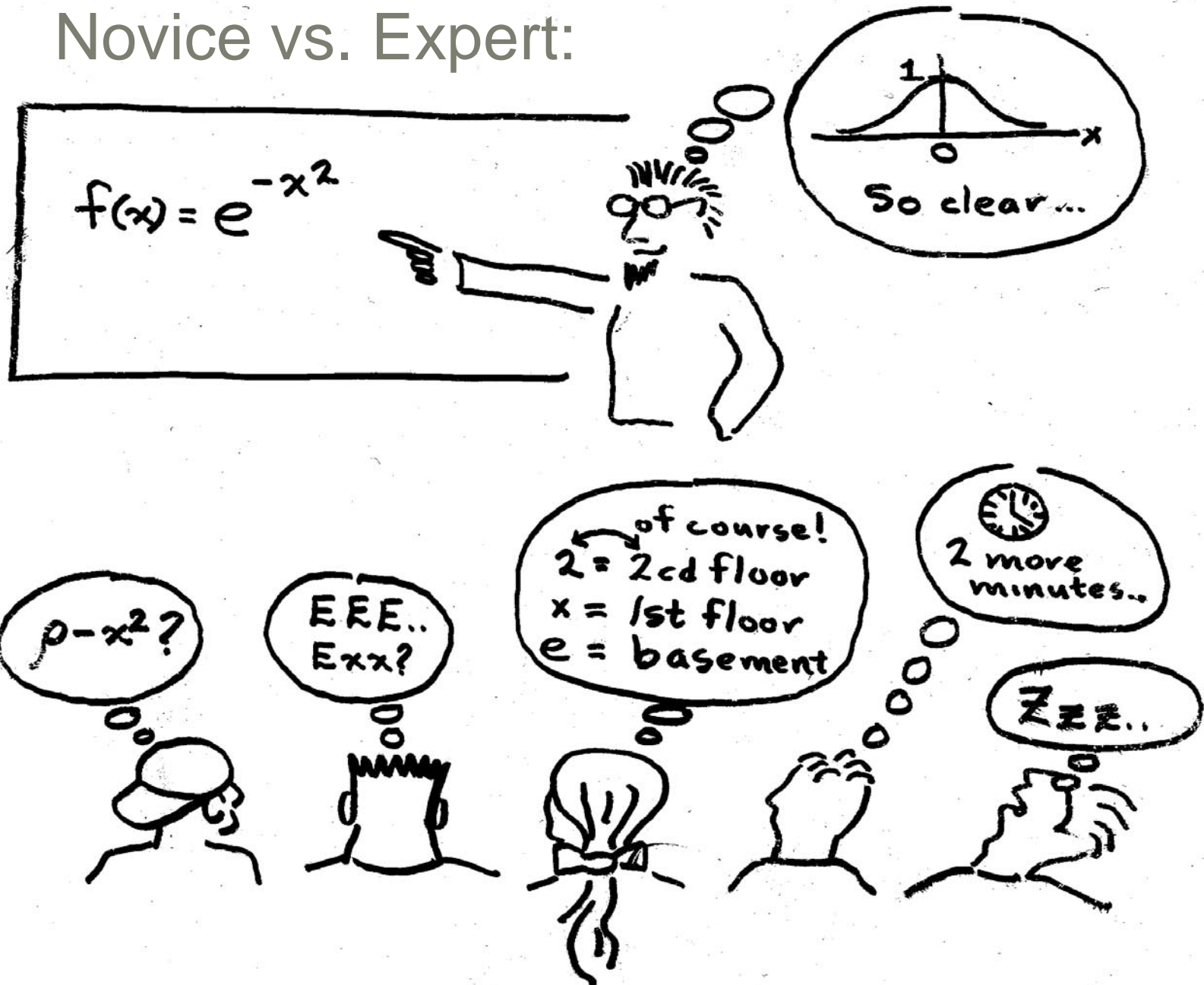
Today



PER Theoretic Background



Novice vs. Expert:

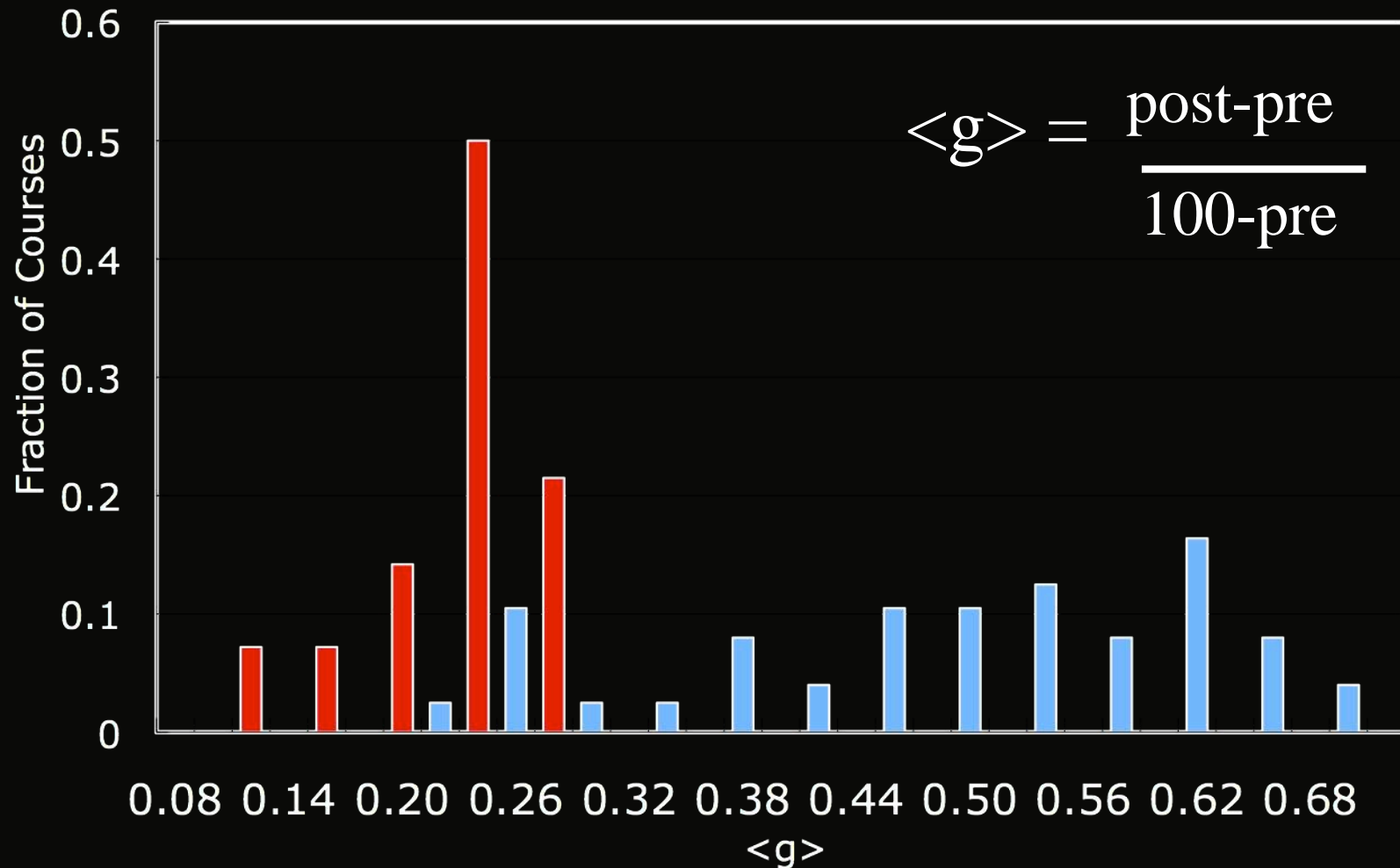


*actively engaging students
is important*

Back to the FCI

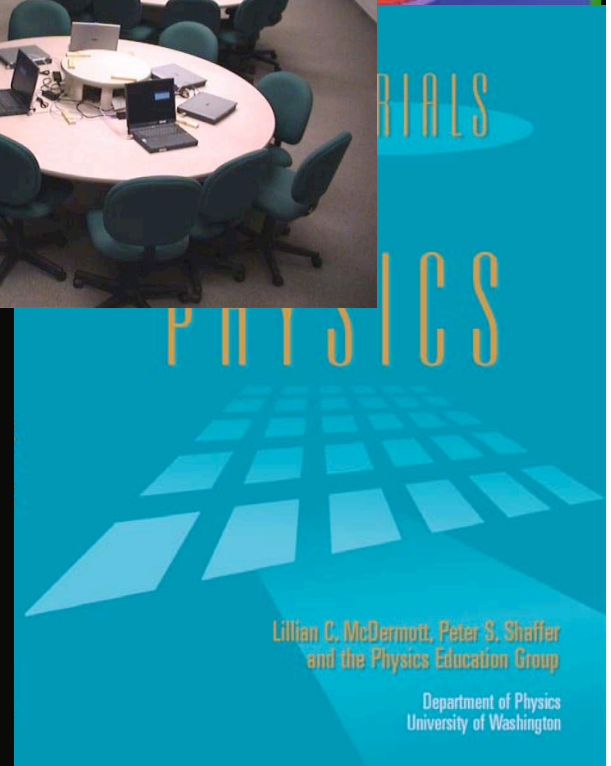
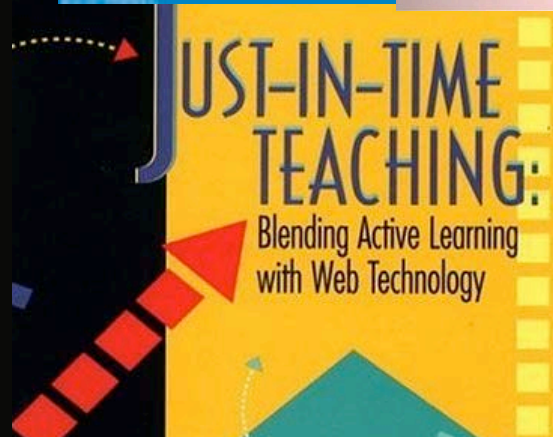
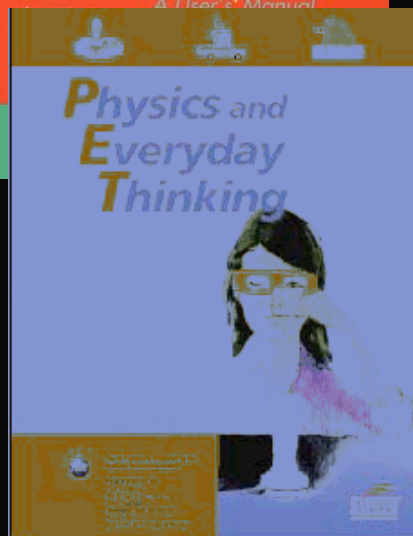
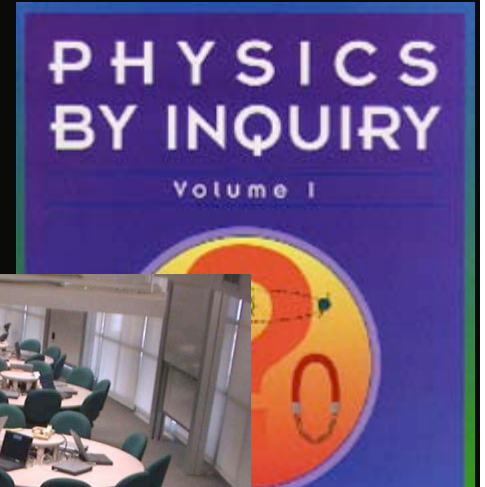
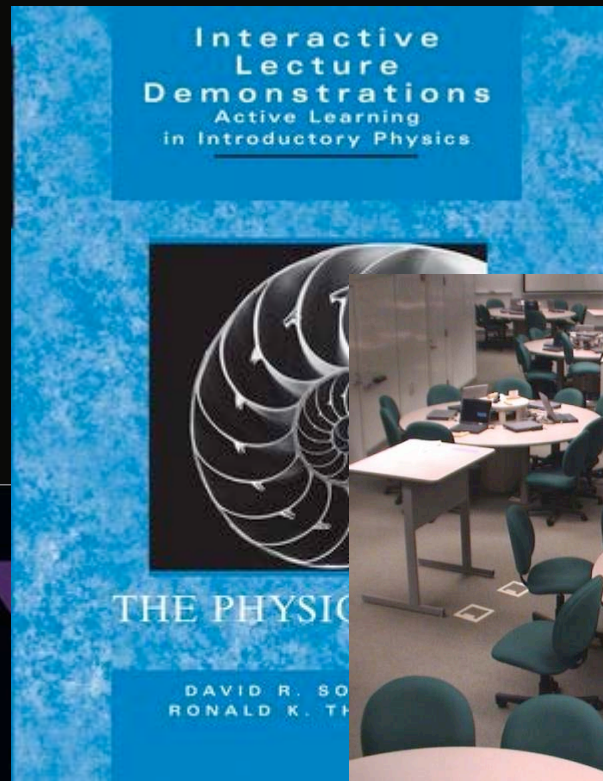
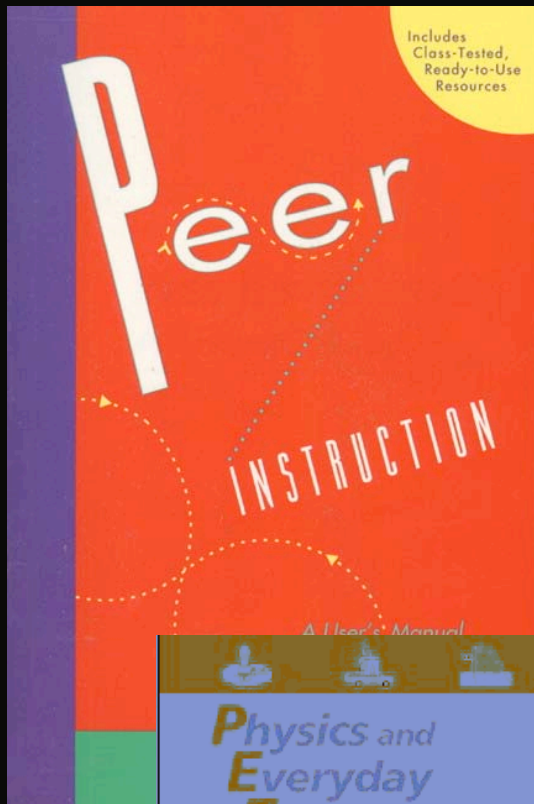
traditional lecture

interactive engagement



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

Many PER curricular innovations



U. Washington Tutorials

50 min/wk, 30 students, 1 grad TA
+ undergrad Learning Assistant
(Weekly prep + LA seminar)

Phys lecture
3-600 students
3 lectures/wk
(No lab)

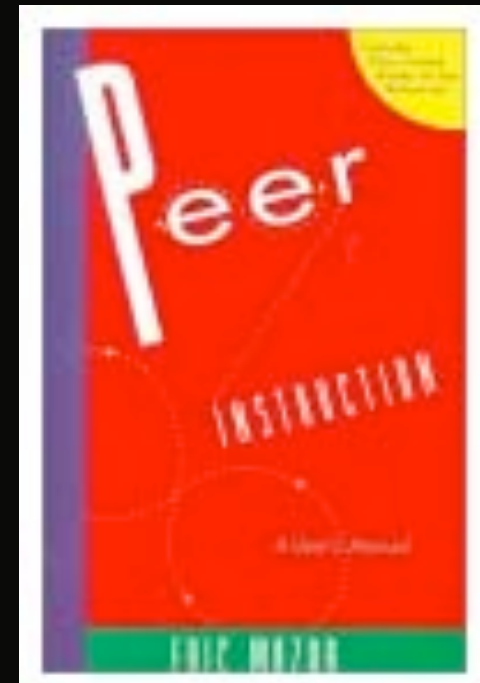
Online HW
System
CAPA or MP

Text
trad or PER
based

Interactive Lectures
Peer Instruction,
pers. resp. system

Pedagogy of clickers

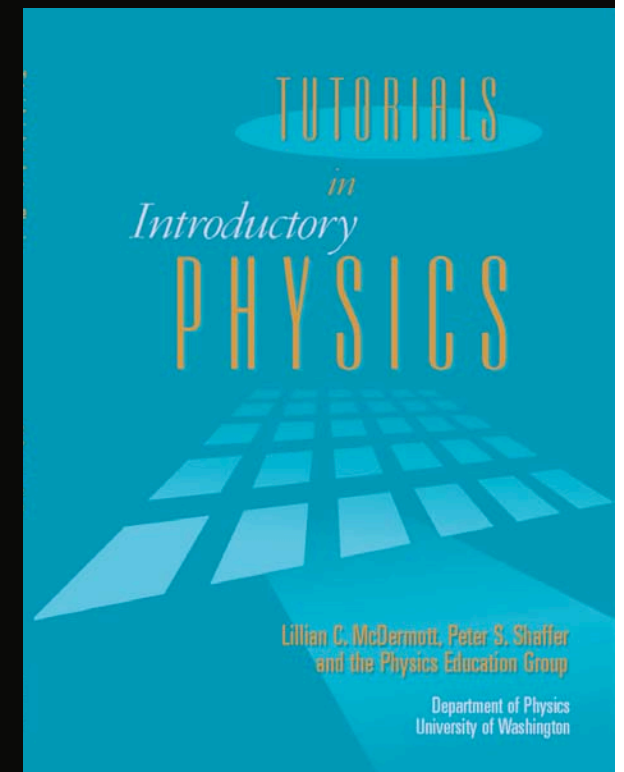
- Peer instruction
- Feedback
 - To students
 - To faculty
- Reasoning
 - Thinking about thinking
- Elicit/confront/resolve



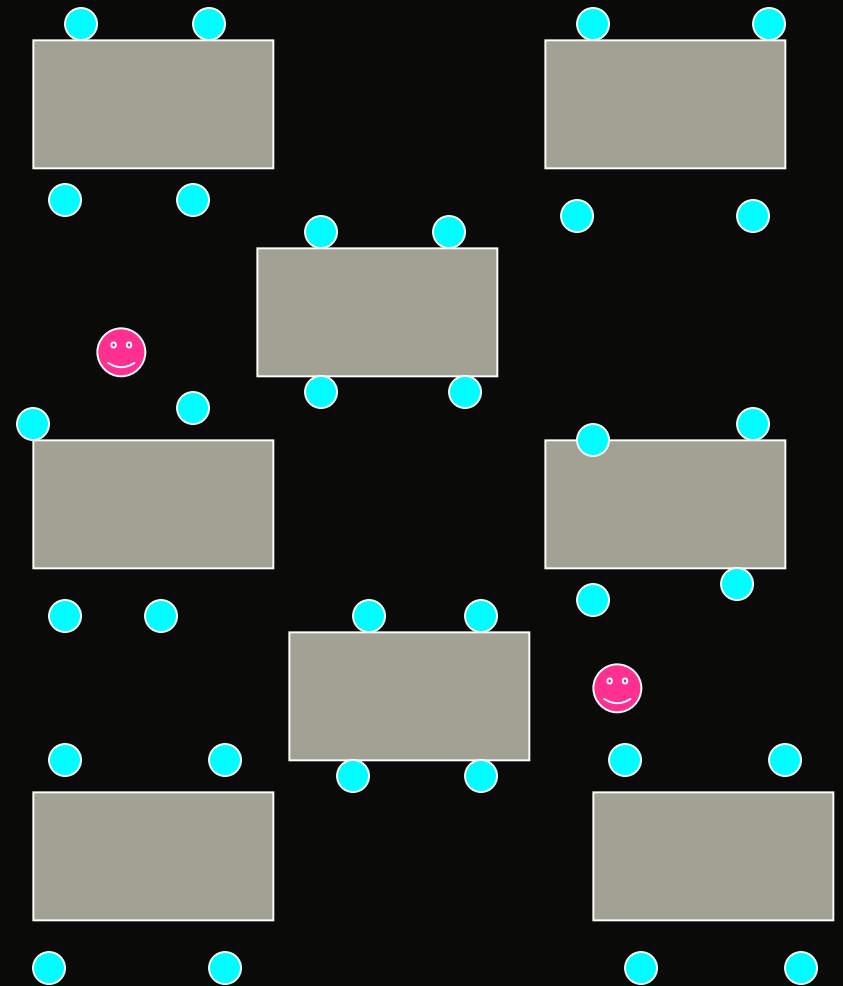
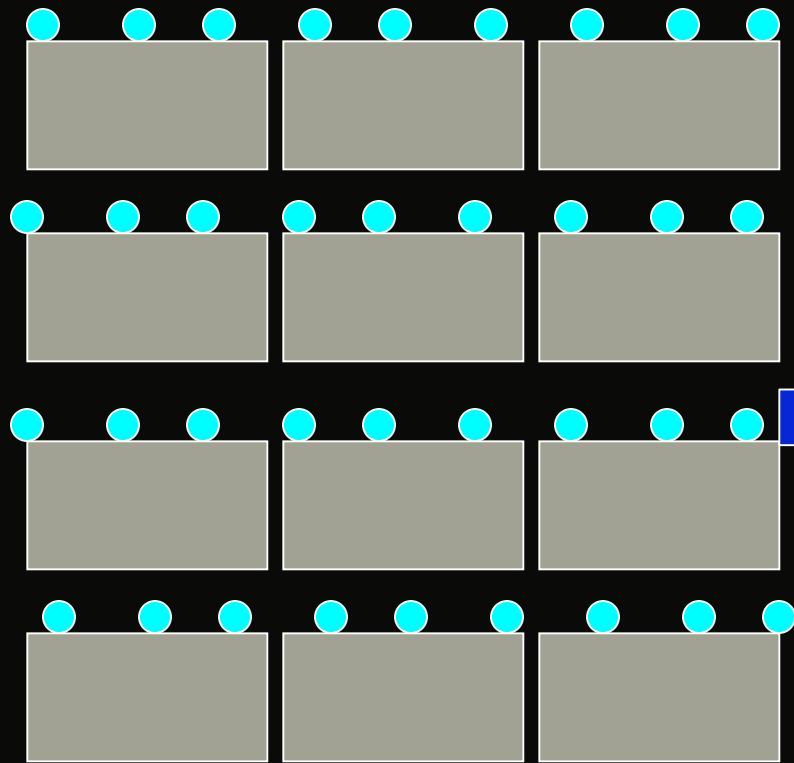
Tutorials in Introductory Physics

Reconceptualize Recitation Sections

- Materials
- Classroom format / interaction
- Instructional Role
- Use of Learning Assistants



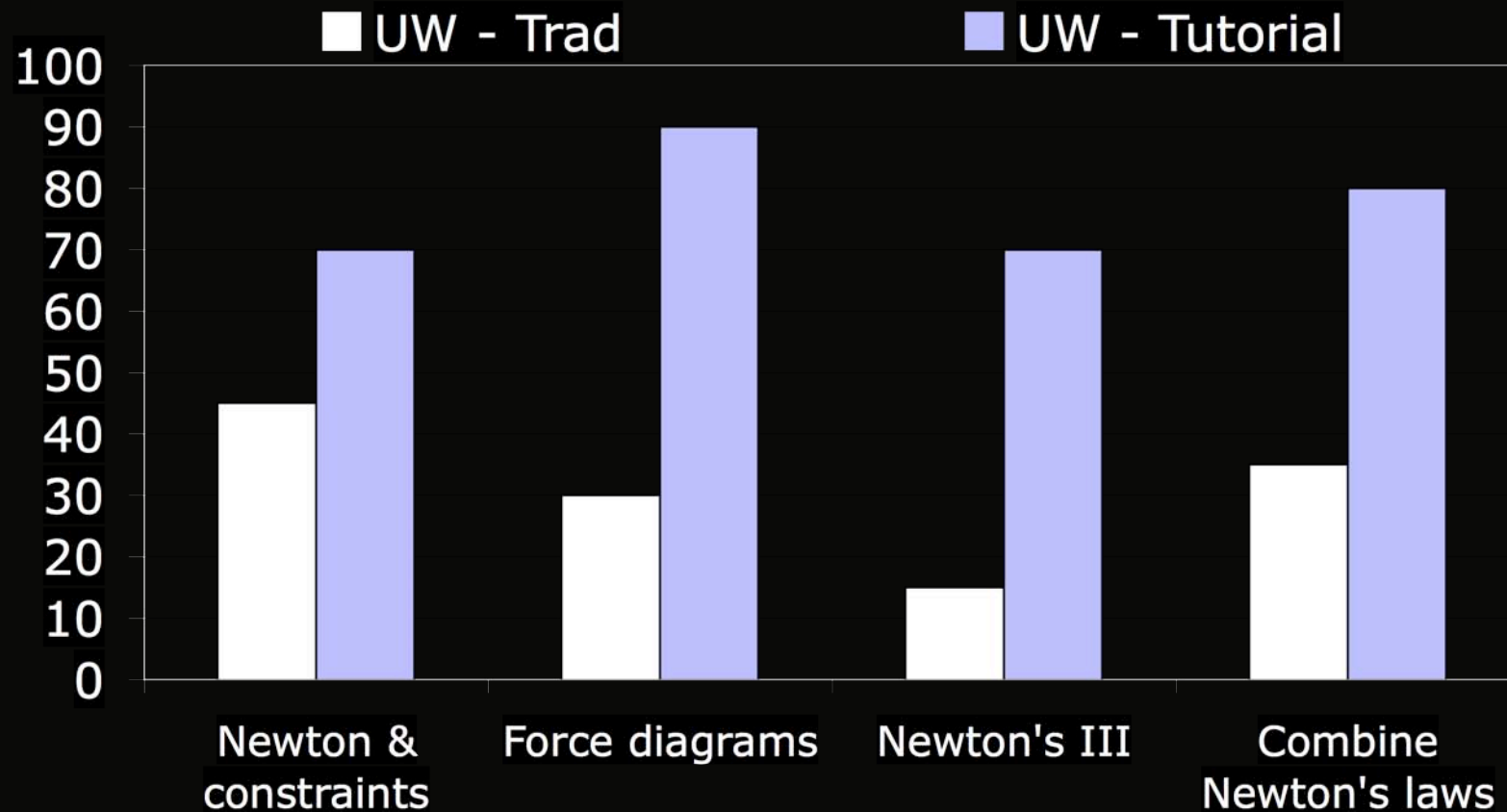
Tutorial vs. Trad'l Recitation



Tutorial

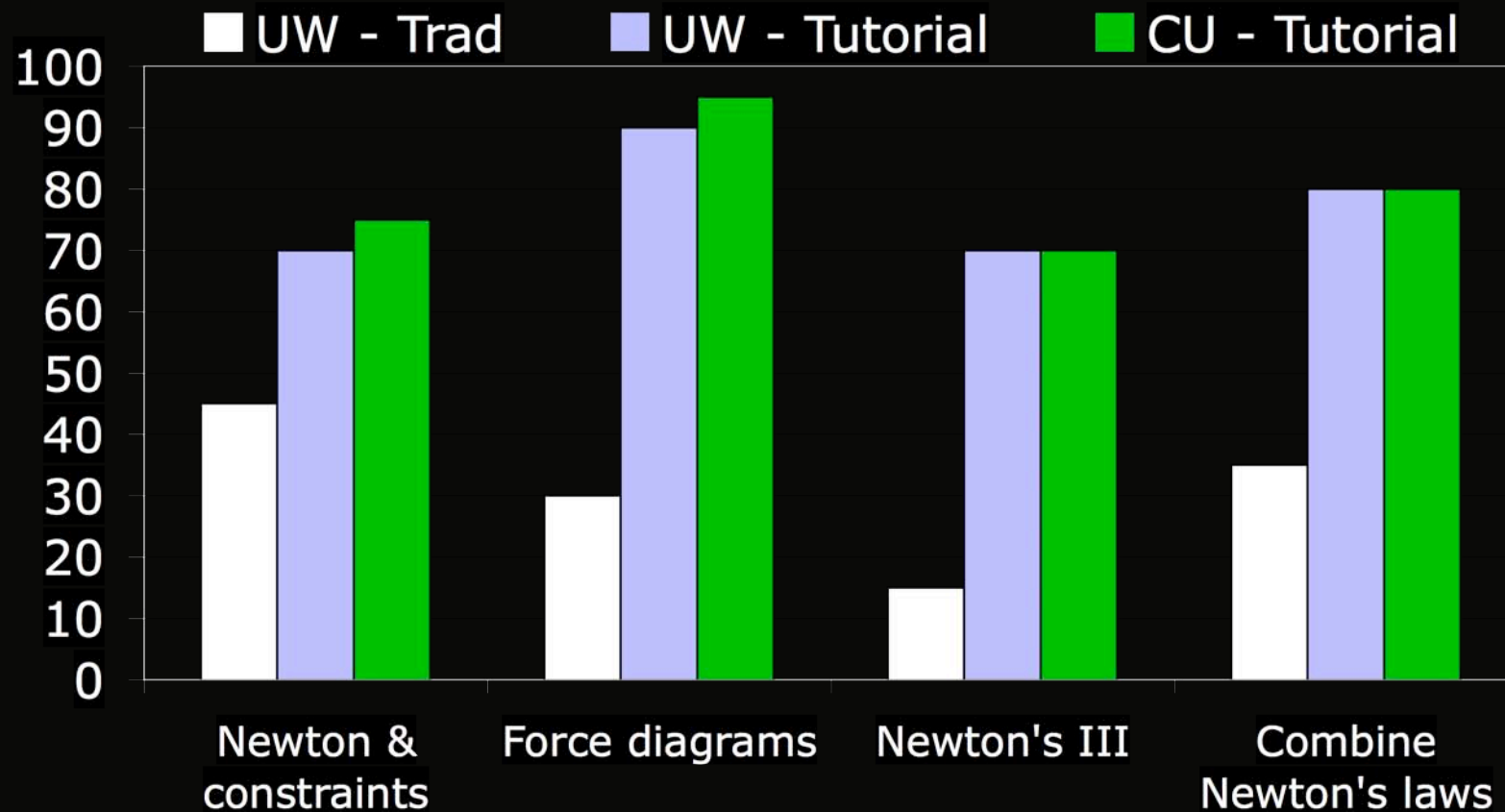


Tutorial Success (at UW)



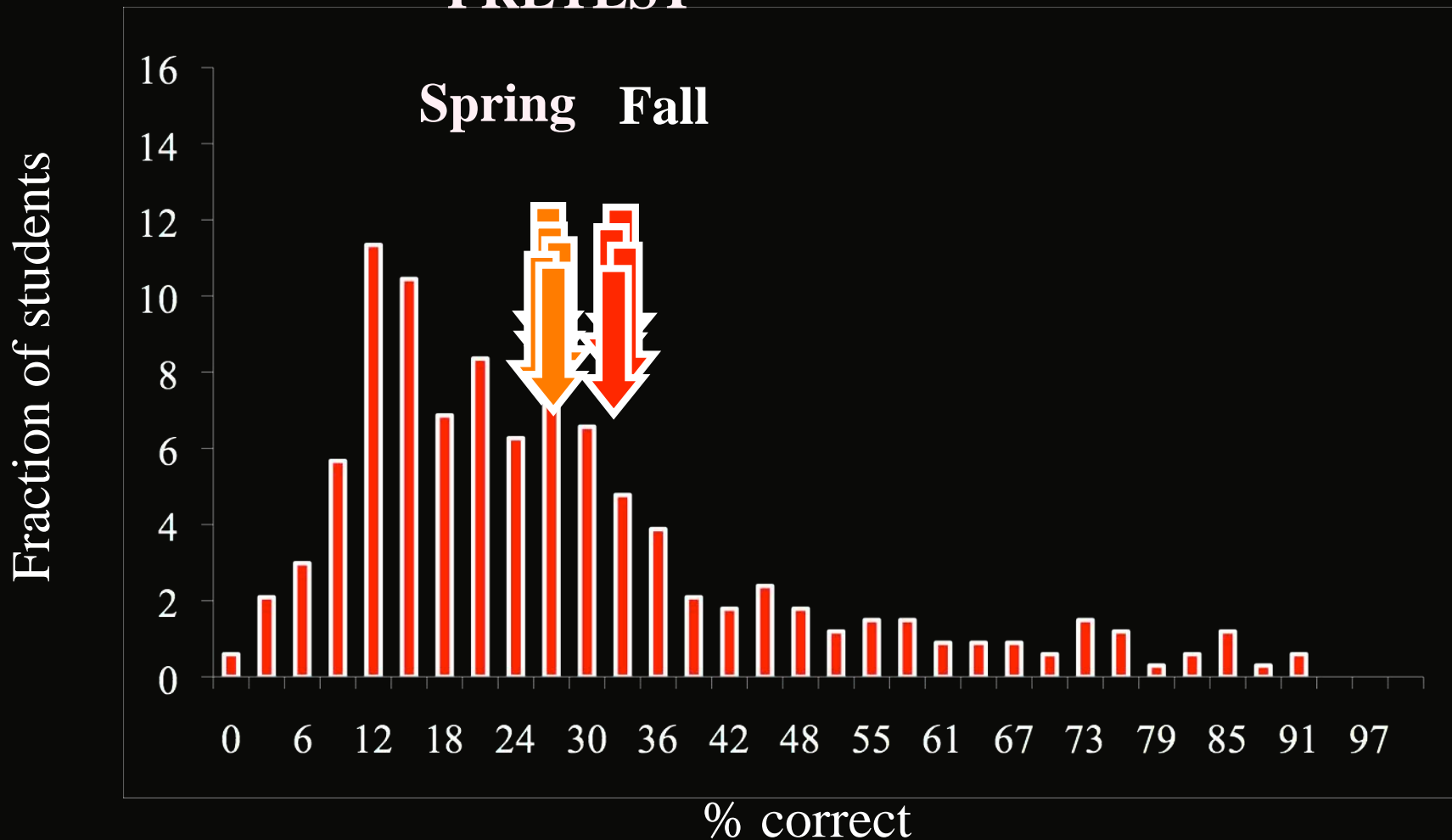
D.E. Trowbridge and L. C. McDermott, (1981). *Am. J. Phys.* **49** (3), 242.

Replication (at CU)

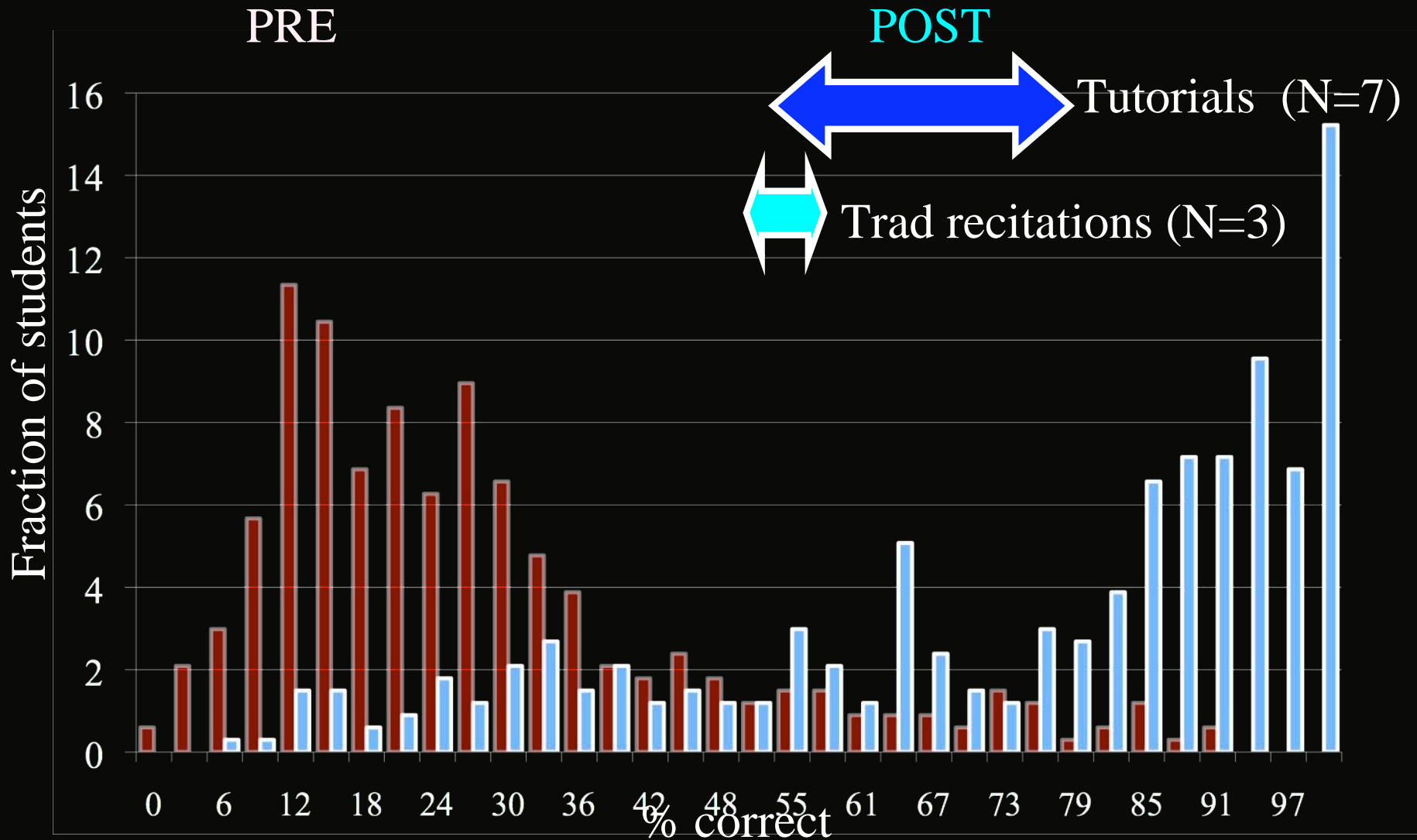


CU: Pre- Post FMCE scores

PRETEST



CU: Pre- Post FMCE scores

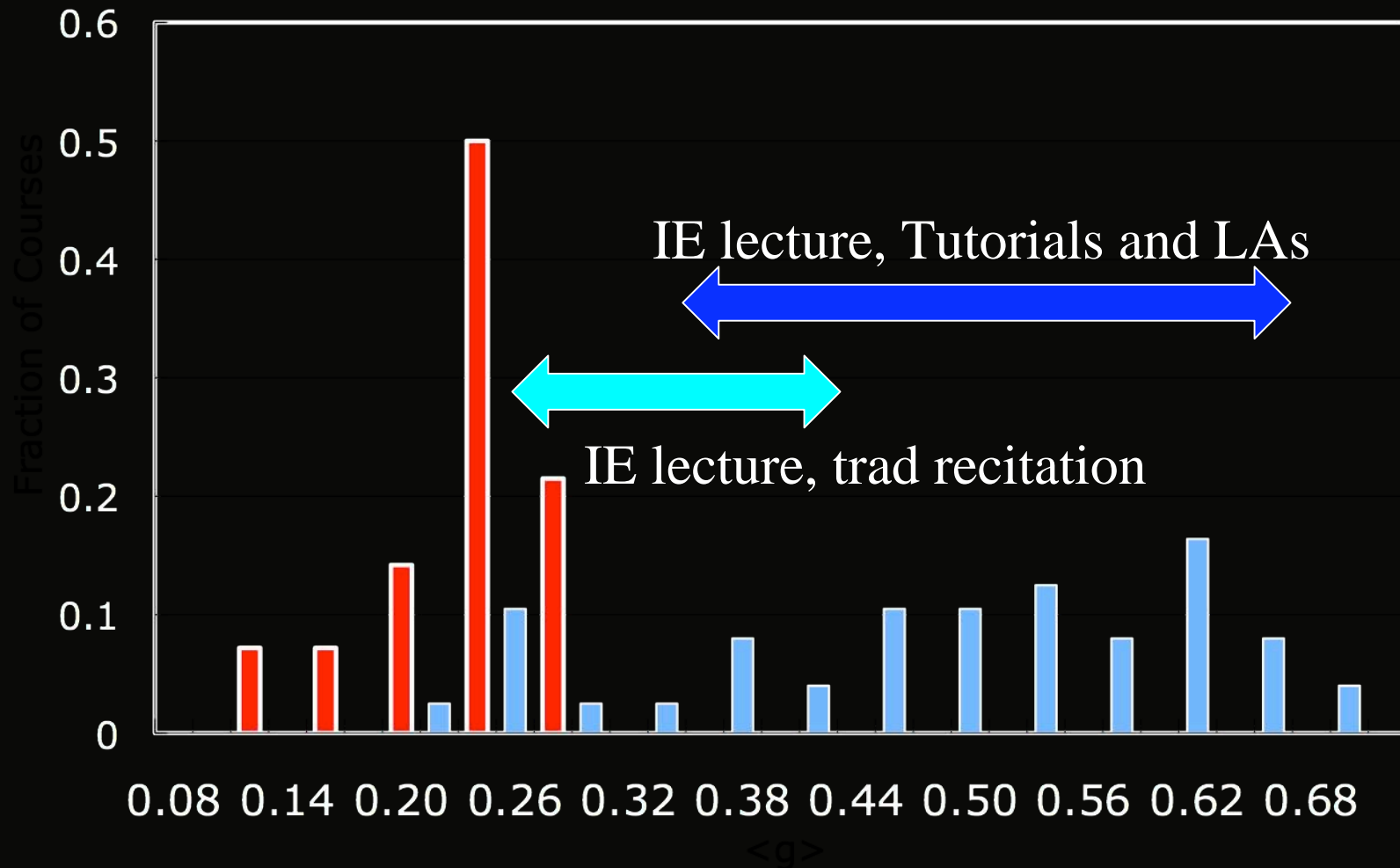


Pollock and Finkelstein (2008). *Physical Review: ST PER*, 4, 010110

FCI/FMCE normalized gain

traditional lecture

interactive engagement

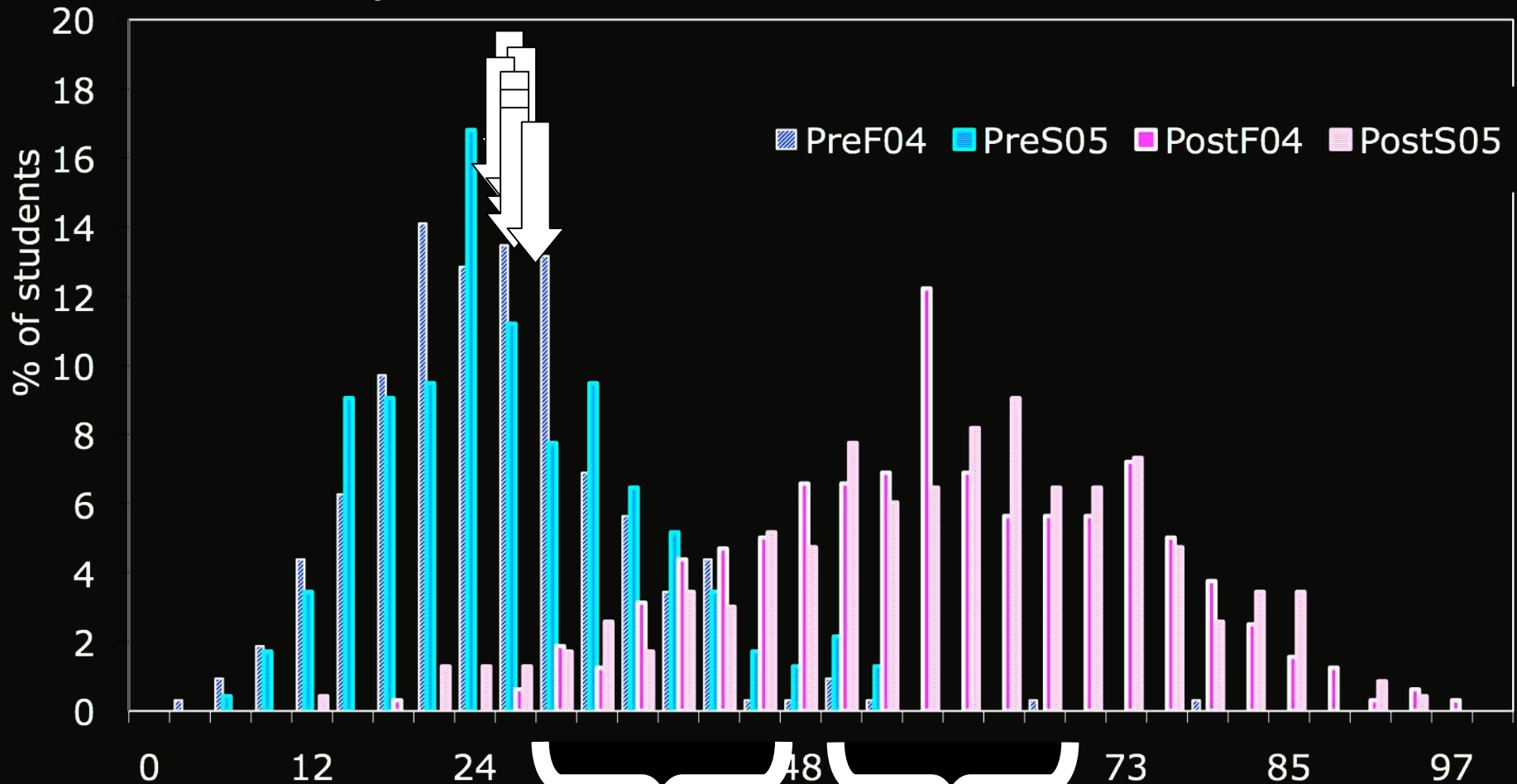


R. Hake, "...A six-thousand-student survey..." AJP 66, 64-74 ('98).

S. Pollock and N. Finkelstein, *Phys. Rev. ST Phys. Educ. Res.* 4, 010110 (2008)

Other classes?

Physics 2: BEMA pre/post



trad post

IE post

Kohlmeyer et al

F04 (N=319) Post: 59%

S05 (N=232): 59%

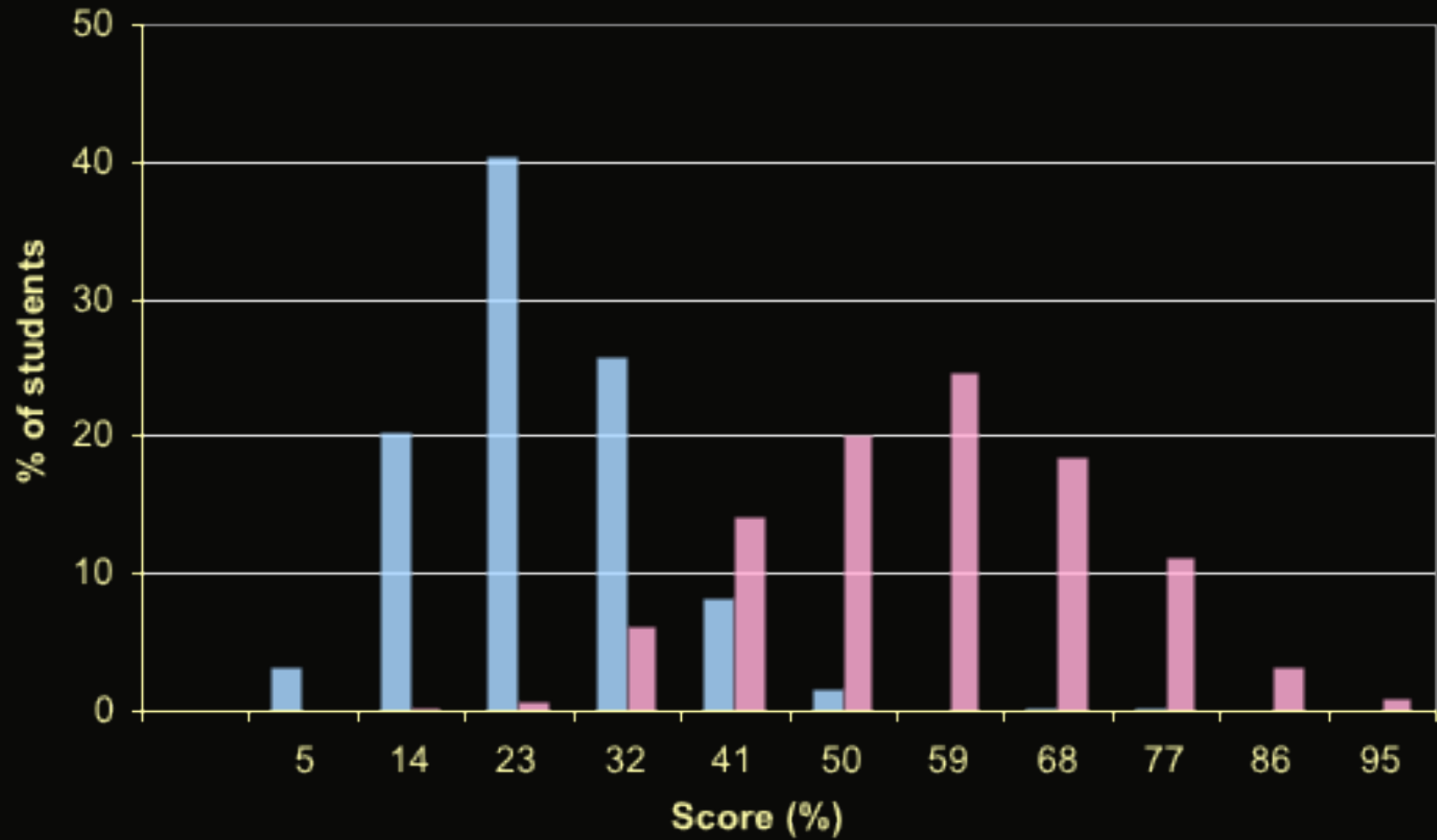
S. Pollock and N. Finkelstein, *Phys. Rev. ST Phys. Educ. Res.* 4, 010110 (2008)

Handoff to non-PER faculty

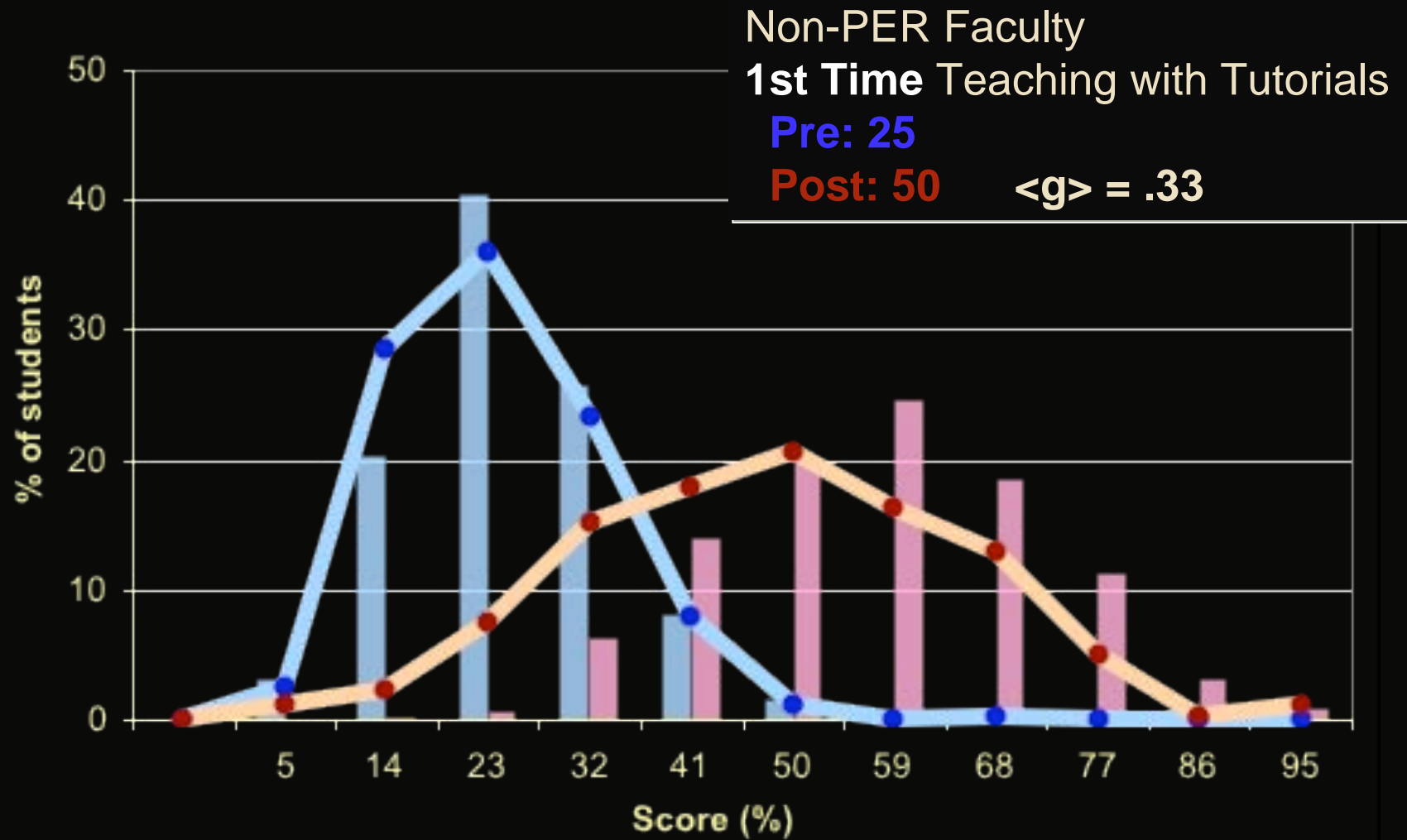
- Use same materials
- Same TA / LA training
- Same course structure /exams etc...

... everything looks the same...(except the instructor)

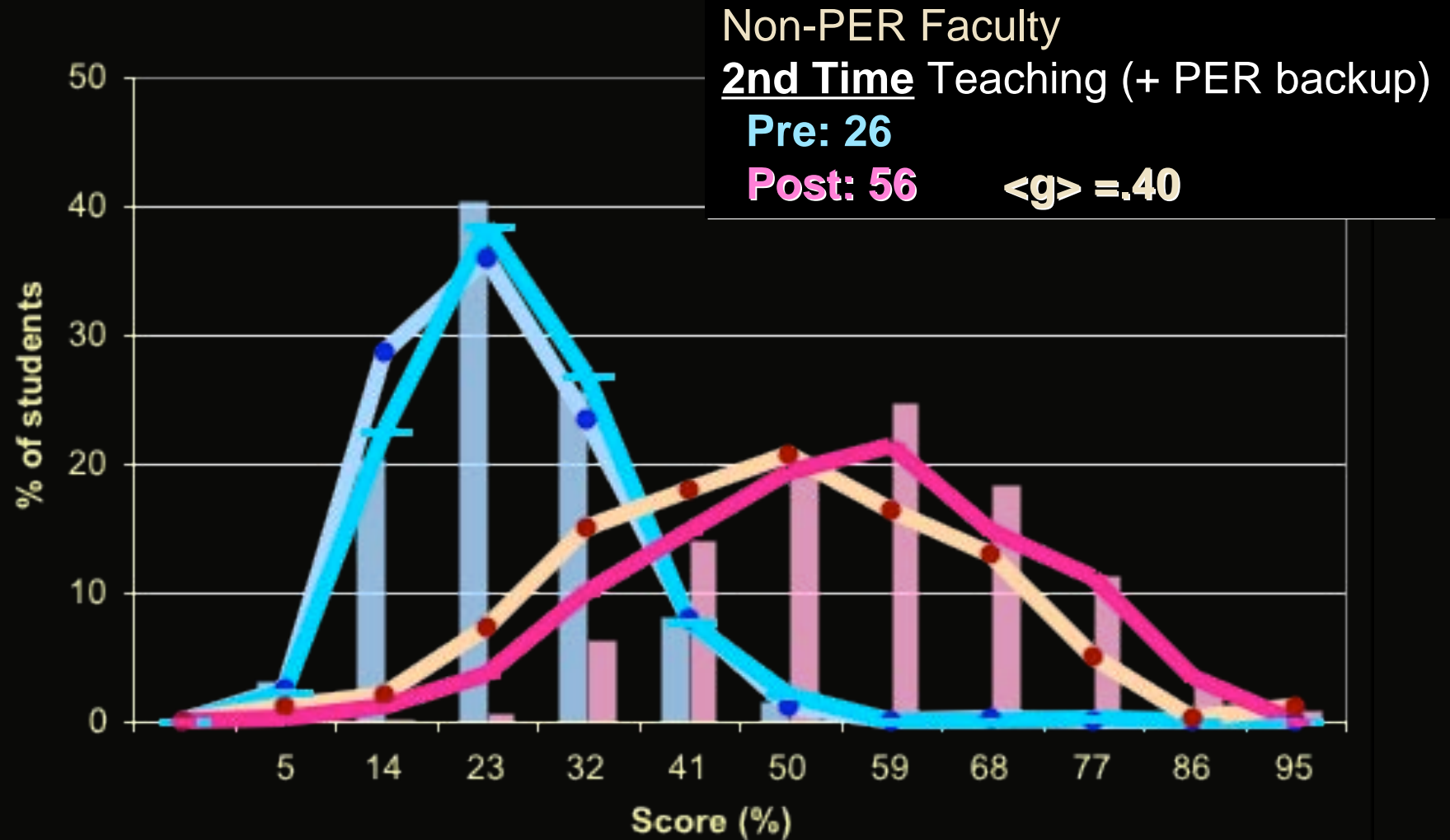
1120 BEMA pre/post



1120 BEMA pre/post



1120 BEMA pre/post



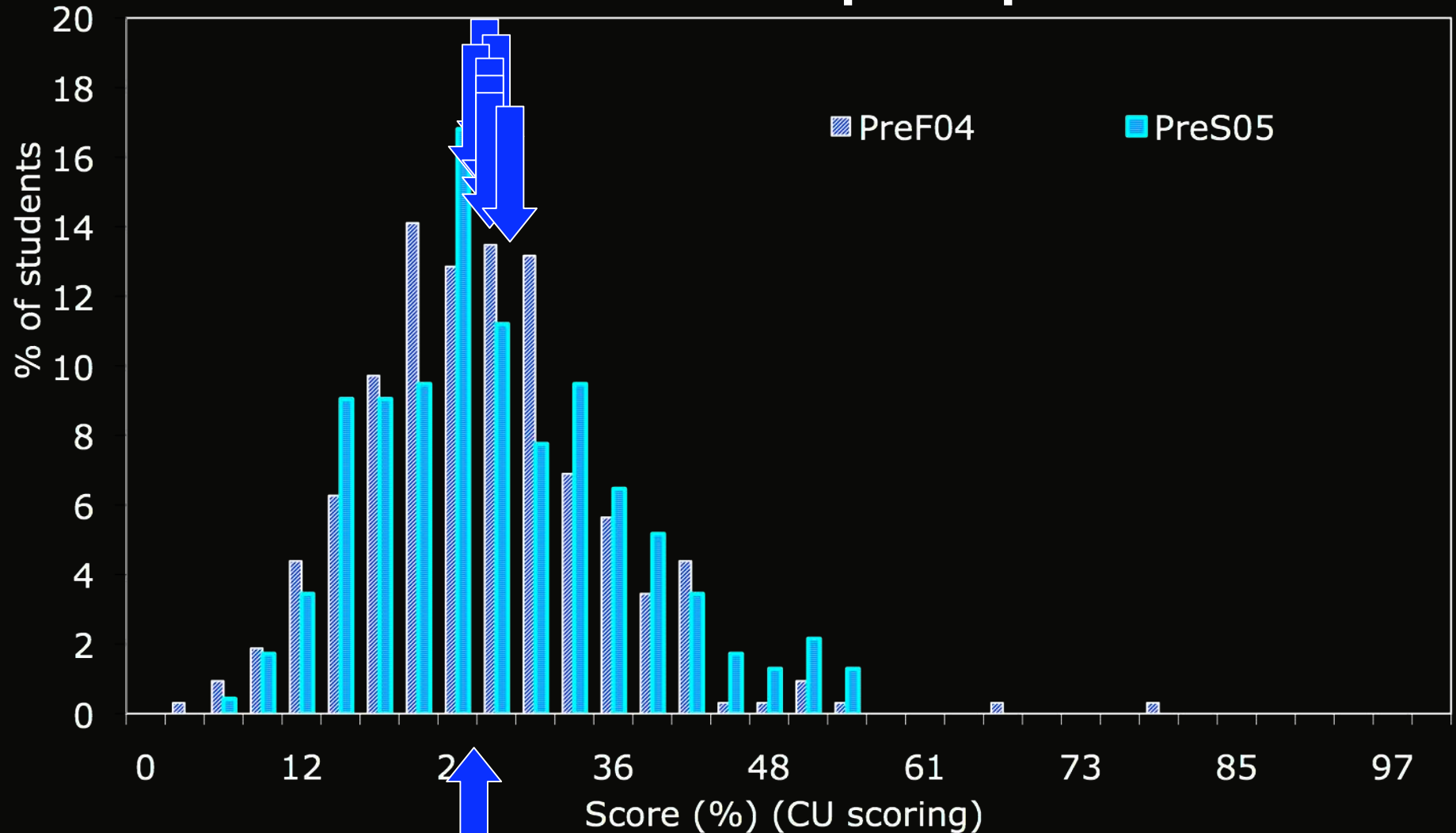
actively engaging is important

*what people know affects
what they learn*

*contexts shape what students
learn (content and beliefs)*

Replication,
but with strong variations
Why?

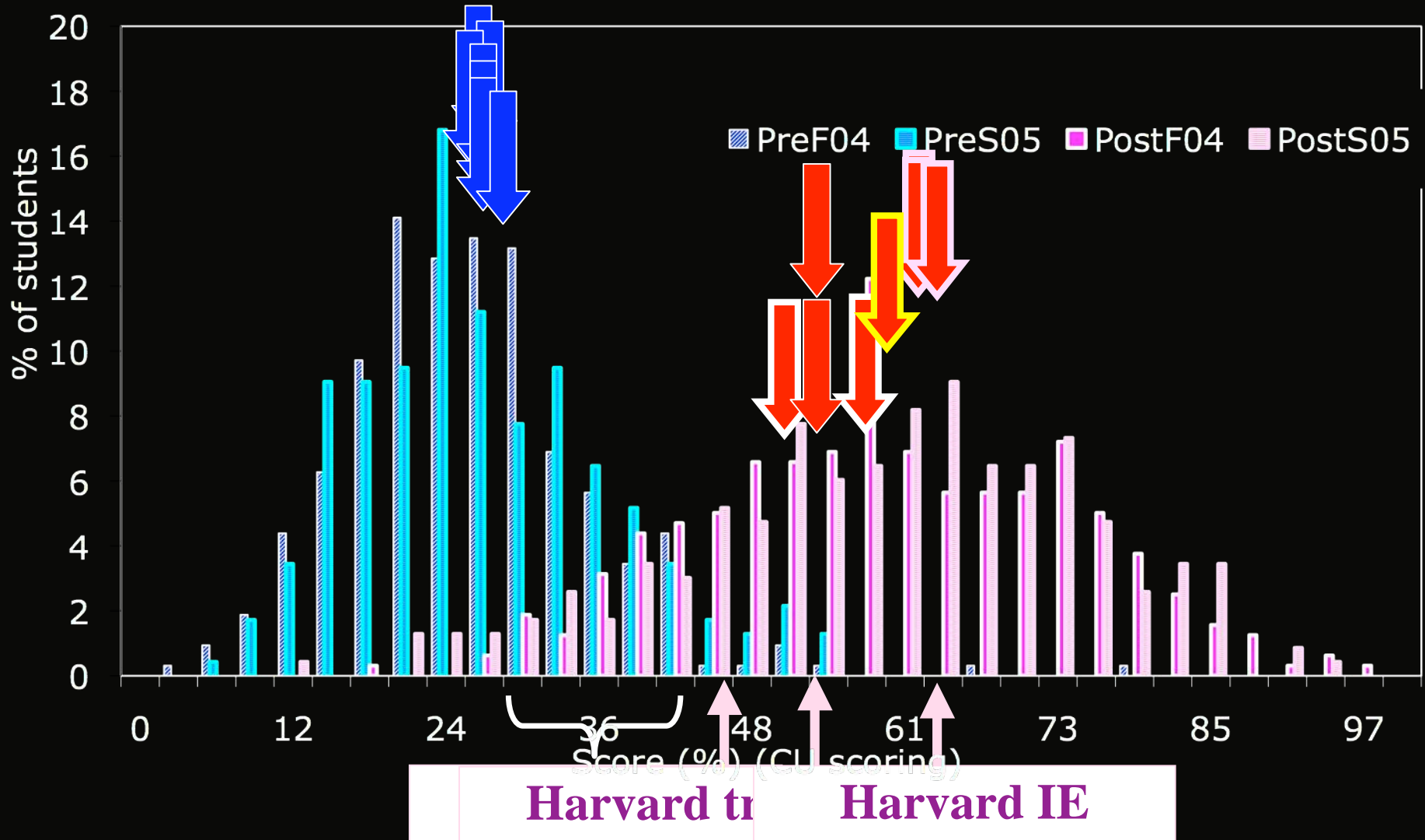
1120 BEMA pre/post



F04 (N=319) Pretest: 26% S05 (N=232): 27%

S. Pollock and N. Finkelstein, *Phys. Rev. ST Phys. Educ. Res.* 4, 010110 (2008)

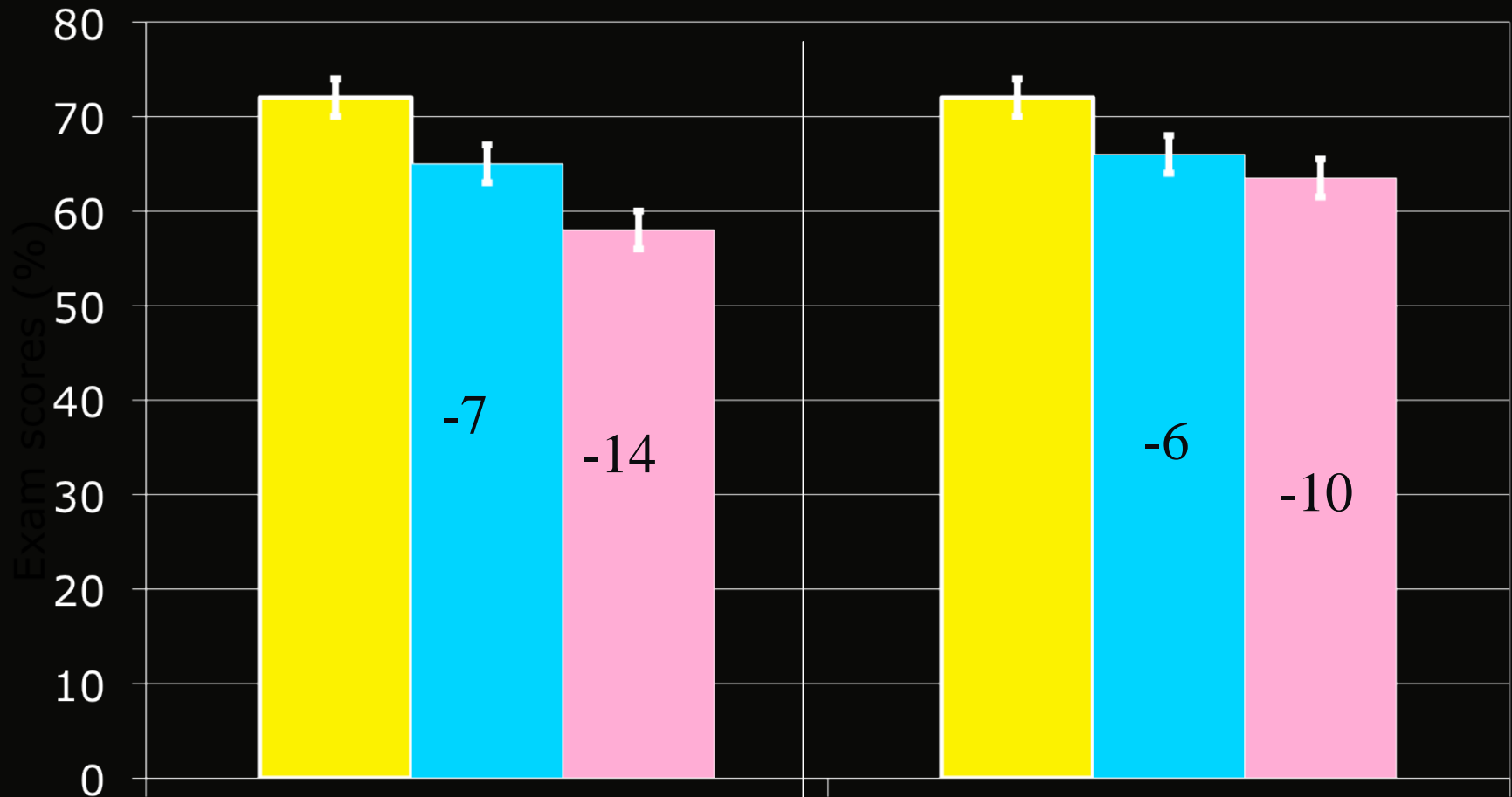
1120 BEMA pre/post



F04 (N=319) Post: 59% S05 (N=232): 59%

S. Pollock and N. Finkelstein, *Phys. Rev. ST Phys. Educ. Res.* 4, 010110 (2008)

Beyond the FMCE: Exam comparisons



Tut-related q's

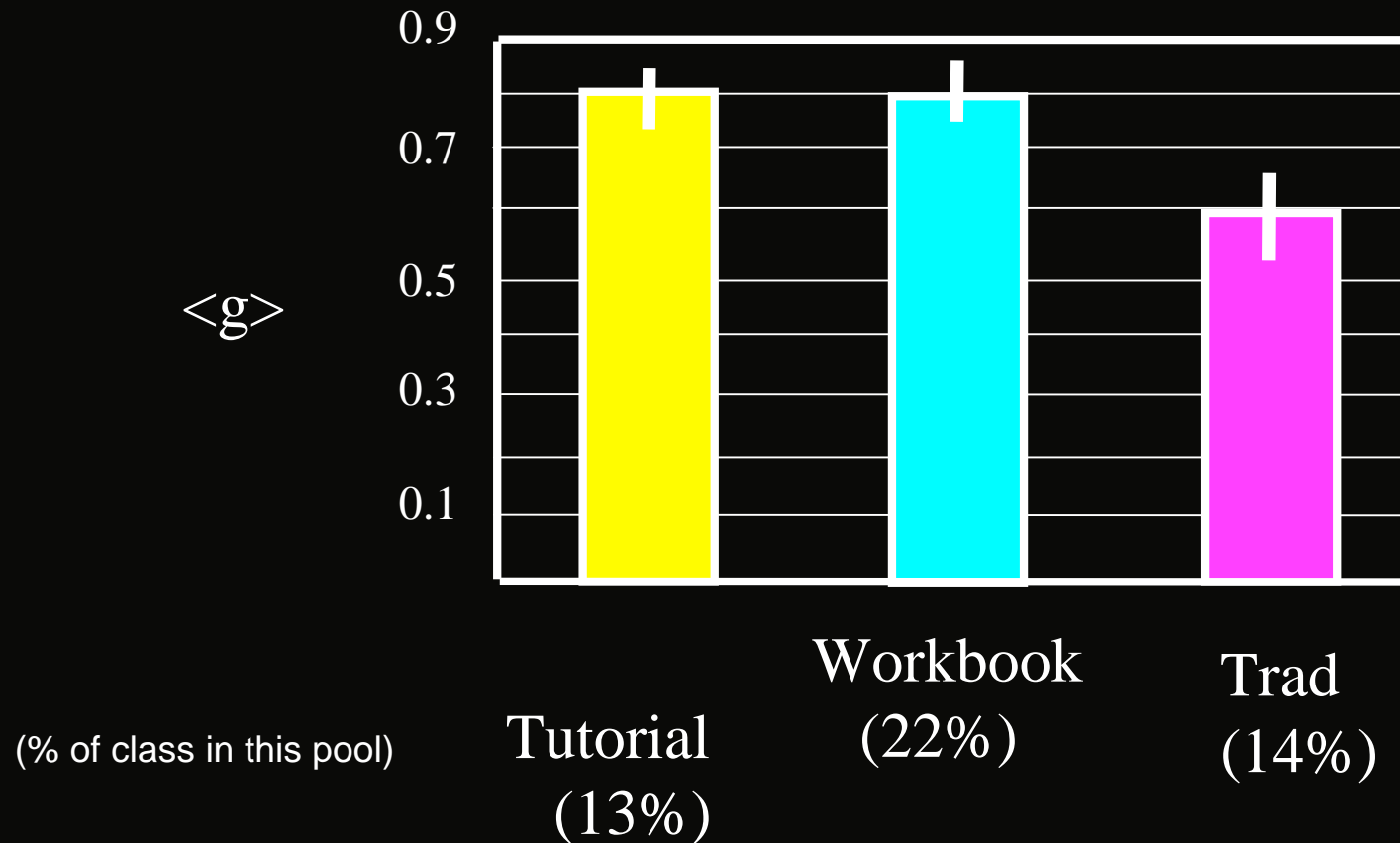
Tutorials

Workbooks

Trad recit

N.B. 12 points is roughly 1 letter grade.

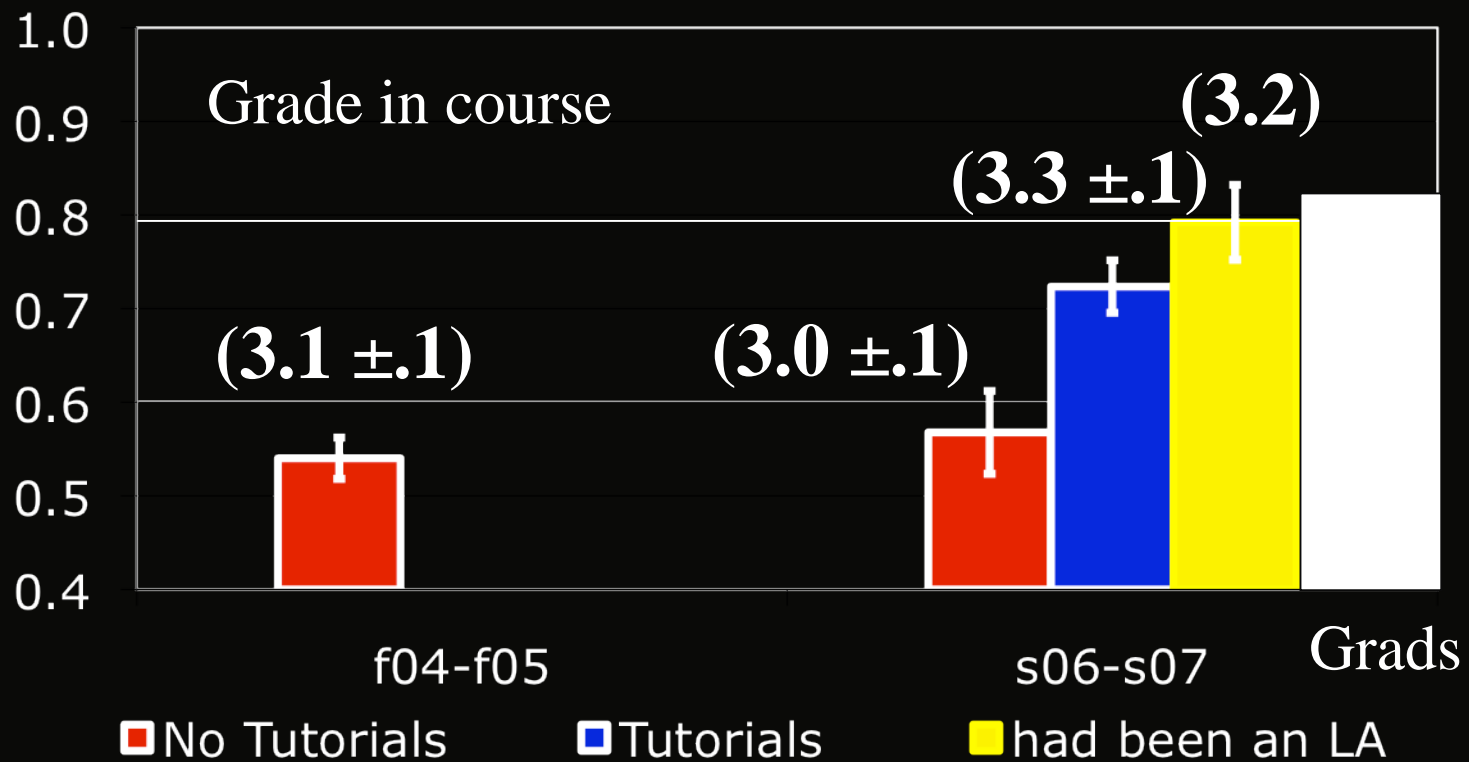
Impact on different pretest populations: "high starters" $50 < \text{pre} < 93\%$



does it last?

Longitudinal

Upper division majors' BEMA scores



Yellow: students who had been E&M LAs

Clickers in Upper-division at CU

Course	← Sp04 → Sp09 →									
Mech & Math I						★		★		
Mech & Math II							★			★
EM I									★	★
EM II										★
QM I									★	★
QM II									★	
Solid State							★		★	★
Stat Mech	★		★			★	★		★	★
Optics								★		
Grad AMO							★	★		★

➤ 12 non-PER ★ and 2 PER ★ faculty

CU Model of Teacher Prep

- Begin *within* science departments
- Learning Assistants:
Use undergrads to implement research-based materials
 - Improve education of all students
 - Model best-practices for all students
 - Increase likelihood students engage in teaching
 - Improve content mastery of future teachers

Conclusions

- Educational practice is a researchable endeavor
 - We can make systematic progress
 - Imperative to include scientists
- Possible to achieve dramatic repeated results
- CU model strongly couples:
 - Reform and Research
 - K12 Teacher prep

**It's not about our teaching,
it's about student learning**

Questions?

Much more at: *per.colorado.edu*

Or stem.colorado.edu