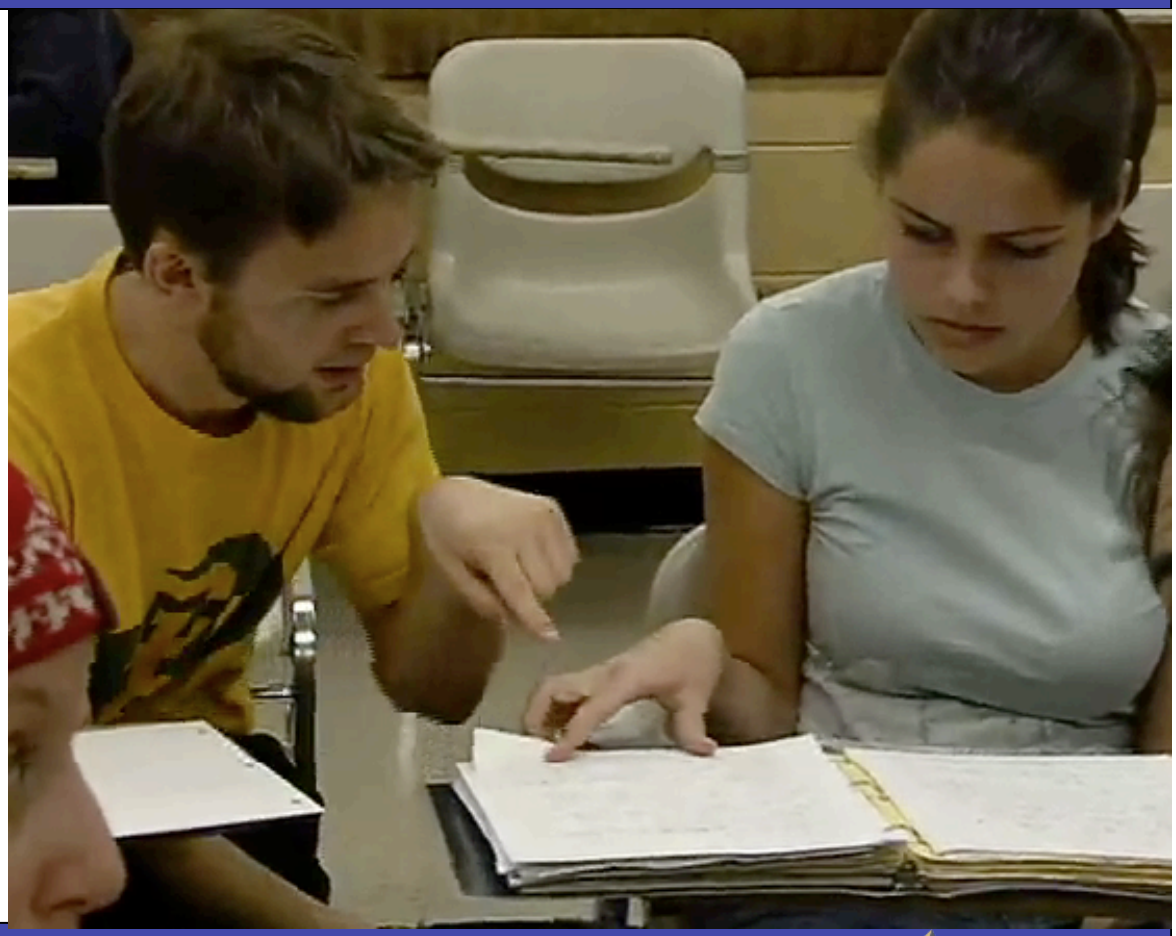
A research-validated approach to transforming upper-division E&M: issues and measures



PER @ CU-Boulder

Steven Pollock

Physics Dept.

University of Colorado at Boulder

Outline

- Overview, and some background
- Building on a research base:
  - Why transform E&M?
  - What changed?
  - Assessment and data
  - Outcomes and research questions

Physics Education Research at CU Boulder

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Ben Van Dusen
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Jessica Hoy
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+ many participating faculty and LAs

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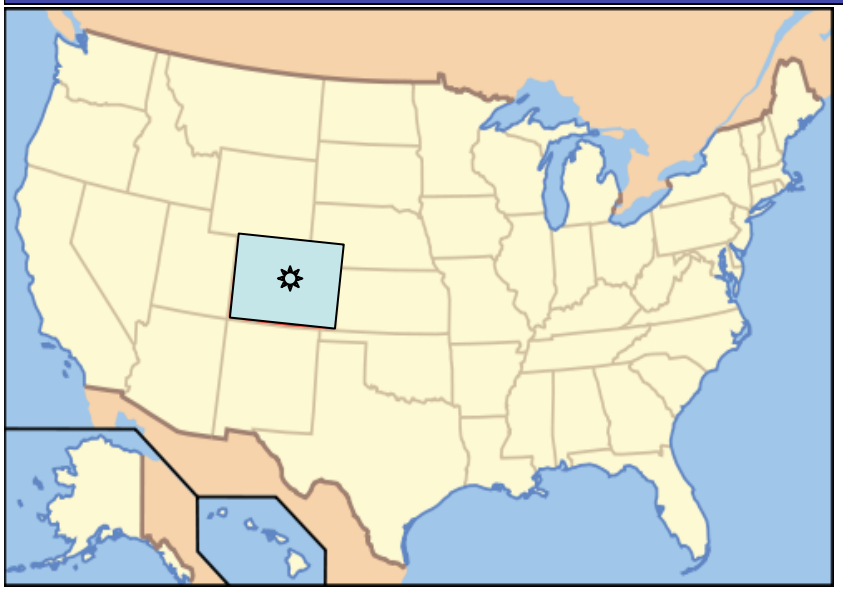
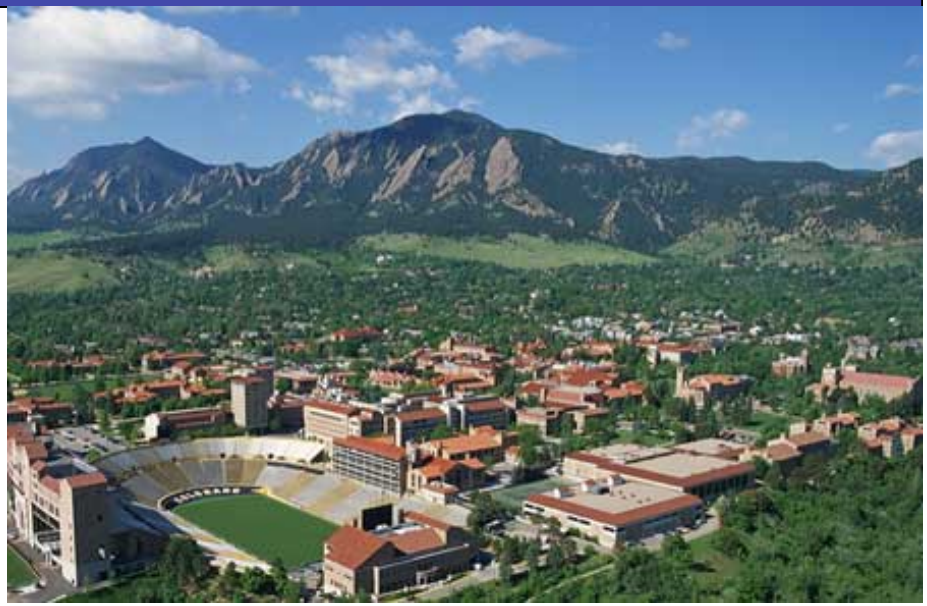
Physics Teacher Education Coalition
American Institute of Physics
American Physical Society
National Math & Science Initiative
Howard Hughes Medical Institute

NSF AAPT PHYSICS EDUCATION APS AIP American Institute of Physics THE WILLIAM AND FLORA HEWLETT FOUNDATION NATIONAL MATH + SCIENCE INITIATIVE WE MULTIPLY SUCCESS Physics Teacher Education Coalition HHMI HOWARD HUGHES MEDICAL INSTITUTE

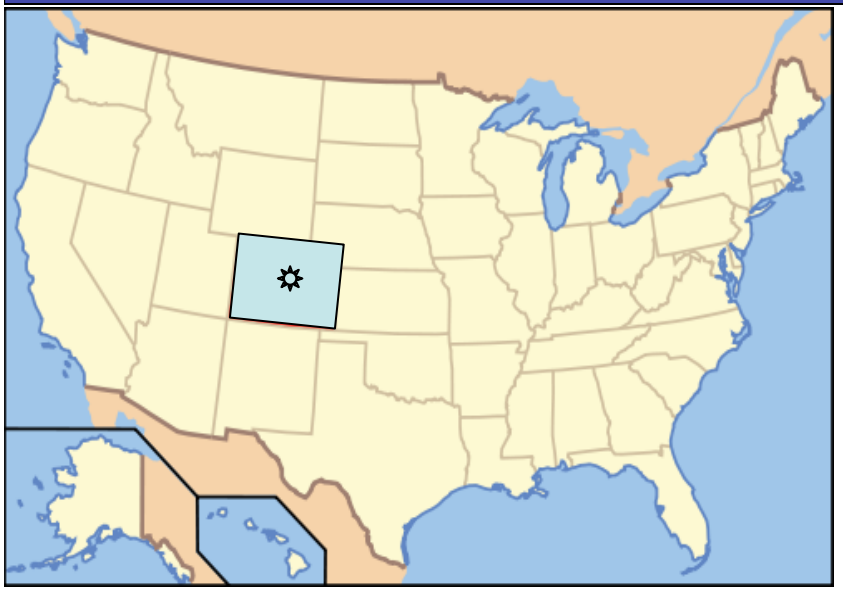
Background at CU Boulder

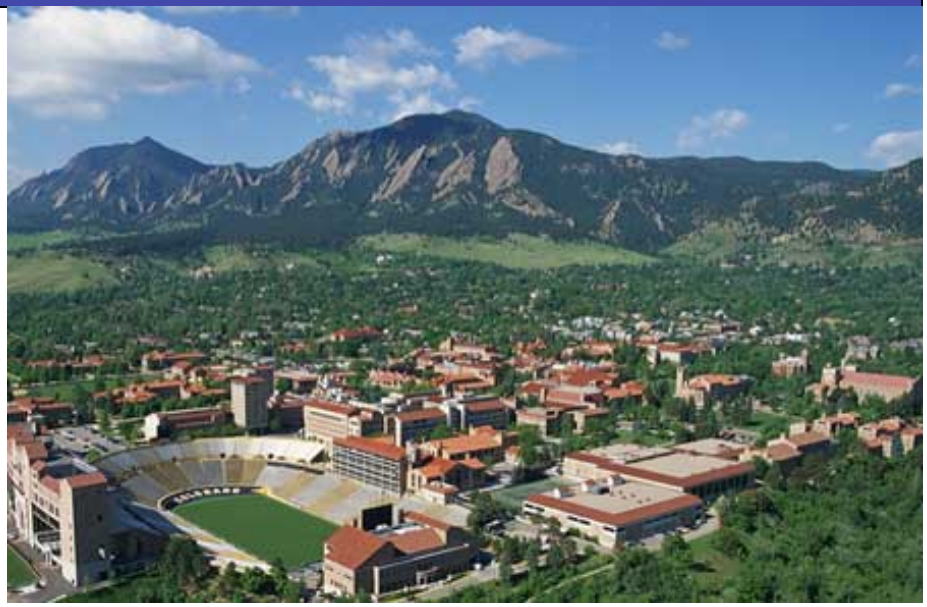




Physics Department
55 faculty
350 undergrad majors
230 graduate students

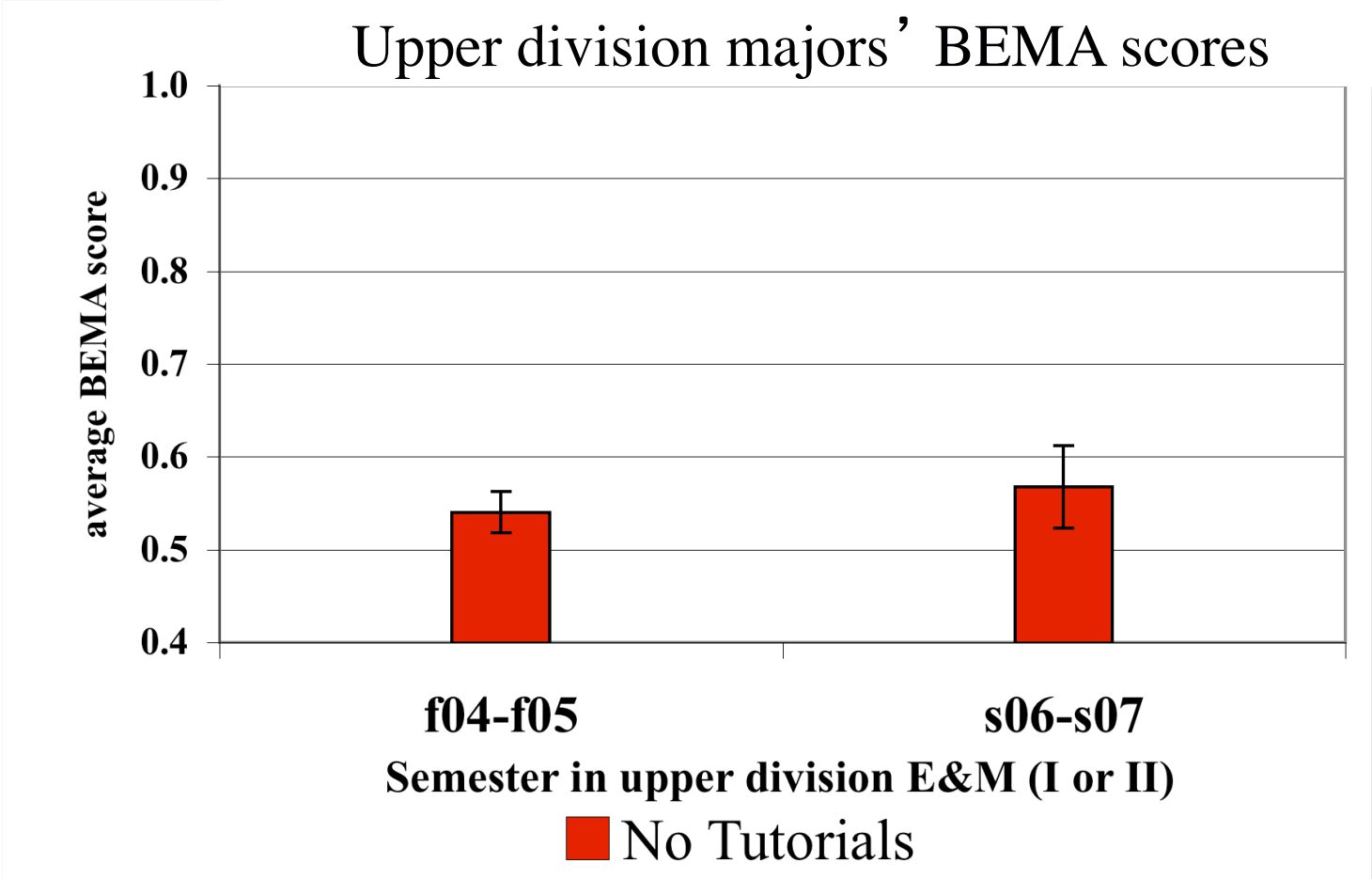
Background at CU Boulder





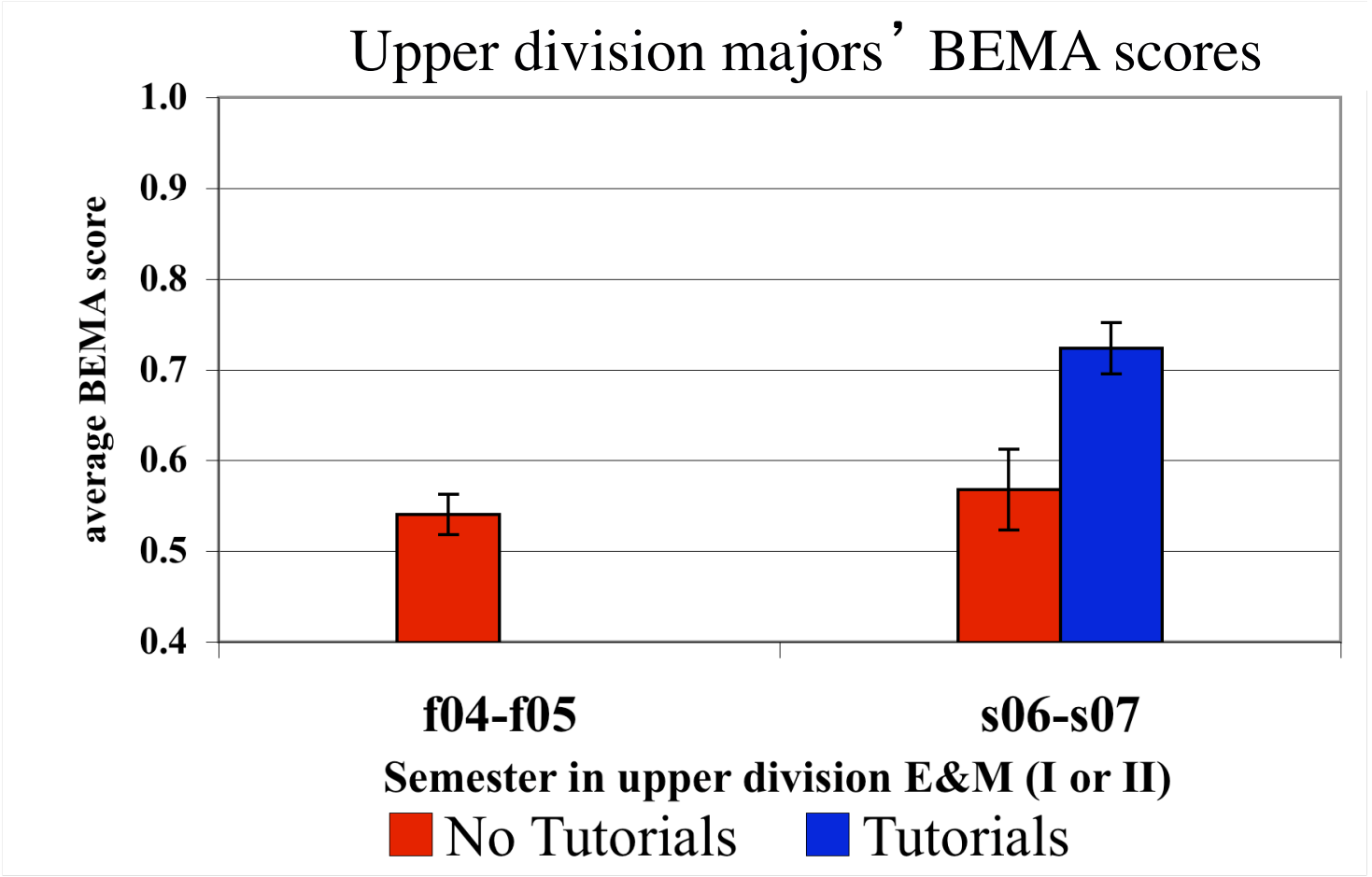
- Clickers & Peer Instruction
- Tutorials in Introductory Physics
- Pre/post assessments

Longitudinal



After upper div. E&M. (Only students who took intro *without* Tutorials)

Longitudinal



BLUE: students who took freshman E&M *with* Tutorials

Why transform junior E&M I?

Lecture with clickers

Washington Tutorials

?

Can our majors learn better from interactive techniques adapted from introductory physics?

Model of Course Transformation

Establish learning goals

Using Research & Assessment

Apply research-based teaching techniques & measure progress

- E&M 1 & II
- QM I
- Class Mech/ Math Methods
- Upper-div labs

Chasteen, Perkins, Beale, Pollock, & Wieman, JCST **40** (4), 70, 2011
Chasteen et al., AJP **80**, 923, 2012, PRSTPER **8** 020108, 2012

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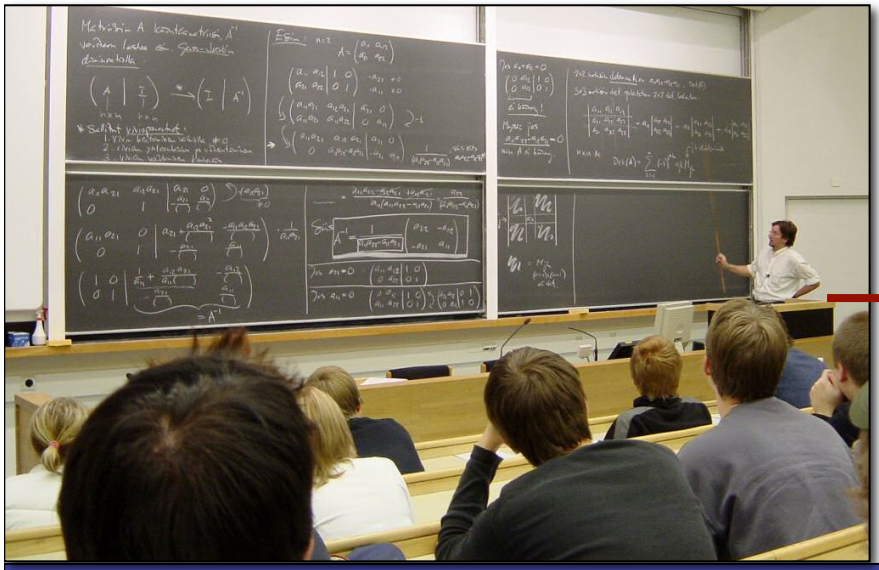
What Changed?

- Faculty collaboration
- Explicit learning goals
- Collect student data!

- Interactive techniques
- Concept Tests
- Modified Homework
- Homework Help Sessions
- Tutorials



Students debate a concept test

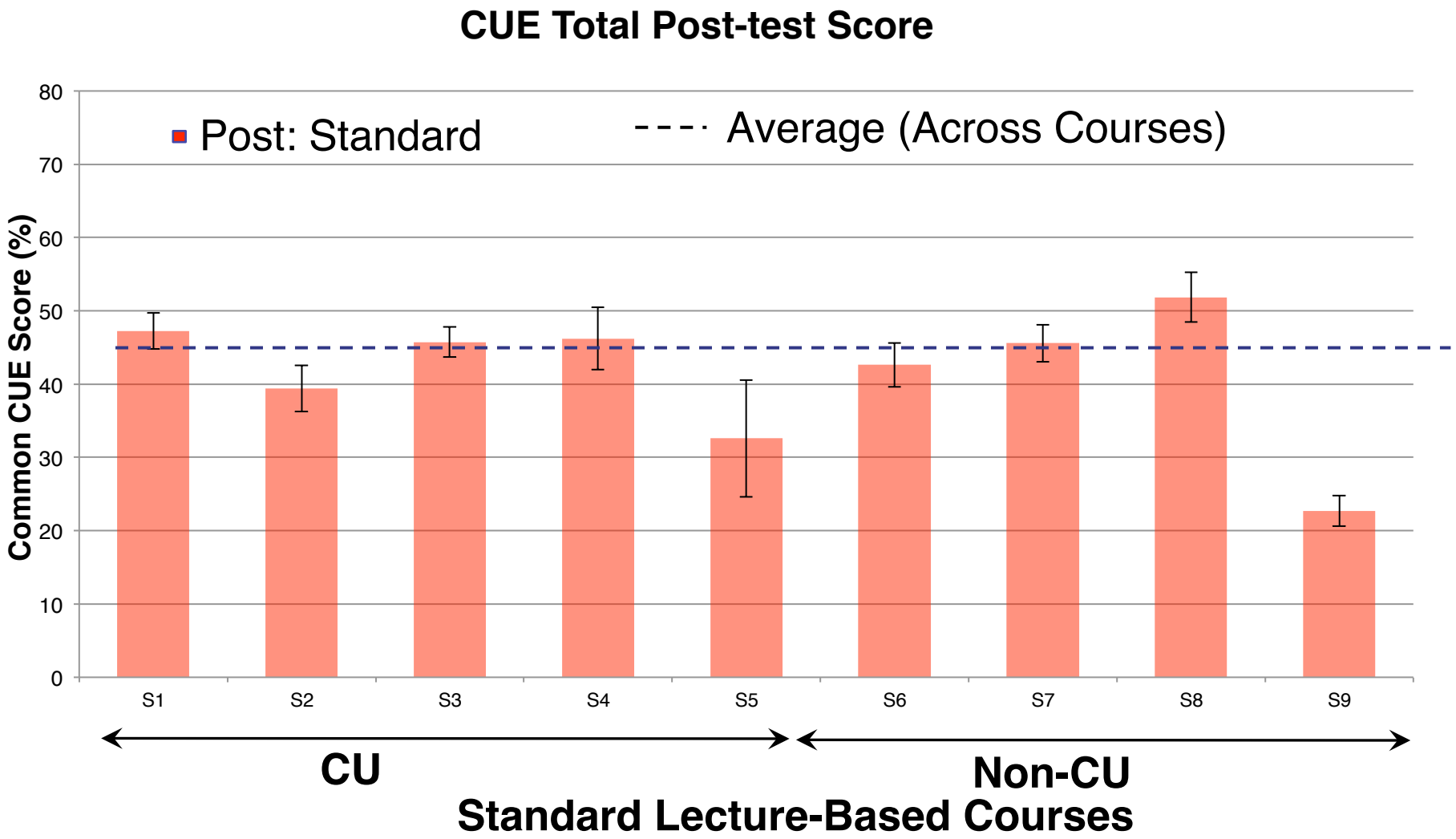
Pepper et al, Chasteen et al, Pollock et al. PERC 2010

Did it Work? Assessments

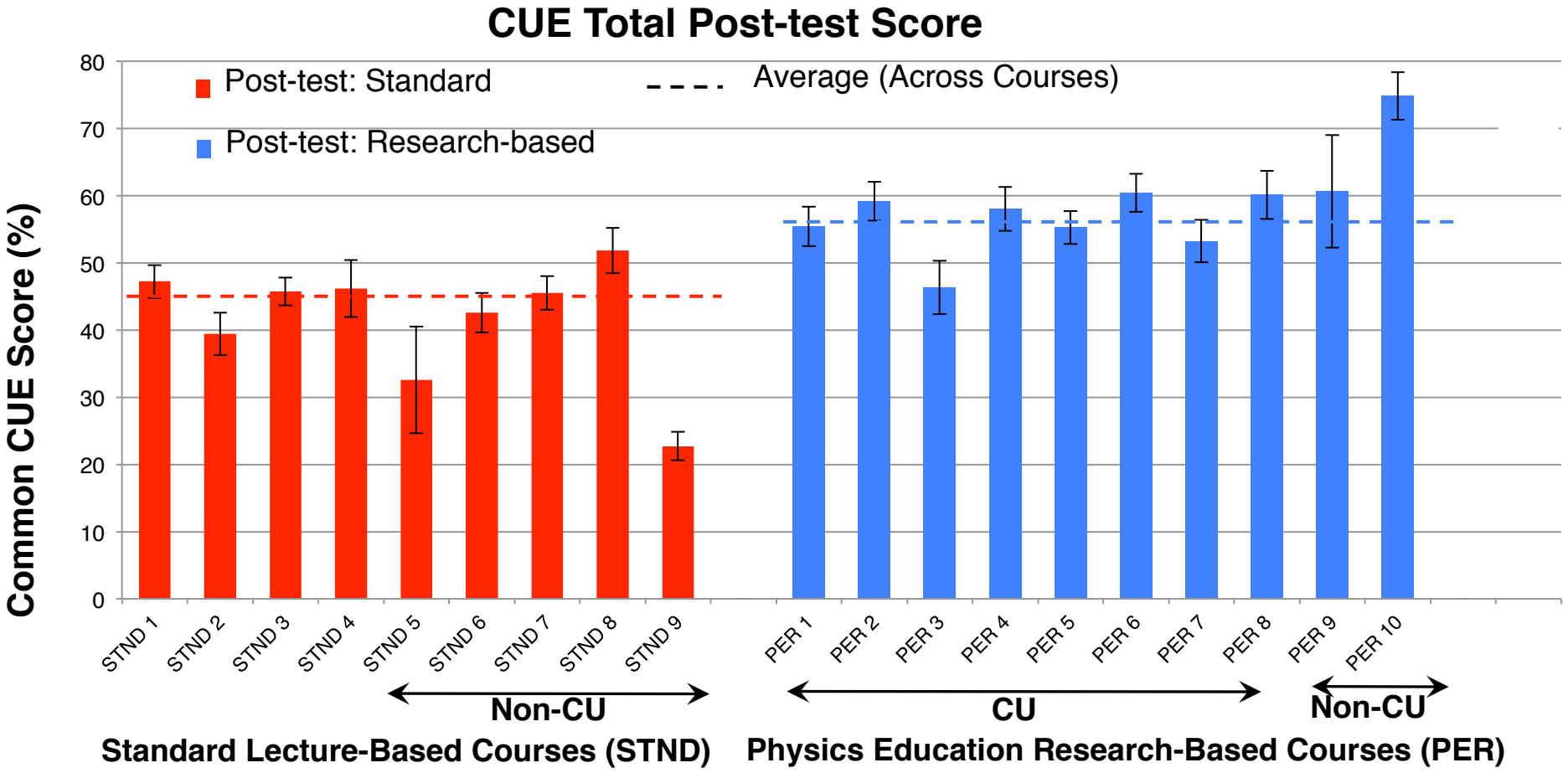
- Compared **Traditional (**9 courses) & **Transformed** (9 courses) at CU and elsewhere (N=515).
- Common **traditional exam questions** (5)
- Developed **Colorado Upper-Division Electrostatics Assessment (CUE)**

  and for E&M II, the **Colorado UppeR-division ElectrodyNamics Test (CURrENT)**

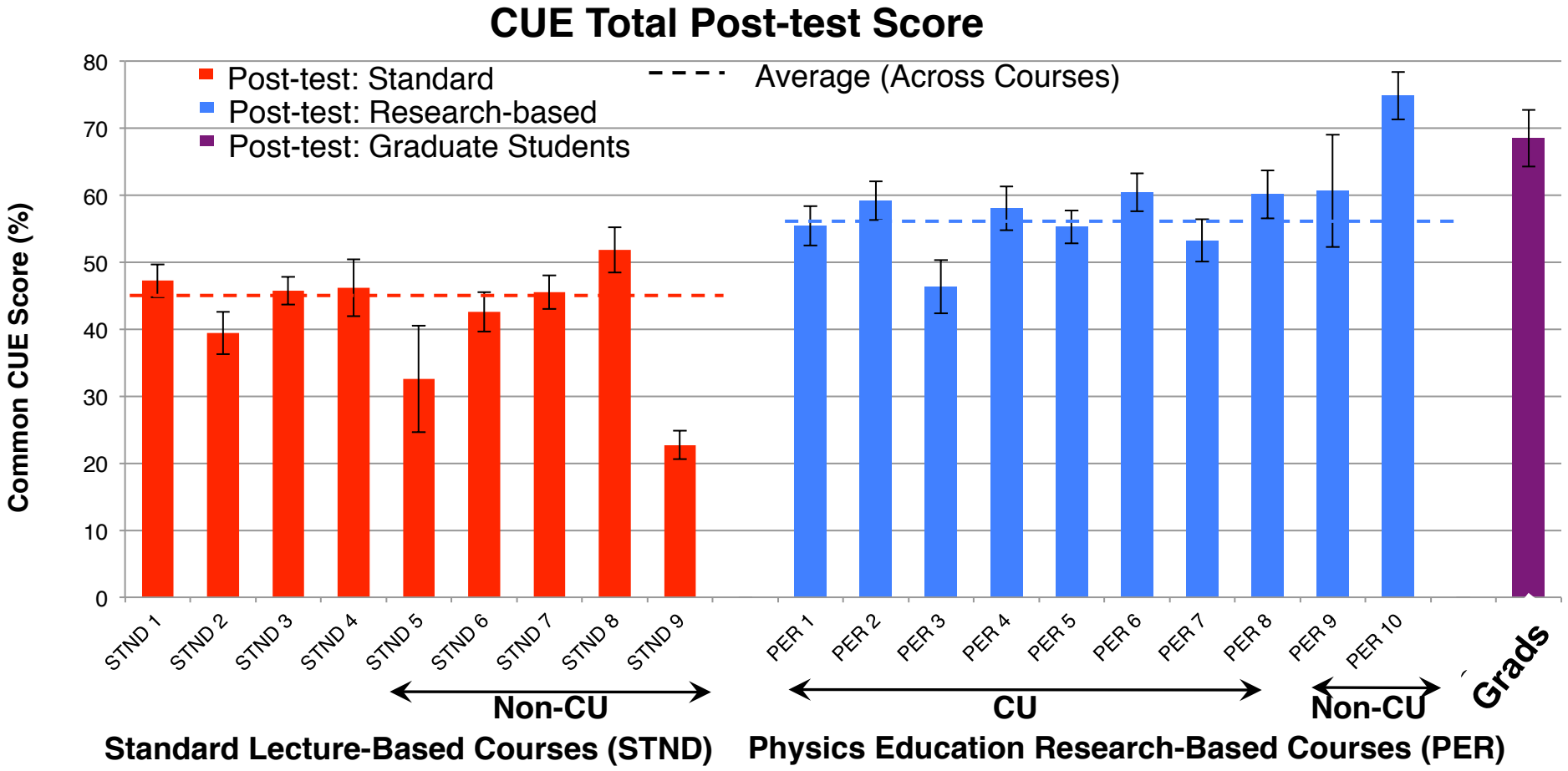
CUE results: Trad courses



CUE results


CUE Total Post-test Score
Post-test: Standard
Post-test: Research-based
Average (Across Courses)
Common CUE Score (%)
80
70
60
50
40
30
20
10
0
STND 1
STND 2
STND 3
STND 4
STND 5
STND 6
STND 7
STND 8
STND 9
PER 1
PER 2
PER 3
PER 4
PER 5
PER 6
PER 7
PER 8
PER 9
PER 10
Non-CU
CU
Non-CU
Standard Lecture-Based Courses (STND)
Physics Education Research-Based Courses (PER)

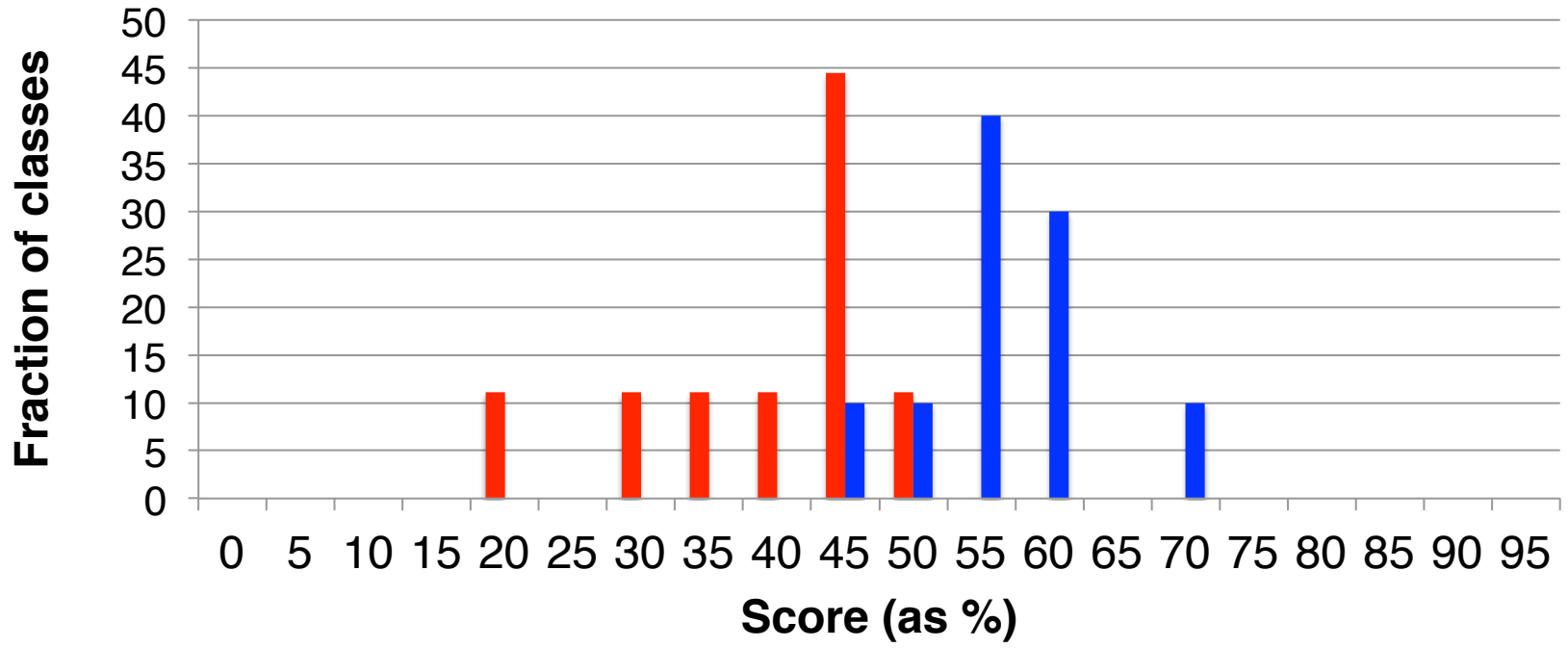
CUE results


CUE Total Post-test Score
Post-test: Standard
Post-test: Research-based
Post-test: Graduate Students
Average (Across Courses)
Common CUE Score (%)
80
70
60
50
40
30
20
10
0
STND 1
STND 2
STND 3
STND 4
STND 5
STND 6
STND 7
STND 8
STND 9
PER 1
PER 2
PER 3
PER 4
PER 5
PER 6
PER 7
PER 8
PER 9
PER 10
Grads
Non-CU
CU
Non-CU
Standard Lecture-Based Courses (STND)
Physics Education Research-Based Courses (PER)

CUE score distribution

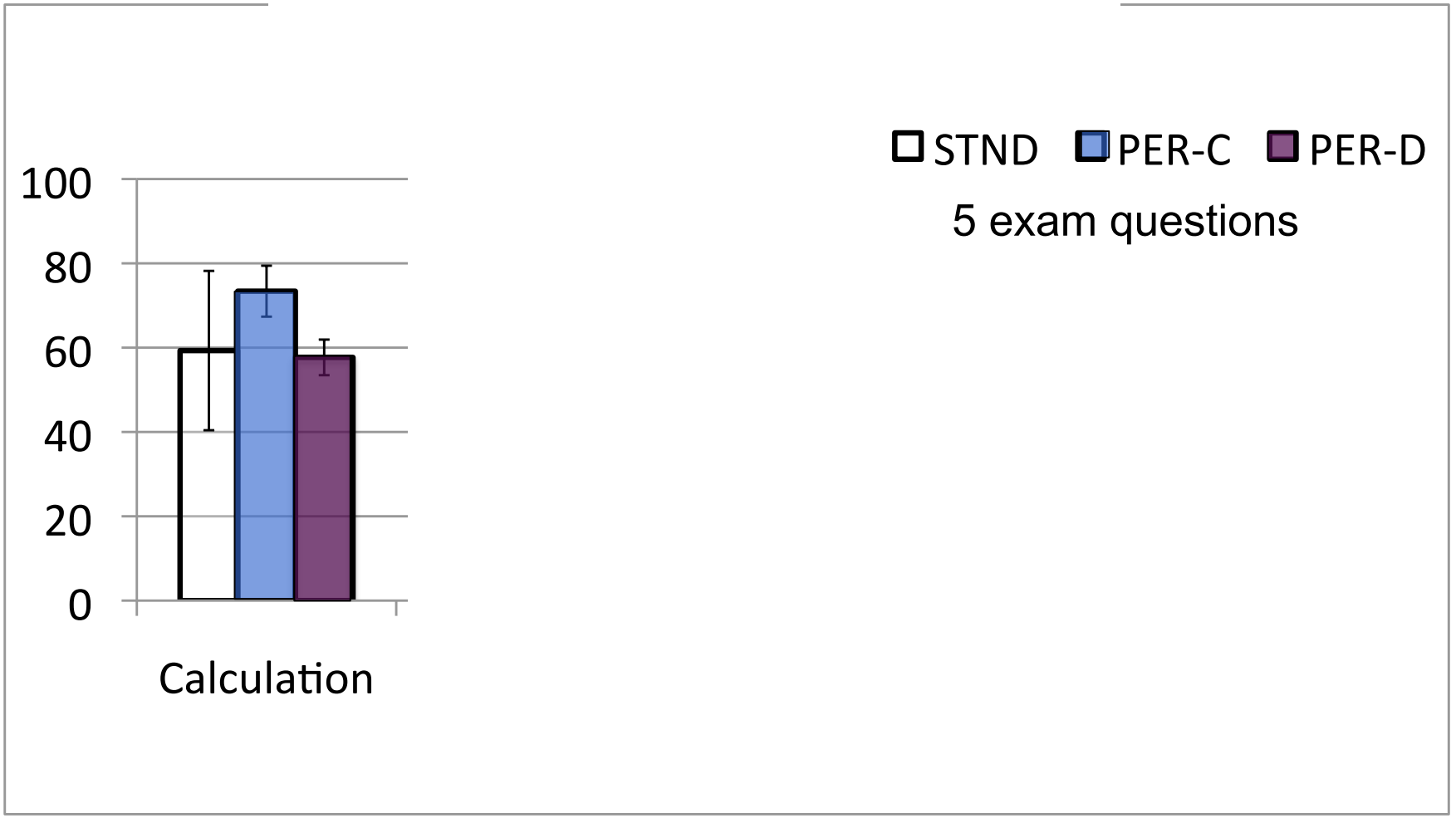
traditional lecture

interactive engagement



N_{tot}=540

Traditional exam questions



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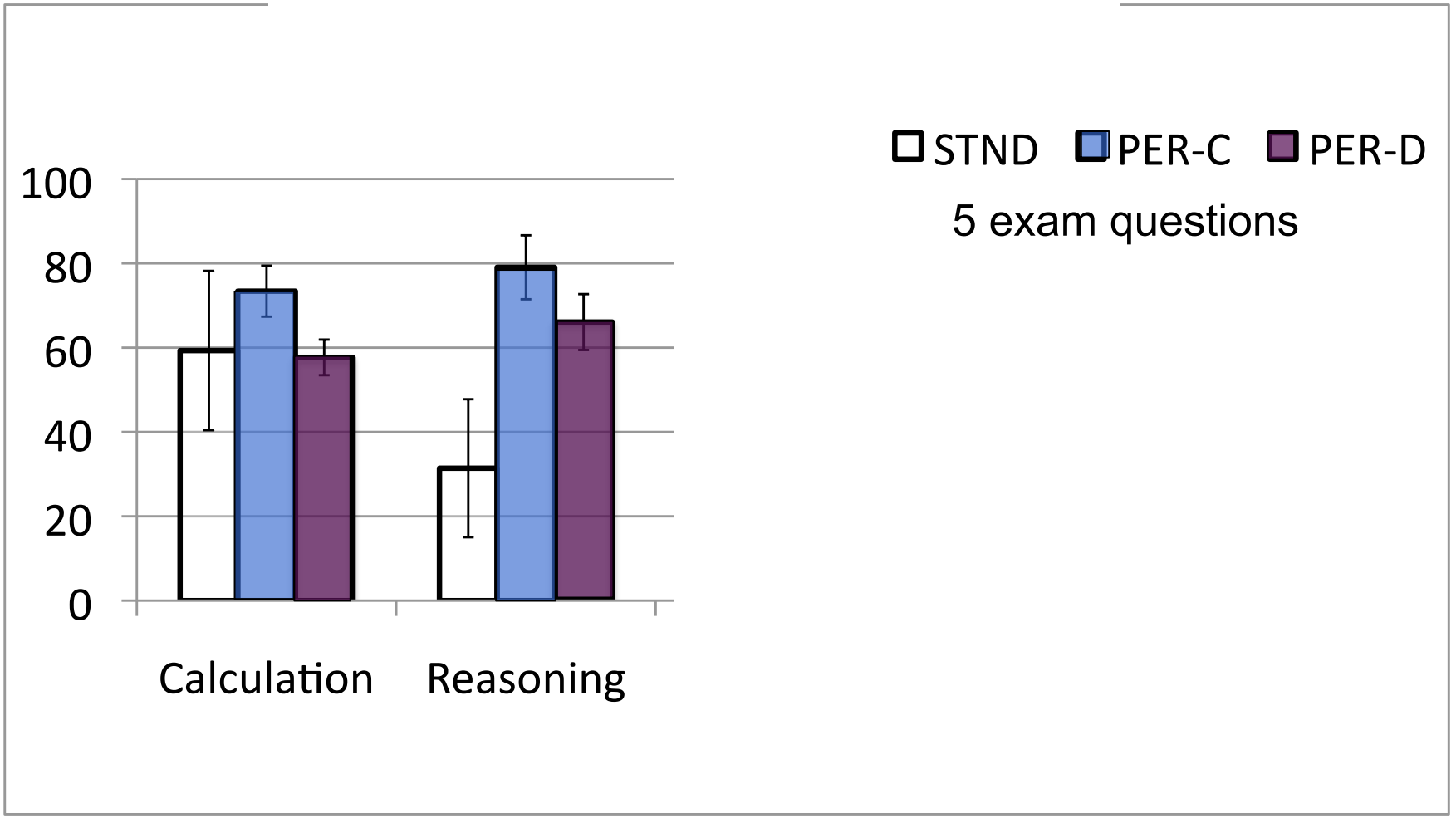
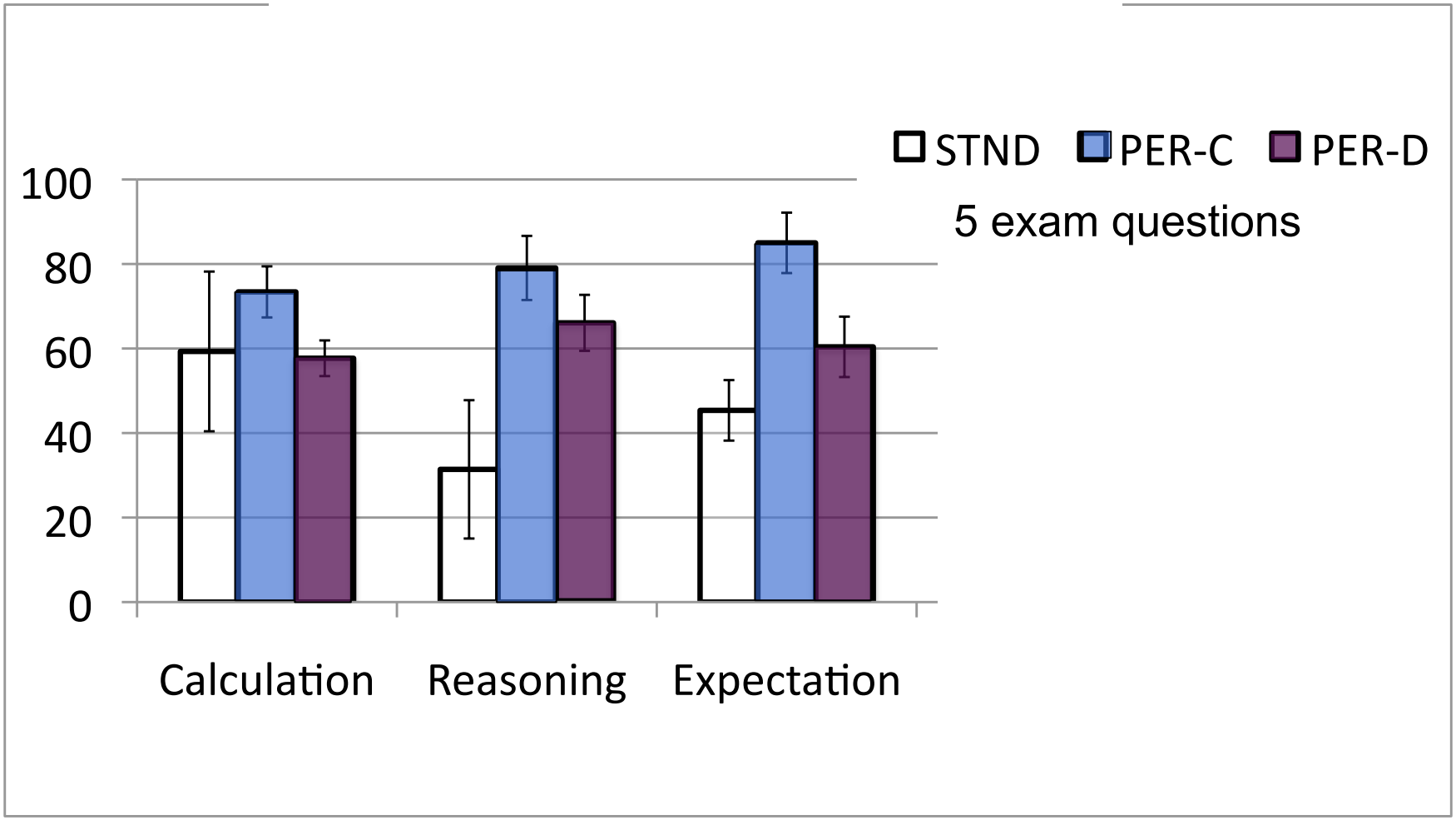
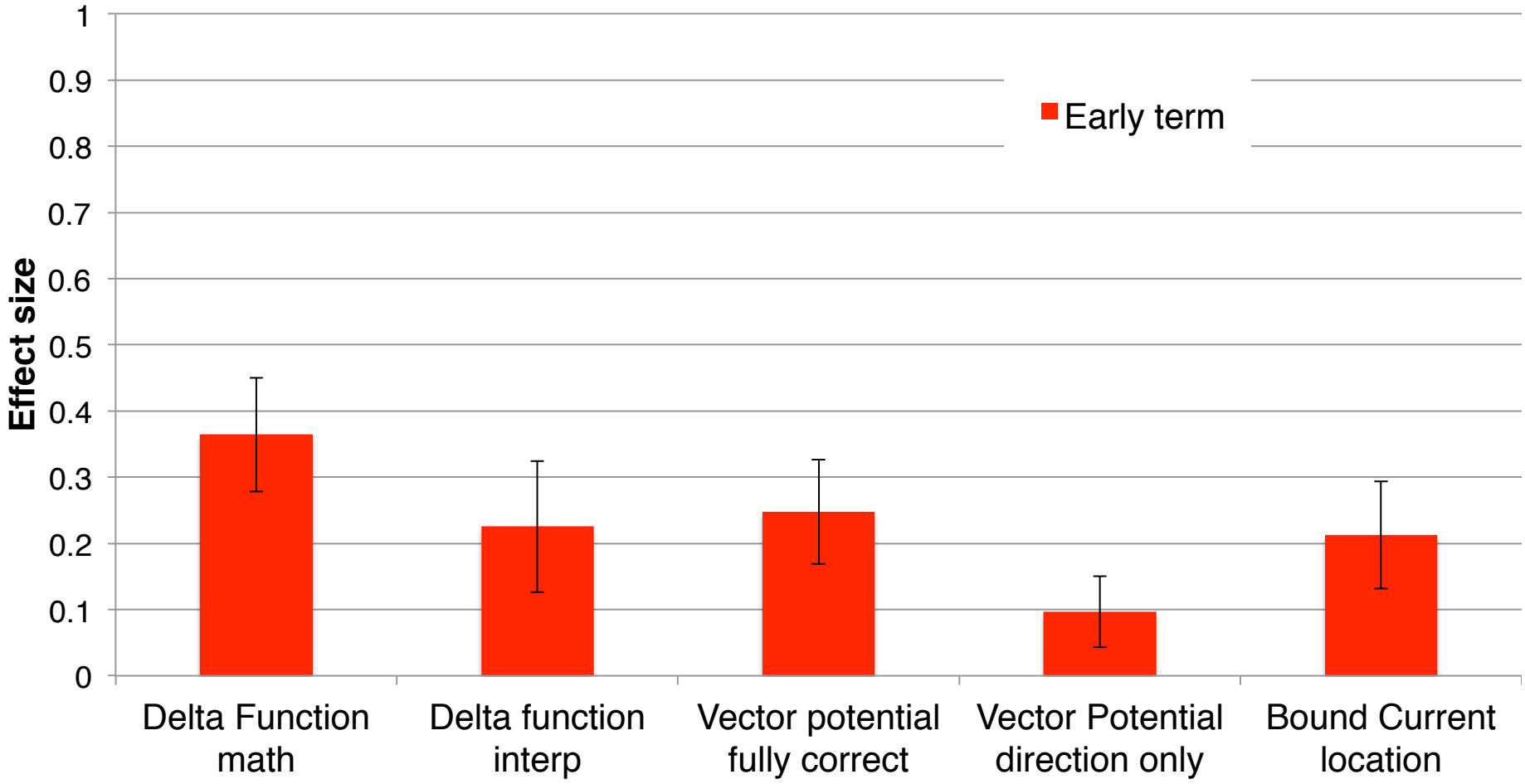


Traditional exam questions



Chasteen et al, PERC 2011, AJP 80 (#10) 2012

Topical Pre-post shifts (effect size)



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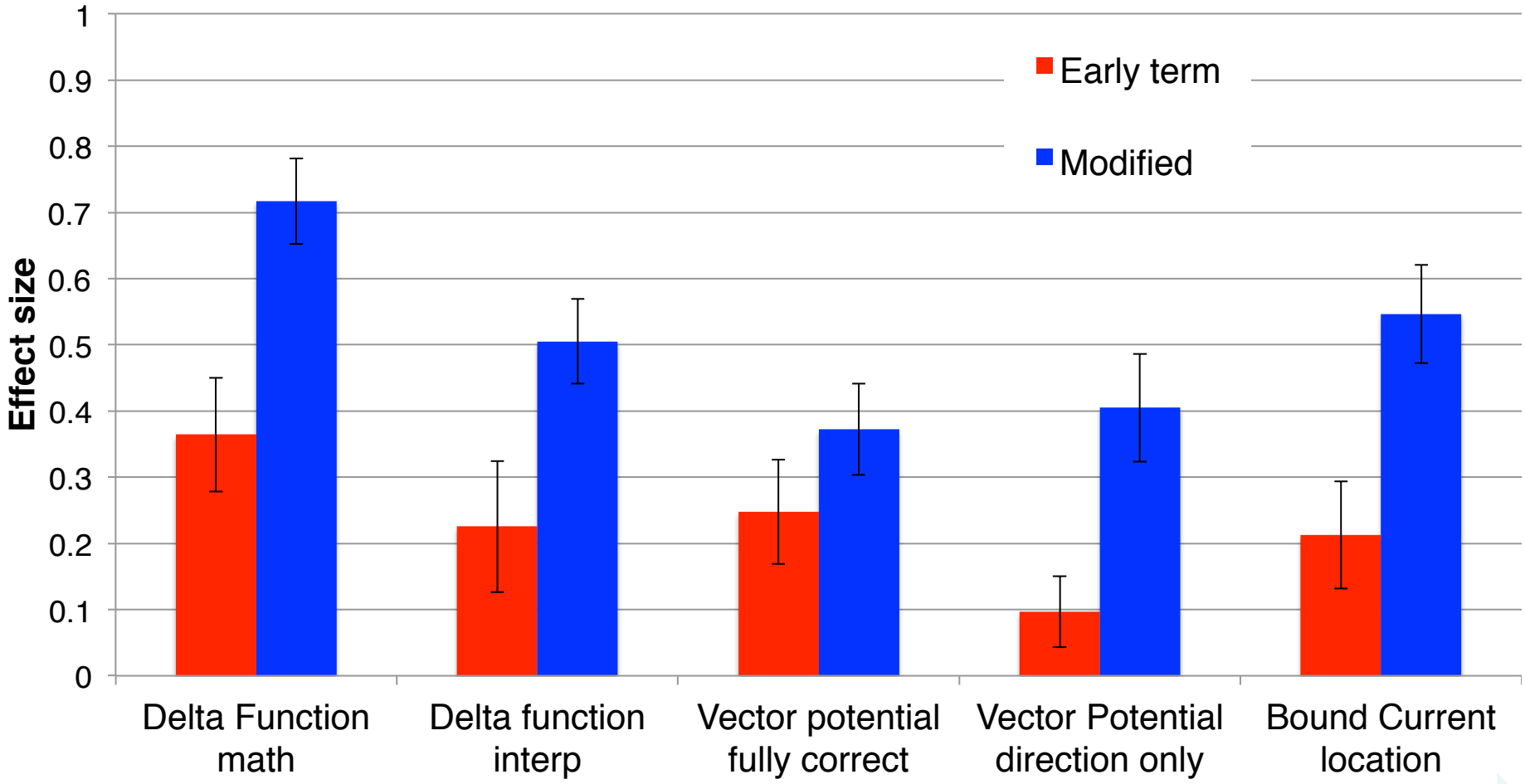
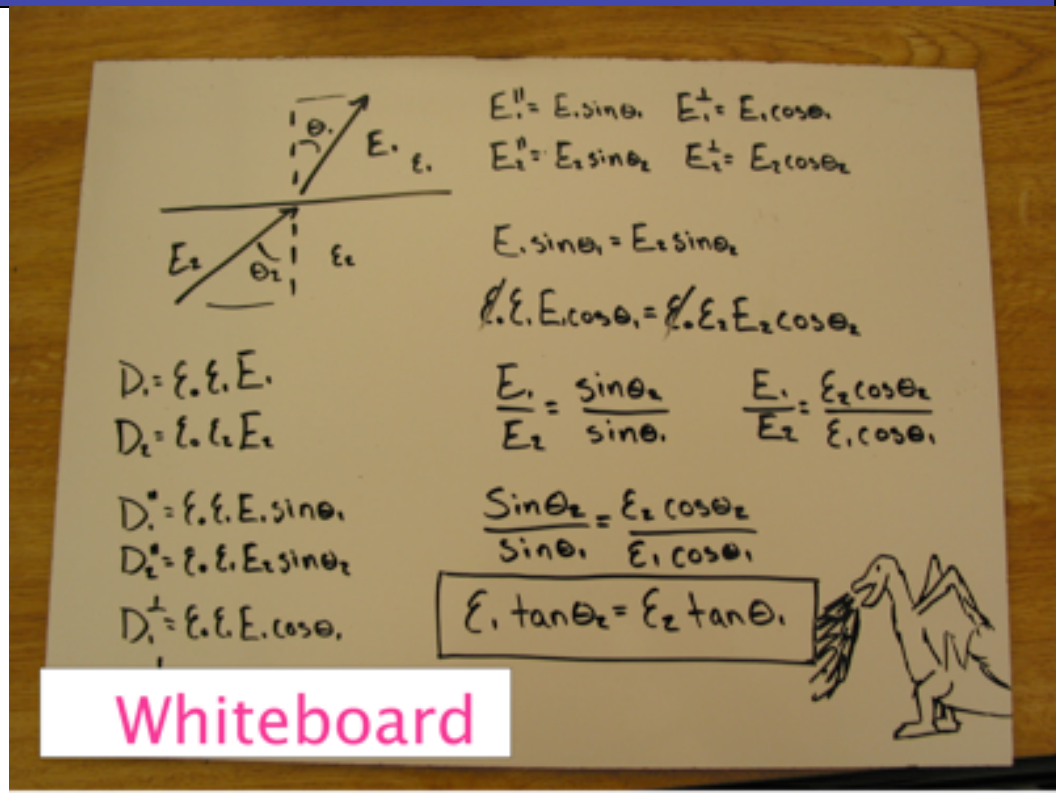


Classroom Techniques

- Traditional lecture, *blended with*

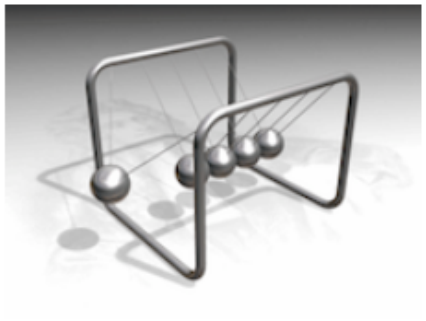
  interactive engagement (e.g. concept tests)
- Simulations & demos
- Small handheld whiteboards
- Tutorials (in or out of class)



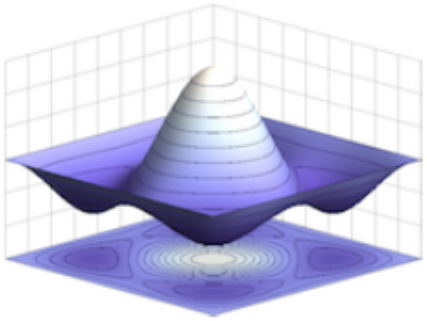
Resources

per.colorado.edu/sei/

Phys 2210: Classical Mechanics / Math Methods



Phys 3220: Quantum I

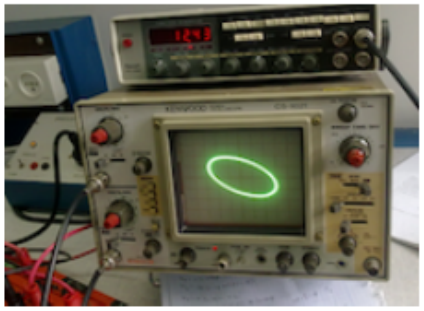


Phys 2130: Modern Physics

Phys 3310: Electricity & Magnetism I (statics)

Phys 3320: Electricity & Magnetism II (dynamics)

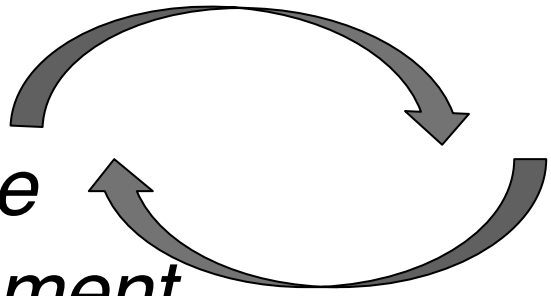
Phys 3340, 4430, 5430: Advanced Lab



Course transformations

Research-based

- Tutorials
- Clicker Questions
- Class activities
- Homeworks



reflective development

Research-validated

- Consensus learning goals
- valid/reliable instruments
- interviews , observations
- pre/post assessments (intermediate or course scale)

Parting thoughts

Course transformation (and broader questions) focusing on upper-div are still at an early stage

- What is the nature of UD student difficulties?
- Do the means to address these differ in substantial ways from lower division?

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Course transformation (and broader questions) focusing on upper-div are still at an early stage

- What is the nature of UD student difficulties?
- Do the means to address these differ in substantial ways from lower division?
- Can we improve student performance in "the canon"?
- What forms of data support faculty buy-in, & how far and how fast can/should we push?

Summary

We are transforming upper division classes:

- Impact on content learning

Included faculty (buy-in?)

Developing materials and resources

Developing assessment instruments

Summary

We are transforming upper division classes:

- Impact on content learning

Included faculty (buy-in?)

Developing materials and resources

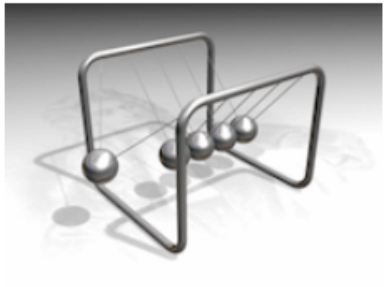
Developing assessment instruments

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

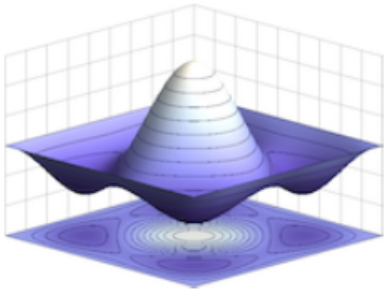
Questions!

Upper division: per.colorado.edu/sei

Phys 2210: Classical Mechanics / Math Methods



Phys 3220: Quantum I



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