Overview of Education Research and Teacher Preparation at the University of Colorado

PER @ CU-Boulder

PHYSICS EDUCATION RESEARCH AT CU-BOULDER
PER.COLORADO.EDU

Joel C. Corbo

Outline

- History of physics education research in the United States
- An overview of physics education research at Boulder
- Some more depth on institutional change (my work!)

What is physics education research?

Physics education research (PER) is the study of how students learn physics.

- **Theoretical:** models of student learning, identity formation, skills development
- **Experimental:** instruments to assess students learning, attitudes and beliefs, impact of interventions
- **Applied:** curricula, teaching techniques, extracurricular programs

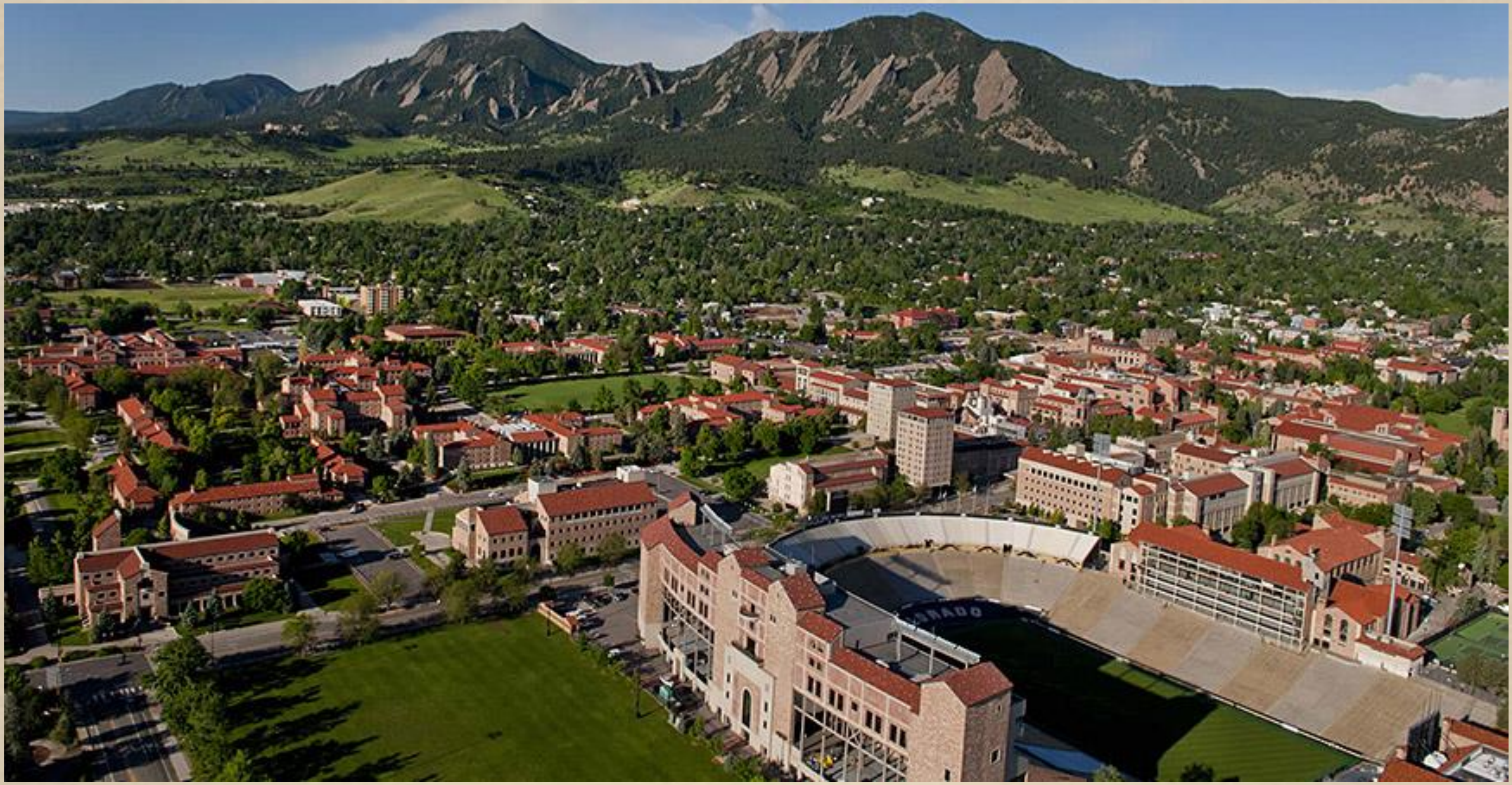
In the US, PER mostly focuses on **undergraduate** physics education.

Brief history of PER in the US

- 1970s: PER emerges as a field (~12 professors at ~5 universities, all “switchers”)
- 1976, ‘78, ‘98: first three successful PER tenure cases at research universities
- 1977: first Ph.D. in PER, from a School of Education
- 1979: first Ph.D. in PER, from a physics department
- 1992: first conceptual assessment published
- 1993: first PER postdoc
- 1996: first commercial publication of PER curricula
- 1997: first annual PER conference
- 1999: American Physical Society: PER is a field of physics
- 1999, ‘01, ‘05: PER journals established

PER groups in the US

CU Boulder



CU Boulder

Public research university

Founded in 1876 (five months before Colorado statehood)

Professors: 2,200 academic and 2,000 research

Students: 27,000 undergraduate and 5,200 graduate

Colleges include: Arts & Sciences; Business; Education; Engineering; Law; Music; Environmental Design; and Media, Communication, and Information

PER at CU

PER group founded in 2003

Research areas:

- Science teacher preparation
- Interactive "PhET" simulations
- Student learning in laboratory and upper-division courses
- Diversity in physics
- Informal physics education
- Institutional change in higher education

Faculty:

- Melissa Dancy
- Michael Dubson
- Noah Finkelstein
- Heather Lewandowski
- Valerie Otero
- Kathy Perkins
- Steven Pollock

Postdocs/Research Scientists:

- Michael Bennett
- Stephanie Chasteen
- Joel Corbo
- Dimitri Dounas-Frazer
- Emily Moore
- Jacob Stanley
- Bethany Wilcox

Students:

- Simone Hyater-Adams
- Allie Lau
- Ian Her Many Horses
- Jessica Hoy
- Laura Kiepura (UG)
- Elise Morgan (UG)
- Katie Rainey
- Enrique Suarez

Science Teacher Preparation

Physics in Everyday Thinking (PET): a one-semester curriculum for elementary school students (also adapted for high schools, college physics, science methods courses, and elementary teacher workshops)

- Student-oriented pedagogy to help students develop physics ideas
- Learning about Learning component, to help students learn about the nature of science and the learning processes of elementary school students

Learning Assistant (LA) program: undergraduate LAs hired to support small-group interactions in STEM courses.

- Students interact with one another, problem-solve collaboratively, and articulate and defend their ideas
- LAs learn about teaching, and are encouraged to pursue K-12 teaching licenses

Valerie Otero

PhET Simulations

The PhET Interactive Simulations project creates free interactive math and science simulations.

- **134 sims** for physics, biology, chemistry, earth science, and math
- 82 translated to **Norwegian**!
- New **iPad app**!

PhET conducts **research** on sim design and use (4-6 interviews per sim) to better understand:

- How and why sims promote learning
- How students engage and interact with sims
- How to use sims in different learning environments

Current research projects include designing sims for **vision-impaired students.**

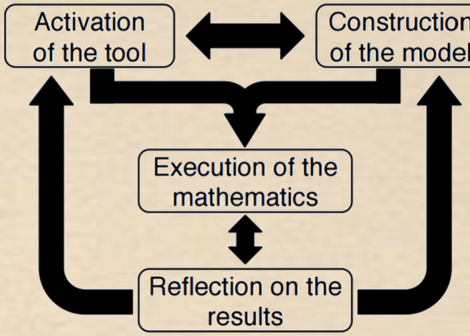
Kathy Perkins

Emily Moore

Elise Morgan

Learning in upper-division physics

ACER framework: Theoretical framework to explore how and why students use particular mathematical tools when solving physics problems.



Steve Pollock

Colorado Upper-division Electrostatics (CUE) diagnostic: Instrument to assess student conceptual understanding of upper-division electrostatics.

Bethany Wilcox

Q5 - A charged, insulating solid sphere of radius R with a uniform volume charge density ρ_o, with an off-center spherical cavity of radius r carved out of it (see Figure).

Find $\vec{E}$ or V at point P, a distance $4R$ from the sphere.

Select only one: **The easiest method would be ...**

A. Direct Integration
B. Gauss's Law
C. Separation of Variables
D. Multipole Expansion
E. Ampere's Law
F. Method of Images
G. Superposition
H. None of these

because ...(select **ALL** that support your choice)

a. ☐ you can calculate $\vec{E}$ or V using the integral form of Coulomb's Law
b. ☐ the sphere will look like a dipole; approximate with $\vec{E}$ or V for an ideal dipole
c. ☐ $\vec{E}$ or V outside a uniform sphere is the same as from a point charge at the center
d. ☐ the location of the cavity doesn't matter, you just need $Q_{enclosed}$ to calculate $\vec{E}$
e. ☐ you can treat this as two uniform spheres, one with charge density ρ_o and one with charge density $-\rho_o$
f. ☐ this will be the same as a uniform sphere with total charge $\frac{4}{3}\pi(R^3 - r^3)\rho_o$
g. ☐ electric fields from multiple sources can be combined through a vector sum
h. ☐ $\nabla^2 V = 0$ outside the cube and you can solve for V using Fourier Series

Learning in physics labs

Studies about learning in physics lab courses focus on how students obtain experimental research skills in the context of upper-division instructional labs.

- **E-CLASS:** Large-scale national survey about students' attitudes and beliefs about experimental physics
- **Modeling:** Observing students' use of model-based reasoning as they complete experimental physics tasks
- **Communication:** Characterizing students' practices for documenting progress on experimental physics tasks
- **Ownership:** Identifying instructional practices that facilitate students' sense of ownership over projects

For more details on some of this work:

- Dimitri will be presenting tomorrow on reflection
- Jacob will be presenting Thursday on communication

Heather Lewandowski

Dimitri Dounas-Frazer

Jacob Stanley

Laura Kiepura

Informal physics education

Partnerships for Informal Science Education in the Community (PISEC): provides opportunities for university students to teach inquiry-based science activities to K-12 populations that are underrepresented in science.

Research areas:

- **K-12 students:** changes in content knowledge and attitudes and beliefs about science.
- **University students:** changes in teaching ability, the ability to communicate in everyday language, and attitudes and beliefs about outreach.
- **Both:** Intersection of racial identity and science identity

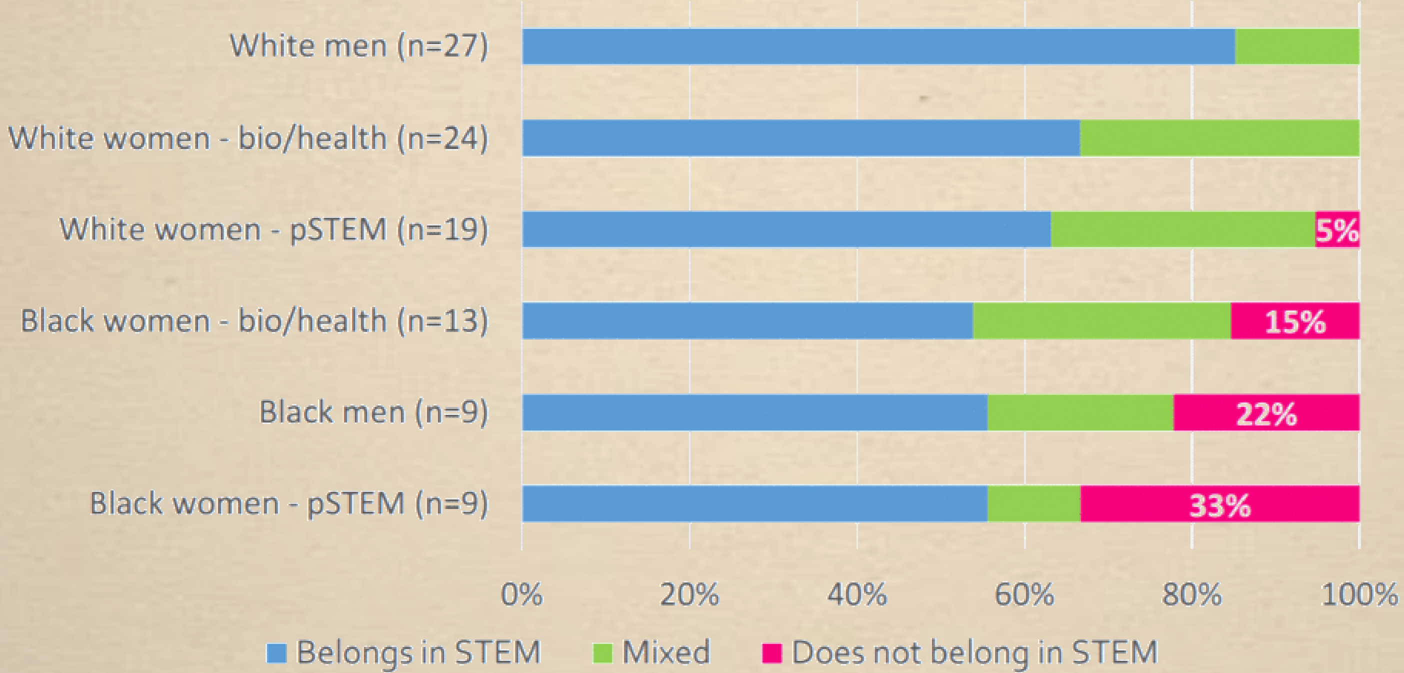
Michael Bennett

Simone Hayter-Adams

Diversity in physics/STEM

Large qualitative dataset: interviews conducted with 317 college seniors in North Carolina (107 STEM majors).

Analysis of question **"Do you feel like you belong in your major? Did you ever feel out of place?"**



Melissa Dancy

Katie Rainey

Change in higher education

STEM Institutional Transformation Action Research (SITAR) Project: influence the culture of STEM departments to improve undergraduate education.

Features of target departmental culture:

- Students are viewed as partners in the education process.
- Educational experiences are designed around clear learning outcomes.
- Educational decisions are evidence-based.
- Active collaboration and positive communication exist within the department and with external stakeholders.
- The department has processes for creating shared vision, assessing progress, learning, and iterating.
- The department values inclusiveness, diversity, and difference.

Noah Finkelstein

Joel Corbo

Improving STEM education is hard!

INTENDED OUTCOME

ASPECT TO BE CHANGED	PRESCRIBED	EMERGENT
INDIVIDUALS	Disseminating Curriculum & Pedagogy 30.4%	Developing Reflective Teachers 33.5%
ENVIRONMENTS	Enacting Policy 27.7%	Developing Shared Vision 8.4%

Henderson, Beach, and Finkelstein, *J. Res. Sci. Teach.* **48**, 952–984 (2011)

Typical change strategies (disseminating curriculum & enacting policy) don't create sustained, systemic change

Departmental Action Teams

Departmental Action Teams (DATs) are externally-facilitated groups that consist of faculty, staff, and students within a single department working on a broad-scale educational issue of departmental importance.

Design principles:

- Diverse Membership
- Participant Agency
- Vision- & Outcomes-driven
- Sustainability
- Regular Meetings
- Frequent Wins
- Evidence-based Decisions
- External Facilitation

Example DAT: Potions Department

Area of Focus (chosen by participants): The underrepresentation of women and students of color among undergraduate majors

5 participants (2014–2015 academic year)

- 2 tenured, 2 untenured, 1 postdoc
- 2 women, 3 men

13 participants (2015–2016 academic year)

- 1 tenured, 3 untenured, 2 staff, 3 grad students, 2 undergrad
- 8 women, 3 men

31 1-hour meetings over 2 years

2 facilitators (including me)

Example DAT: Activities & Outcomes

Major activities & outcomes:

- Analysis of 10-year **dataset** on student trajectories through the major, and creation of a **report** for the department
- Led project to **redesign department website** to help attract and retain underrepresented students
- Led conversations about **excellence, inclusion, and exclusion** within the department and collected ideas for improvement
- Organized outreach to **admitted students**, especially women and students of color
- Identified gaps in the current student **mentoring** system
- Working with building manager designate some **gender-neutral bathrooms**
- Creation of a **Committee on Representation, Retention, and Recruitment**

Example DAT: Participant Quotes

DAT participants felt that the DAT was a **valuable use of their time**, they were **making change**, and they were engaging with **people who care**.

> "I enjoyed talking with those people, I enjoyed thinking about those issues . . . I liked to hang out with them for an hour every two weeks."

> "It's valuable in that I feel like we are moving towards really effecting change."

> "Why are so many of these things the DAT did . . . not part of the department plan? . . . It's frustrating to me that the [department] community here doesn't seem to care . . . So working with people who care . . . that was just really nice."

Example DAT: Participant Quotes

Facilitation was essential to the success of the DAT.

> “They kept us on track. They made sure that there was communication all the time. They did what . . . a typical faculty member won't do, which is to send emails and to hold people to a meeting schedule and to assign jobs.”

> “Having [the facilitators] moderate the DAT seems to reduce any preexisting hierarchy among members of the DAT that exists from department structures. This is appreciated by us junior members!”

Questions?