# 2014 Physics Education Research Conference

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PREFACE

The theme of the 2014 Physics Education Research Conference was “Outpacing New Technologies with Novel Pedagogies: The Role of PER in the Transforming Landscape of Higher Education.” This conference highlighted the interaction of educational technologies with new pedagogical approaches to classroom teaching such as MOOC, flipped classrooms and online courses. The roughly 305 conference attendees were encouraged to gain a deeper understanding of these technology-driven classroom environments and to consider how physics education researchers can guide and assess these environments. This year’s conference presented 162 contributed posters over two sessions, six symposium sessions with 32 poster presentations, a workshop on Raising Calculus to the Surface in Physics: Explorations using Surfaces, and three roundtable discussions on Flipped Physics Teaching, Competency-Based Assessment: Goals and a Research Agenda, and the Utility and Prospects of Computers Coaching Students in Physics.

This year’s AAPT/PERC Bridging Session highlighted work by Mike Dubson on “Apples vs. Oranges: Comparison of Student Performance in a MOOC vs. a Brick-and-Mortar Course” and Jim Fairweather on “Technology And Instructional Reform In STEM Education: Beyond the Classroom.” In addition to their papers, many contributed papers in this volume also address this year’s theme with the remainder representing the diversity of directions within PER which help this volume fulfill its purpose of providing an annual snapshot of the field.

The Editors thank this year’s conference organizers Danny Caballero, Mats Selen, and Tim Stelzer, the American Association of Physics Teachers (AAPT), and the Physics Education Research Leadership and Organizing Council (PERLOC) for putting together yet another successful and well-run meeting.

This marks the second year that the Proceedings will be published on-line through comPADRE with sponsorship by the American Association of Physics Teachers. The Proceedings’ online submission process for contributed papers and referee reports are supported each year by Lyle Barbato and Bruce Mason who work closely with the PERC Proceedings Editors to make improvements to the system and ensure that everything runs smoothly. We wish to thank Lyle and Bruce for their excellent work and ongoing commitment to the PER community and the PERC Proceedings.

Last but not least, this volume owes its existence to the referees, who volunteer their time and expertise to help improve the quality of the papers published in the Proceedings. This year we had 134 reviewers who reviewed the 103 papers submitted to the Peer Reviewed Section.

The Editors thank:

Elise Agra, John Aiken, Saalih Allie, Nathaniel Amos, Cecilia Astolfi, Gordon Aubrecht, II, Ryan Badeau, Charles Baily, Ramón Barthelemy, Ian Beatty, Robert Beichner, Jennifer Blue, Scott Bonham, Andrew Boudreaux, Andre Bresges, Eric Brewe, David Brookes, Benjamin Brown, Juan Burciaga, Marcos Caballero, Ying Cao, Stephanie Chasteen, Jacquelyn Chini,

See you next summer in Baltimore!

Paula V. Engelhardt
Outgoing Editor
Conference Overview

Outpacing New Technologies with Novel Pedagogies: The Role of PER in the Transforming Landscape of Higher Education

Students' unprecedented access to information on-line is dramatically and irreversibly transforming higher education. This transformation provides fantastic opportunities to improve education, but at the same time we are presented with the equally fantastic risk of losing the core elements that make higher education so valuable. Whether it has been on-line homework, electronic voting systems, or screen-casted lectures, the physics community has been on the bleeding edge of new educational technology.

Our community must engage in a scholarly dialog around these new environments including the opportunities they afford, the challenges they present, and the research enterprise necessary to address these. The opportunities for access and equity in MOOC, on-line, hybrid, and flipped classrooms, as well as the challenges these new educational models present for engagement, assessment, and community development are all important aspects to consider. Conference participants will gain deeper insight into these technologically-driven environments by discussing the magnitude and rapidity of these changes, developing an understanding of the national dialog around on-line education, and discussing how physics education research can guide the development of new pedagogies for and assessments of these environments. We are grateful to all of the speakers, session organizers and participants for creating such an exciting and thought-provoking conference.

Organizers:

Danny Caballero, Michigan State University
Mats Selen, University of Illinois at Urbana-Champaign
Tim Stelzer, University of Illinois at Urbana-Champaign

The organizing committee of the PERC 2014 would like to express gratitude to the following individuals for their invaluable assistance in creating this conference:

The plenary speakers: Michael Dubson, James Fairweather, Ken Koedinger, and Carl Wienman; Lyle Barbato and Bruce Mason with ComPADRE; Tiffany Hayes, Cerena Cantrell, Janet Lane, and Pearl Watson from AAPT; and the PERC Proceedings Editors: Paula Engelhardt, Alice Churukian and Dyan Jones.
**Program**

**WEDNESDAY, JULY 30**

3:00 – 4:30 pm  | BRIDGING SESSION  
Northrop Auditorium  | Speaker: **Mike Dubson**  
  | Apples and Oranges: Comparing a MOOC with a Standard Class

Speaker: **Jim Fairweather**  
Technology and Instructional Reform in STEM Education: Beyond the Classroom

5:00 – 6:30 pm  | BANQUET AND KEYNOTE  
Meridian Ballroom  | Speaker: **Ken Koedinger**  
  | From Cognitive Science to Physics Education and Back

7:00 – 8:30 pm  | CONTRIBUTED POSTER SESSION I  
Meridian  | Odd-numbered posters: 7:00 – 7:45 pm  
Foyer/Summit  | Even-numbered posters: 7:45 – 8:30 pm

**THURSDAY, JULY 31**

8:30 – 10:00 am  | CONTRIBUTED POSTER SESSION II  
Meridian  | Odd-numbered posters: 8:30 – 9:15 am  
Foyer/Summit  | Even-numbered posters: 9:15 – 10:00 am

10:30 – 12:00 am  | PARALLEL SESSION I  
Pathways  | Getting Involved in Online PER  
Think 4  | Reform expansion beyond a single classroom  
Pinnacle  | Gender issues in introductory physics: Recruitment, performance, and retention
Inventor 1  | Raising Calculus to the Surface in Physics: Explorations using Surfaces  
Think 3  | The utility and prospects of computers coaching students in physics

12:00 – 1:30 pm  | LUNCH

1:30 – 3:00 pm  | PARALLEL SESSION II  
Pathways  | Competency-Based Assessment: Goals and a Research Agenda  
Think 4  | Game-Based and Game-Informed Approaches to Physics Instruction  
Pinnacle  | Using technology to enhance physics teaching: Research-based technology innovations
Inventor 1  | Flipped Physics Teaching  
Think 3  | Instructional Goals and Research Methods in the International PER community: A GIREP Symposium

3:30pm - 4:15pm  | PLENARY SUMMARY TALK  
Meridian Ballroom  | Speaker: **Carl Wieman**  
  | A Synthesis and Wrap Up of PERC 2014
Apples and Oranges: Comparing a MOOC with a Standard Class

Michael Dubson, University of Colorado at Boulder

In the Fall of 2013, we taught Physics 1 (Calc-based Mechanics) to 800 tuition-paying freshmen at the University of Colorado at Boulder. Almost simultaneously, we taught a MOOC version of the course, through Coursera, to an initial audience of 15,000 students from around the world. We made the two versions of the course as similar as possible. The MOOC students saw the same lectures, with the same Concept Tests, received the same homework assignments, and took the same exams with same time constraints, as the students in the brick-and-mortar course. The physics background knowledge FMCE pre-test scores of the two groups were remarkably similar, but less than 2% of those enrolled in the MOOC had the grit to complete the course. Those gritty 2% performed almost as well as our CU freshmen students with matching pretest scores.

Technology and Instructional Reform in STEM Education: Beyond the Classroom

James Fairweather, Michigan State University

Research in postsecondary education has focused on the pedagogical effectiveness of technology in the classroom. Most relevant literature focuses on students’ cognitive development, professional development of faculty members, and course and curricular translation into digital platforms. The AAU Initiative for the Reform of Undergraduate Education shows that many of the factors affecting the successful use of technology in STEM education lie beyond individual faculty members and students. Reward structures that influence faculty time allocation are set at the institutional level. Administrators select educational software to control costs rather than to maximize learning. This presentation draws on recent experience with the AAU Initiative to describe the variety of factors potentially affecting faculty and student use of technology in teaching and learning.
Active Learning Works: What Next? How technology can help develop better learning theory and applications

Kenneth R. Koedinger, Carnegie Mellon University

Learning by doing has long history of proponents from John Dewey through Herbert Simon to many contemporary discipline-based education researchers, especially in physics education. We can build on this history by not only applying relevant theory in course designs and evaluation, but by also adding to theory of what active learning strategies work, why they work, and under what circumstances. I present an analysis of instructional complexity indicating 30 dimensions of instructional design options that, when combined, produce trillions of possible instructional choices. We need more theory to understand when “active” methods are not helpful, when certain “passive” methods are, and what are the best combinations given the specific nature of the cognitive processes we want our course to change. I illustrate the use of cognitive task analysis methods to develop cognitive models that guide the design of instructional materials including advanced educational technologies. I will discuss examples of such technologies that have not only been a way to personalize and scale active learning methods, but they have also provided a scientific instrument to help advance learning theory.

A Synthesis and Wrap Up of PERC 2014

Carl E. Wieman, Stanford University