PERLOC

Physics Education Research Conference 2009:

Physics Education Research across Paradigms

July 29-30, 2009
The University of Michigan, Ann Arbor MI

Like the Chicago Bean reflects the city in an unforgettable way, we hope that PERC2009 will help you reflect on your research and teaching and make your summer AAPT and PERC conferences an unforgettable experience.

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Additional Information, email addresses, etc. can be found at:

http://www.compadre.org/PER/perc/browse.cfm

The PERC 2009 Organizing Committee would like to express our gratitude to the following individuals who went beyond the call of duty in helping us with the Conference organization. Without them the organization of PERC2009 would have been impossible:

Lyle Barbato, Cerena Cantrell, Noah Finkelstein, Tiffany Hayes, Warren Hein, Charles Henderson, Mike Loverude, Bruce Mason, Mel Sabella, Rachel Scherr, Chandralekha Singh, and John Thompson.

Introduction: About PERC2009 – Physics Education Research across Paradigms

Did you ever wonder how neurologists, psychologists, sociologists or anthropologists study 'Learning' by looking at fundamentally different things? Can a similar 'Learning' phenomenology be present in neural function, cognitive processes, social participation or culture mediation?

Those interested in understanding 'Learning' from more than one perspective usually encounter the acrimonious relationship between researchers working in different paradigms (see for eg. Anderson, Reder and Simon, 1996; Greeno, 1997; Anderson, Reder and Simon, 1997; Anderson, Reder, Greeno and Simon, 2000). This led UC Berkeley Mathematician and former American Educational Research Association president Alan Schoenfeld to claim in his 1999 AERA presidential address :

> "*there is still, in large measure, a schism between "fundamentally cognitive" and "fundamentally social" studies of human thought and action*".

PER is an effervescent and unique field of research that implicitly resides at a crossroad between diverse traditions and frameworks adopted to study learning: cognitive constructs, social and cultural dynamics and increasingly neural processes. Although individual PER researchers work within preferred paradigms, as a whole PER has not been exclusive in its commitment to a single paradigm.

The theme of PERC 2009 is "Physics Education Research Across Paradigms." The conference features leading researchers in cognitive psychology, in social and cultural studies and in neuroscience: Andrea diSessa, Anna Sfard, Michael Posner and Kevin Dunbar. These researchers will shed light on how cutting-edge research on learning is conducted within each framework and how different research methodologies apply to PER.

The purpose of this conference is to ask collectively how 'Learning' can be studied in PER. One of the objectives of PERC 2009 is to identify the characteristic properties of various research frameworks and the kinds of questions each framework can answer best. By looking at the different frameworks used to study learning and the interplay between them, a goal of PERC 2009 is to build bridges between the frameworks and bridges between our community and researchers in the various disciplines. The ultimate goal of PERC 2009 is to work towards "*an integrated theoretical perspective that provides an adequate unified view of the way we think and act*" (Schoenfeld, 1999). We expect attendees to have a broader understanding of 'Learning' as construed within different paradigms and consequently to have a broader palette of tools to use when doing PER.

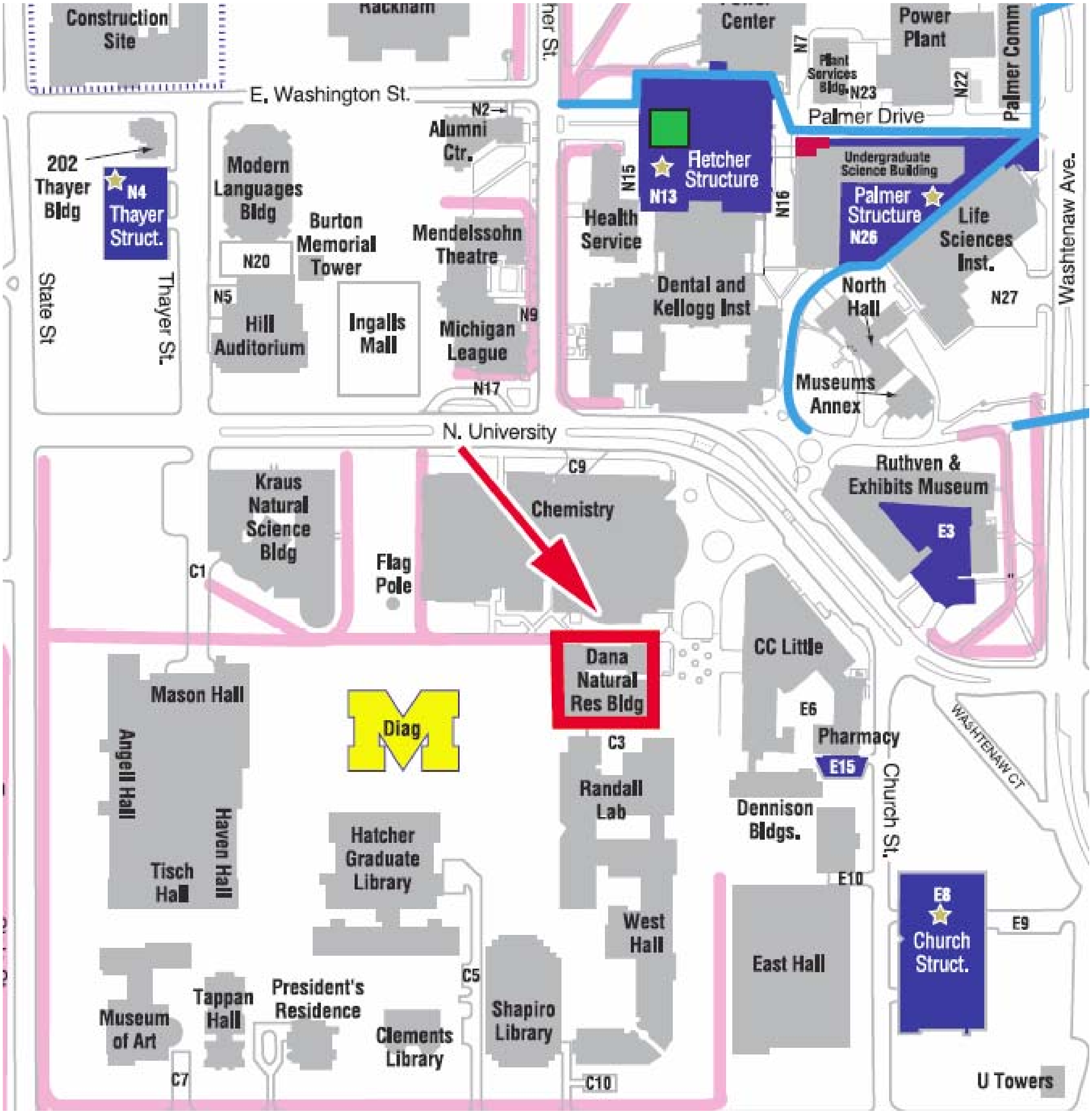
With the best wishes for a productive Conference, PERC2009 organizers

Tetyana Antimirova, Nathaniel Lasry and Marina Milner-Bolotin

References:

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher*, 25(4), 5-11.
Anderson, J. R., Reder, L. M., & Simon, H. A. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher*, 26(1), 18-21.
Greeno, J. G. (1997). On claims that answer the wrong questions. *Educational Researcher*, 26(1), 5-17.
Schoenfeld, A. (1999). Looking toward the 21st Century: Challenges of educational theory and practice. *Educational Researcher*, 28(7), 4-14.

Map of the University of Michigan



Buildings of interest for PERC 2009: Dennison, Dana Natural Resource Building, Michigan League Ballroom

PERC2009 Schedule at a Glance

Time	Session	Location
	Wednesday, July 29th	
3:30 pm – 5:30 pm	**PER Bridging Session**: Three presentations by invited speakers and a discussion	Dennison 170
6:00 pm – 10:00 pm	**Banquet & Contributed Poster Session Part I:** all posters are displayed (odd - numbered posters are discussed from 8:00 pm – 9:00 pm and even-numbered posters are discussed from 9:00 pm – 10:00 pm.)	Michigan League Ballroom
	Thursday, July 30th	
8:30 am – 9:45 am	**Special Session 1**: Invited Workshops; Targeted Poster Sessions, Round Table Discussions	Dana 1024, 1028 Dennison 110, 120, 130
9:45 am – 10:00 am	Coffee Break	Michigan League Concourse
10:00 am – 10:55 am	**Poster Session Part II:** all posters are displayed (odd - numbered posters discussed from 10:00 am – 10:25 am; even-numbered posters discussed from 10:30 am – 10:55 am.)	Michigan League - Hussey and Vandenbur
11:00 am – 12:15 pm	**Special Invited Speaker Panel**	Dennison 170
12:15 pm – 1:30 pm	**Lunch**, Announcements, etc.	Michigan League Concourse (Michigan Room)
1:30 pm – 2:30 pm	**Special Session 2:** Invited Workshops; Targeted Poster Sessions, Round Table Discussions	Dana 1024, 1028 Dennison 110, 120, 130
2:30 pm – 2:45 pm	Coffee Break	Michigan League Concourse
2:45 pm – 3:45 pm	**Special Session 3:** Invited Workshops; Targeted Poster Sessions, Round Table Discussions	Dana 1024, 1028 Dennison 110,120, 130
4:00 pm – 5:30 pm	**Round Table Report:** Conference summary and Q&A session.	Dennison 170

Invited Talks: Wednesday, July 29, 2009

3:30 pm - 5:30 pm

PER Bridging Session (Dennison 170)

Presiding: Lasry

3:30 pm

Bridging Cognitive and Neural Aspects of Classroom Learning

Michael Posner, Sackler Institute for Developmental Psychobiology, mposner@uoregon.edu

A major achievement of the first twenty years of neuroimaging is to reveal the brain networks that underlie fundamental aspects of attention, memory and expertise. We examine some principles underlying the activation of these networks. These networks represent key constraints for the design of teaching. Individual differences in these networks reflect a combination of genes and experiences. While acquiring expertise is easier for some than others the importance of effort in its acquisition is a basic principle.

Networks are strengthened through exercise, but maintaining interest that produces sustained attention is key to making exercises successful. The state of the brain prior to learning may also represent an important constraint on successful learning and some interventions designed to investigate the role of attention state in learning are discussed. Teaching remains a creative act between instructor and student, but an understanding of brain mechanisms might improve opportunity for success for both participants.

4:00 pm

Causality in Pieces: The Construction of Causal Schemes

Andrea diSessa, University of California at Berkeley, adisessa@soe.berkeley.edu

I will present two case studies of different early high school classes constructing (with no direct instruction from teachers) ways of explaining temperature equilibration. Students were asked to explain, when a cold glass of milk is left on the kitchen table, how and why does it come to room temperature? The first case study shows an unusually clear example where students build an essentially correct causal explanatory scheme (Newton's law of heating) pretty much simply by combining a number of reasonably well-documented intuitive ideas. The second case study shows a similar construction, but of an incorrect causal scheme. Because the elements used in the first case have been reasonably well-studied, we can determine both what had to change in the pieces and how the pieces were combined. This leads to a list of plausibly general "mechanisms of learning.

4:30 pm

Moving between Discourses: From Learning-as-Acquisition to Learning-as-Participation

Anna Sfard, Michigan State University, sfard@netvision.net.il

These days, the times of incessant changes, everything seems to be fluid, including our ways of looking at the world and of talking about it. Although easily noticeable also in 'hard' sciences, nowhere is this conceptual fluidity more conspicuous than in research on human learning. In this talk, after a very brief historical review, I will concentrate on two basic metaphors for learning in which current educational research seems to be grounded: the metaphors of learning-as-acquisition and of learning-as-participation. It will be claimed that these metaphors generate discourses which are incommensurable rather than incompatible - discourses which, although seemingly contradictory, can live side by side without any risk to the consistency of the research enterprise. Researches should be choosing their leading metaphor according to their needs. Using empirical examples as illustration, I will discuss the relative advantages and disadvantages of each of the two options.

5:00 pm

Questions to the invited speakers

***Contributed Posters should be set up between 5:30 pm and 8:00 pm**

6:00 pm - 10:00 pm

Banquet and Poster Session - ***ticket required***

Presiding: Milner-Bolotin

6:00pm (Michigan League Ballroom)
The Biology of Physics: What the Brain Reveals about our Understanding of the Physical World
Kevin Niall Dunbar, University of Toronto, dunbar@utsc.utoronto.ca

Fundamental concepts in physics such as Newtonian mechanics are surprisingly difficult to learn and discover. Physicists, philosophers, and educators have painstakingly detailed the use of concepts such as force yet the underlying mechanisms involved in the use of these concepts has been elusive. Over the past decade we have been using functional Magnetic Resonance Imaging (fMRI), brain damaged populations, and other neuroimaging techniques to uncover the neural substrates of conceptual change. Using tasks derived from physics, chemistry, and biology we have found that conceptual change often involves the inhibition of prior knowledge and/or the recategorization of knowledge. The specific brain sites that we have discovered as being involved in conceptual change are the prefrontal cortex, the anterior cingulate as well the dorsolateral prefrontal cortex. These regions are part of a network of brain sites that are involved in changes in knowledge use that are modulated both by experience and situational factors. In this presentation I outline our findings and the implications for educational interventions.

8:00pm, Contributed Poster Session PART I, Cash Bar*
Posters will remain on display for the duration of the conference

8:00 pm - 9:00 pm (odd-numbered posters) and 9:00 pm – 10:00 pm (even- numbered posters)

*All contributed posters will be displayed.

Biographies of Invited Speakers

Andrea diSessa, University of California at Berkeley, Graduate School of Education

Corey Professor of Education Andrea diSessa is a member of the National Academy of Education. He has a PhD in physics from MIT, and an AB, also in physics, from Princeton. His research centers around conceptual and experiential knowledge in physics, and large-scaled and deep implications of the use of computers in education ("new literacies"). His current work focuses on student ideas concerning "patterns of behavior and control"--aka dynamical systems theory. He was a fellow at the Center for Advanced Study in the Behavioral Sciences in 1997-98 and 2007-08. He wrote the books Changing Minds: Computers, Learning and Literacy (2000); and Turtle Geometry: The Computer as a Medium for Exploring Mathematics (with H. Abelson, 1981); and edited the volume Computers and Exploratory Learning (with C. Hoyles, R. Noss, and L. Edwards, 1995).

Kevin Niall Dunbar, University of Toronto

Professor of Psychology

Kevin Dunbar grew up in Bray, County Wicklow, Ireland. He attended The National University of Ireland at University College, Dublin where he obtained a B.A. and M.A degrees. In 1980 he began work on his PhD. in the Department of Psychology at the University of Toronto working on attention and automaticity. In 1985 he moved to Carnegie Mellon University to begin postdoctoral work with Professor David Klahr on reasoning and problem solving in science. They developed a model of scientific reasoning and proposed a dual space search model of scientific thinking in both adults and children. In 1988 he moved to McGill University in Montreal to become Assistant professor of Psychology. He continued his work on scientific thinking and discovery applying it to more complex domains such as molecular biology. At McGill, he pioneered a new way of investigating complex thinking in science, investigating scientists as they worked at their own lab meetings (using video, audio, photographs and documents supplemented by interviews. This new "invivo approach" makes it possible to investigate the social, cognitive, and situational factors that are at the core of science. Prof. Dunbar was promoted to Associate and then Full professor at McGill University. In 2001 he moved to Dartmouth College where he was both Professor of Education and Professor of Psychological and Brain Sciences. Here he helped pioneer the field of Educational Neuroscience conducting neuroimaging work on students' conceptual changes in both Physics and Chemistry, as well as investigating students' understandings of physics exhibits at science museums. In 2007 he moved to the University of Toronto Scarborough to become a professor of Psychology. His current research at Toronto is on the cognitive, social, and situational factors that lead students to leave the sciences. In particular he is investigating the events that happen in undergraduate science labs that may lead women and men students to abandon science. Coupled with this work, he continues to investigate the brain based mechanisms that lead students to ignore data that are inconsistent with their prior expectations, and impede students understanding and use scientific analogies. These parallel lines of research make it possible to provide accounts of the underpinnings of conceptual changes that occur in undergraduate science classes and suggest different types of interventions that could be used to benefit science education. The goals of this work are thus subsumed under the field of Educational Neuroscience first proposed by Petitto & Dunbar in 2004.

Michael Posner, Sackler Institute for Developmental Psychobiology

Professor Emeritus at the University of Oregon, Eugene Oregon

Adjunct Professor of Psychology in Psychiatry at the Weill Medical College of Cornell

Michael Posner is currently Professor Emeritus at the University of Oregon and Adjunct Prof. of Psychology in Psychiatry at the Weill Medical College of Cornell, where he served as founding director of the Sackler Institute. Posner developed with Marcus Raichle studies of imaging the human brain during cognitive tasks. He has also worked on the anatomy, circuitry, development and genetics of three attentional networks underlying maintaining alertness, orienting to sensory events and voluntary control of thoughts and ideas. His methods for measuring these networks have been applied to a wide range of neurological, psychiatric and developmental disorders and to normal development and school performance. His current research involves a longitudinal study of children prior to school designed to understand the interaction of specific experience and genes in shaping attention and self regulation.

Anna Sfard, Michigan State University

Lappan-Phillips-Fitzgerald Professor of Mathematics Education

Division of Science and Mathematics Education

Anna Sfard is a professor of mathematics education in the University of Haifa and has been the first holder of Lappan-Phillips-Fitzgerald endowed chair in Michigan State University. Her research focuses on the development of mathematical discourses in individual lives and in the course of history. She is the author of *Thinking as communicating: Human development, the growth of discourses, and mathematizing* and the recipient of 2007 Freudhental Medal for research in mathematics education.

https://www.msu.edu/~sfard/

Thursday, July 30th: Detailed Schedule

8:30 am – 9:45 am	**Special Session 1** **Invited Workshops (W), Targeted Poster Sessions (TP), Roundtable Discussions (RTD) PART I** **(W1) Methods and Experimental Designs in Cognitive Studies (Dennison 110)** *Jose P. Mestre, University of Illinois, mestre@uiuc.edu* *Michael Posner, University of Oregon, mposner@uoregon.edu* **(TP-A) Cognitive Issues in Developing Curriculum for Upper-Level Physics Courses (Dennison 120)** *Chandralekha Singh, University of Pittsburgh, Department of Physics, University of Pittsburgh, clsingh@pitt.edu* **(TP-B) Foundations of Course Reform for Introductory Physics (Dennison 130)** *David E. Pritchard, MIT, dpritch@mit.edu* *Analia Barrantes, MIT , analiab@mit.edu* *Andrew Pawl, MIT, aepawl@mit.edu* *Brian Belland, Utah State University , brian.belland@usu.edu* **(TP-C) Negotiating Meaning: Rethinking and Re-Interpreting Knowledge (Dana 1024)** *Edit Yerushalmi, edit.yerushalmi@weizmann.ac.il* **(W-2) Qualitative Research Methods (Dana 1028)** *Valerie K. Otero, University of Colorado at Boulder, valerie.otero@colorado.edu* *Kara Gray, University of Colorado at Boulder*
9:45 am–	**Break (15 minutes)**
10:00 am – 10:55 am	**Poster Session PART II. Refreshments provided (Michigan League – Hussey & Vandenburg).** All posters are displayed (odd - numbered posters discussed from 10:00 am – 10:25 am; even-numbered posters discussed from 10:30 am – 10:55 am.
11:00 am – 12:15 pm	**Special Invited Speaker Panel (Dennison 170)** *Presiding: Antimirova, Lasry, Milner*
12:15 pm – 1:25 pm	**Luncheon (Michigan Room, Michigan League Concourse)** ***Announcements, etc.***

Special Session 2

Invited Workshops (W), Targeted Poster Sessions (TP), Roundtable Discussions (RTD)

1:30 pm – 2:30 pm

PART II

(TP-B) Foundations of Course Reform for Introductory Physics (Dennison 130)

David E. Pritchard, MIT, dpritch@mit.edu; Analia Barrantes, MIT , analiab@mit.edu

Andrew Pawl, MIT, aepawl@mit.edu; Brian Belland, Utah State University , brian.belland@usu.edu

(TP-C) Negotiating Meaning: Rethinking and Re-Interpreting Knowledge (Dana 1024)

Edit Yerushalmi, edit.yerushalmi@weizmann.ac.il

(TP -D) Broadening Our Lens: Socio-Cultural Perspectives in PER (Part I: artifacts and mediation) (Dennison 110)

Noah Finkelstein,University of Colorado at Boulder, noah.finkelstein@colorado.edu
Chandra Turpen,University of Colorado at Boulder

(RTD-2) Cognition of an Expert Tackling an Unfamiliar Conceptual Physics Problem (Dennison 120)

David Schuster, Western Michigan University, david.schuster@wmich.edu
Adriana Undreiu, University of Virginia's College at Wise, Department of Natural Sciences

2:30 pm

Coffee Break (15 minutes): Refreshments provided (Michigan League Concourse)

Special Session 3

2:45pm – 3:45pm

Invited Workshops (W), Targeted Poster Sessions (TP), Roundtable Discussions (RTD)

PART III

(TP-A) Cognitive Issues in Developing Curriculum for Upper-Level Physics Courses (Dennison 120)

Chandralekha Singh, University of Pittsburgh, Department of Physics, University of Pittsburgh, clsingh@pitt.edu

(TP-E) Broadening Our Lens: Socio-Cultural Perspectives in PER (Part II: communities & social interaction) (Dennison 110)

Noah Finkelstein, University of Colorado at Boulder, Department of Physics, noah.finkelstein@colorado.edu
Chandra Turpen, University of Colorado

(RTD-1) Where do the Student Conceptions Come from? Light and Optics Case (Dennison 130)

Derya Kaltakci, Physics Education Group, Department of Physics, University of Washington, kaderya@metu.edu.tr Ali Eryilmaz, eryilmaz@metu.edu.tr

4:00pm – 5:30pm **Round Table Report (Dennison 170)**
Presiding: Antimirova, Lasry

Discussants & plenary speakers summarize the results of the RT sessions, posters and the entire conference; audience questions are welcome.

Led by round table speakers, targeted poster session discussants, and invited speakers

Descriptions of Invited Workshops

Thursday, July 30th

8:30 am

(W-1) Methods and Experimental Designs in Cognitive Studies (Dennison 110)

Jose P. Mestre, University of Illinois, mestre@uiuc.edu
Michael Posner, University of Oregon, mposner@uoregon.edu

Whereas PER focuses on how students learn and perform physics tasks (especially those we are interested in teaching them), cognitive psychology research (CPR) focuses more broadly on how the mind works when engaged in cognitive tasks. This talk will review some of the approaches to experimental design and methodology in CPR and PER, ranging from garden variety behavioral studies, to studies using eye-tracking devices functional Magnetic Resonance Imaging (fMRI), electroencephalography (EEG), magnetoencephalography (MEG) and transcranial magnetic stimulation (TMS). The strengths and weaknesses of each method will be addressed in terms of what can, and cannot be learned about human learning, cognitive performance, and ultimately teaching. The session will conclude with views of what PER and CPR can learn from each other.

(W-2) Qualitative Research Methods (Dana 1028)

8:30 am

Valerie K. Otero, University of Colorado at Boulder, valerie.otero@colorado.edu

This workshop for those who want to learn more about carrying out a qualitative research study. We will briefly review the Generic Inductive Analysis method and then participants will analyze two or three different types of qualitative data. Participants will code data, make claims, and support these claims with evidence from the data. We will also discuss benefits and limitations of qualitative research. Finally, we will review two different software packages for transcribing and analyzing data and we will review the article on qualitative research in the new volume Getting Started in PER. Participants will leave ready to launch into their own qualitative research study.

Descriptions of Invited Targeted Posted Sessions

Thursday, July 30th

8:30 am and 2:45 pm (offered twice)

(TP- A) Cognitive Issues in Developing Curriculum for Upper-Level Physics Courses

Chandralekha Singh, Department of Physics, University of Pittsburgh, clsingh@pitt.edu

In the last few decades, several exemplary introductory physics curricula have been developed that take into account cognitive issues in the teaching and learning of physics. This session will focus on how physics education researchers, in recent years, have begun developing and evaluating curricula for upper-level physics courses that account for cognitive issues. The poster presenters will discuss cognitive approaches to designing upper-level physics curriculum pertaining to different subject matters. They will particularly focus on analyzing the issues that are common across different subject matters and those that are particularly important for their topic of interest. Presenters will also discuss the importance of various cognitive issues in the design of upper-level courses compared to their importance in developing introductory physics curriculum.

TP1. Observations of General Learning Patterns in an Upper-Level Thermal Physics Course

David E. Meltzer, Arizona State University

I will discuss some observations from using interactive-engagement instructional methods in an upper-level thermal physics course over a two-year period. From the standpoint of the subject matter knowledge of the upper-level students, there was a striking persistence of common learning difficulties previously observed in students enrolled in the introductory course, accompanied, however, by some notable contrasts between the groups. More broadly, I will comment on comparisons and contrasts regarding general pedagogical issues among different student sub-populations, for example: differences in the receptivity of lower- and upper-level students to diagrammatic representations; varying receptivity to tutorial-style instructional approach within the upper-level population; and contrasting approaches to learning among physics and engineering sub-populations in the upper-level course with regard to use of symbolic notation, mathematical equations, and readiness to employ verbal explanations.

TP2. Learning about Student Learning in Intermediate Mechanics: Using Research to Improve Instruction

Bradley Ambrose, Grand Valley State University

Ongoing research in physics education has demonstrated that physics majors often do not develop a working knowledge of basic concepts in mechanics, even after standard instruction in upper-level mechanics courses [1]. A central goal of this work has been to explore the ways in which students make--or do not make--appropriate connections between physics concepts and the more sophisticated mathematics (e.g., differential equations, vector calculus) that they are expected to use. Many of the difficulties that students typically encounter suggest deeply-seated alternate conceptions, while others suggest the presence of loosely or spontaneously connected intuitions. Analysis of results from pretests (ungraded quizzes), written exams, and informal classroom observations will be presented to illustrate specific examples of these difficulties. Also to be presented are examples of particular instructional strategies (implemented in Intermediate Mechanics

TP3.Cognitive Development at the Middle-Division Level

Corinne A. Manogue and Elizabeth Gire, Oregon State University

One of the primary goals, as students transition from the lower-division to upper-division courses is to facilitate the cognitive development needed for work as a physicist. The Paradigms in Physics curriculum (junior-level courses developed at Oregon State University) addresses this goal by coaching students to coordinate different modes of reasoning, highlighting common techniques and concepts across physics topics, and setting course expectations to be more aligned with the professional culture of physicists. This poster will highlight some of the specific ways in which we address these cognitive changes in the context of classical mechanics and E&M courses.

This work is supported in part by NSF grant DUE 0618877.

TP4. Cognitive Issues and Approaches to Improving Students' Understanding of Quantum Mechanics

Chandralekha Singh and Guangtian Zhu, University of Pittsburgh Learning quantum mechanics is challenging. Our group is investigating cognitive issues in learning quantum mechanics and developing quantum interactive learning tutorials (QuILTs) and tools for peer-instruction based upon cognitive task analysis. Many of the tutorials employ computer-based visualization tools to help students take advantage of multiple representations and develop better intuition about quantum phenomena. We will discuss the aspects of the cognitive design of the quantum mechanics curriculum that are similar or different from introductory courses and discuss why the analysis of cognitive issues is important for bridging the gap between quantitative and

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8:30 am and 1:30 pm (offered twice)

(TP - B) Foundations of Course Reform for Introductory Physics

David E. Pritchard, MIT, dpritch@mit.edu
Analia Barrantes, MIT , analiab@mit.edu
Andrew Pawl, MIT, aepawl@mit.edu
Brian Belland, Utah State University , brian.belland@usu.edu

At the heart of course reform lies the question "What do we want the students to learn?" and its complement "What do the students want to get from our course?". Each question has two parts: what skills should students master for the final examination, and what skills should they retain at some later point in their lives, for example at graduation? This targeted poster session reports a series of studies exploring these questions and shows the use of various PER-based diagnostic instruments to evaluate an approach to problem solving inspired by the answers we found. Since the posters represent work in progress, audience opinion and suggestions will be solicited.

TP1. What Else (Besides the Syllabus) Should Students Learn in Introductory Physics?

David E. Pritchard, MIT
Brian Belland, Utah State University
Analia Barrantes, MIT

Course reform begins with a set of objectives. We started with a Delphi Study based on interviews with experts, developed orthogonal responses to "what should we teach non-physics majors besides the current syllabus topics?" AAPT attendees, atomic researchers, and PERC08 attendees were asked for their selections. All instructors rated "sense-making of the answer" very highly and expert problem solving highly. PERers favored epistemology over problem solving, and atomic researchers "physics comes from a few principles". Students at three colleges had preferences anti-aligned with their teachers, preferring more modern topics, and the relationship of physics to everyday life and to society (the only choice with instructor agreement), but not problem solving or sense-making. Conclusion #1: we must show students how old physics is relevant to their world. Conclusion #2: significant course reform must start by reaching consensus on what to teach and how to hold students' interest (then discuss techniques to teach it).

TP2. What do A Students Learn that D Students don't?

Analia Barrantes, MIT
David E. Pritchard, MIT

We have compared performance of students scoring 1 standard deviation below average (D group) with students scoring 1 standard deviation above average (A group) on final exam problems requiring analytic solutions and written plans. While the D group received 38% fewer total points than the A group, the differences were more dramatic with respect to getting an entire problem correct: for both analytic solutions and plans of attack the A group relative to the D group gave ~ 3.6 times more good answers, and failed to identify all of the physical principles about 3.8 times less often. We found that students' written plans of attack closely correlated with their analytic solutions in both groups. We suggest that the typical "one topic per week" organization of introductory courses does not prepare students to identify the physical principles that apply to problems that might involve any of the concepts in the course.

TP3. What Do Seniors Remember from Freshman Physics?

Analia Barrantes, MIT
Andrew Pawl, MIT
David E. Pritchard, MIT

We have given a group of 56 MIT Seniors who took mechanics as Freshmen a written test similar to the final they took at that time, plus the MBT and C-LASS standard instruments. Students unlikely to have reviewed the material in the interim scored half as well as they did as Freshmen on the written part of the test. Their facility with energy and kinematics was comparable to D-level Freshmen. They were less able than D-level Freshmen to construct simultaneous equations describing a dynamics problem, but more able to recognize a two-stage problem and develop subgoals. Their mean score on the MBT was essentially unchanged from the post-test taken as Freshmen, though there were significant shifts in responses to ten of 26 questions. Attitudinal surveys indicate that half the Seniors believe the mechanics course content will be useful to them, while the vast majority believe physics teaches valuable problem solving skills.

TP4. Modeling Applied to Problem Solving

Andrew Pawl, MIT
Analia Barrantes, MIT
David E. Pritchard, MIT

Applied to Problem Solving (MAPS) is a pedagogy that helps students transfer instruction to problem solving in an expert-like manner. Declarative and Procedural syllabus content is organized and learned (not discovered) as a hierarchy of General Models. Students solve problems using an explicit Problem Modeling Rubric that begins with System, Interactions and Model (S.I.M.). System and Interactions are emphasized as the key to a strategic description of the system and the identification of the appropriate General Model to apply to the problem. We have employed the pedagogy in a three-week review course for students who received a D in mechanics. The course was assessed by a final exam retest as well as pre and post C-LASS surveys, yielding a 1.2 standard deviation improvement in the students' ability to solve final exam problems and a statistically significant positive shift in 7 of the 9 categories in the C-LASS.

1. M. Wells, D. Hestenes, and G. Swakhamer, "A Modeling Method for High School Physics Instruction", Am. J. Phys. 63, 606-619 (1995).

8:30 am and 1:30 pm (offered twice)

(TP - C) Negotiating Meaning: the role of assessment rubrics and diagnostic guidelines

Edit Yerushalmi, Weizmann Institute of Science, [*edit.yerushalmi@weizmann.ac.il*](mailto:edit.yerushalmi@weizmann.ac.il)

Teachers frequently make sample solutions available to their students, expecting them to learn from their mistakes. However many teachers are concerned that only few of their students engage in such an activity. What happens when students are given time and credit for identifying mistakes they have made by referring to the sample solution? What do students believe qualifies as "diagnosis"? Our data consists of diagnosis work by 180 Arab-Israeli high school physics students, and 30 American students taking introductory algebra based physics. The findings indicate that while the instructor expected students to focus on the weaknesses of their solutions, many reflected also on their personal involvement in the solution process, their opinion as to the adequacy of the problem statement, etc. Students used the sample solution as a template and identified as deficiency any external deviation of their solution from it. Abstract Type: Targeted Poster Session

TP1. Quiz Corrections: Improving Learning by Encouraging Students to Reflect on their Mistakes

Charles Henderson, Western Michigan University, Kathleen A. Harper, Denison University

Most introductory physics instructors are disheartened that students typically view tests and quizzes as summative evaluations and, therefore, miss the tremendous opportunity to learn from their mistakes. One way to address this problem is for the instructor to assign and collect written student assessment corrections. We have experimented with methods for dealing with this sort of assessment correction that require minimal instructor time. In this poster we i) provide some theoretical arguments supporting this practice, ii) describe several variations of assessment corrections that we have used, and iii) provide some data related to its effectiveness.

TP2. Categorization of Problems to Assess and Improve Student Proficiency as Teacher and Learner

Chandralekha Singh, Department of Physics and Astronomy, University of Pittsburgh

The ability to categorize problems is a measure of expertise in a domain. In order to help students learn effectively, instructors and teaching assistants (TAs) should have pedagogical content knowledge. They must be aware of the prior knowledge of students, consider the difficulty of the problems from students' perspective and design instruction that builds on what students already know. In this targeted poster, we discuss the response of graduate students enrolled in a TA training course to categorization tasks in which they were asked to group problems first from their own perspective, and later from the perspective of introductory physics students. A majority of the graduate students performed an expert-like categorization of physics problems. However, when asked to categorize from the perspective of introductory students', most students expressed dismay, claiming that either the task was either impossible or pointless. We will discuss how categorization can be a useful tool for scaffolding and improving pedagogical content knowledge of instructors.

TP3. Assessment of Student Problem Solving Processes

J. Docktor, University of Minnesota

K. Heller, University of Minnesota

At Minnesota we have been developing a rubric to evaluate students' written solutions to physics problems that is easy to use and reasonably valid and reliable. The rubric identifies five general problem-solving processes and defines the criteria to attain a score in each (useful description, physics approach, application of physics, math procedures, and logical progression). An important test of the instrument is to check whether these categories represent the actual processes students engage in during problem solving. We will report an analysis of problem-solving interviews conducted with students enrolled in an introductory physics course and discuss the implications of these results for the rubric.

TP4. Self-Diagnosis, Scaffolding and Transfer: A Tale of Two Problems

A. Mason, Department of Physics and Astronomy, University of Pittsburgh

E. Cohen, Department of Physics and Astronomy, University of Pittsburgh

C. Singh, Department of Physics and Astronomy, University of Pittsburgh

E. Yerushalmi, Weizmann Institute of Science

Helping students learn from their own mistakes can help them develop habits of mind while learning physics content. Based upon cognitive apprenticeship model, we asked students to self-diagnose their mistakes and learn from reflecting on their problem solution. Varying levels of scaffolding support were provided to students in different groups to diagnose their errors on two context-rich problems that students originally solved in recitation quizzes. The level of scaffolding necessary for successful self-diagnosis and performance on the transfer task was strongly dependent on the difficulty in invoking and applying physics principles to solve the problems and how far the transfer was. Moreover, a high level of sustained scaffolding may be necessary to teach students problem-solving skills. This targeted poster will summarize our findings from self-diagnosis and near and far transfer associated with two context-rich problems that students self-diagnosed such that one self-diagnosed problem was unusually difficult.

TP5. Students' Perceptions of a Self-Diagnosis Task

Rafi Safadi, The Academic Arab College for Education in Israel, Haifa

Edit Yerushalami, Weizmann Institute of Science

Teachers frequently make sample solutions available to their students, expecting them to learn from their mistakes. However many teachers are concerned that only few of their students engage in such an activity. What happens when students are given time and credit for identifying mistakes they have made by referring to the sample solution? What do students believe qualifies as "diagnosis"?

Our data consists of diagnosis work by 180 Arab-Israeli high school physics students, and 30 American students taking introductory algebra based physics. The findings indicate that while the instructor expected students to focus on the weaknesses of their solutions, many reflected also on their personal involvement in the solution process, their opinion as to the adequacy of the problem statement, etc. Students used the sample solution as a template and identified as deficiency any external deviation of their solution from it.

1:30 PM **(TP - D) Broadening Our Lens: Socio-Cultural Perspectives in PER (Part I: artifacts and mediation)**

Noah Finkelstein,University of Colorado at Boulder, noah.finkelstein@colorado.edu

Chandra Turpen,University of Colorado at Boulder

Research in physics education has conducted significant work at understanding student ideas and applying such understanding to the design of curricular reforms and evaluation instruments. Studies of classroom practices are beginning to appear more frequently and suggest that we, as a community, may benefit from a broader theoretical lens. This session focuses on applications of socio-cultural theories to education research in physics and physics teacher preparation. It includes studies that examine: introductory college classrooms and after-school programs as cultural systems, building a learning community related to becoming and being a physics teacher, educational tools as mediating artifacts in student learning and engagement, and the creation of contexts supportive of all students in learning physics. n Part 1 of this session, we will focus on the role of tools and curricula as mediating artifacts in student learning.

TP1. Broadening Our Lens: Introduction to the Sessions

Noah D. Finkelstein and Chandra Turpen
University of Colorado

These two sessions, while coupled, can stand individually. Following each set of posters we will hold a discussion focussing on the particular theme of that session. While poster presentations listed here will be presented during the allocated slots, all 7 posters (from the two sessions) will be available for each session.

TP2. Computer Simulations to Classrooms: Cultural Tools for Learning Physics

Noah Podolefsky
University of Colorado

The PhET computer simulations (sims) have been demonstrated as successful tools for teaching and learning physics. In this poster we situate PhET sims in a socio-cultural-historical context, focusing on the Wave Interference sim as an example. Sims are cultural tools designed to embody certain norms and practices of the physics community, particularly learning through exploration. This poster focuses on the interaction between three scales of cultural tools: representations (graphs, pictures, etc.), learning tools (sims), and learning environments. Sims can strongly influence the nature of student engagement in the classroom, but they are not magic pills. Classroom environments can drive certain types of activity, but we are not fated to recapitulate traditional educational practices. We will examine critical features of tools across these three scales which support student learning through engaged exploration.

Edward Price, Charles De Leone and Clarisa Bercovich-Guelman,
California State University, San Marcos

Technological tools are widely used in physics education. Many researchers have examined student learning gains associated with activities utilizing technology. Less attention has been given to the role of tools in shaping classroom practices and student interactions. By emphasizing the mediating role tools play, activity theory is ideally suited for examining the impact of tools on classroom culture. This poster uses activity theory to explore two examples where Tablet PCs were used in introductory physics classes. In one example, every student used a Tablet PC to collaborate in small groups during a laboratory course. In a second example, groups of students in an active learning-based course used one Tablet PCs for group work, which the instructor projected during whole class discussions. Use of the Tablet PCs is identified with changes in the nature of student collaboration and in the classroom practices required to support desired class norms.

TP4. Evolution of Socio-Cultural Perspectives in My Research

Valerie Otero, University of Colorado

Over the past 10 years I have been using socio-cultural theoretical perspectives to understand how people learn physics in a highly interactive, inquiry-based physics course such as Physics and Everyday Thinking. As a result of using various perspectives (e.g. Distributed Cognition and Vygotsky's Theory of Concept Formation), my understanding of how these perspectives can be

Edward Price, Charles De Leone and Clarisa Bercovich-Guelman,
California State University, San Marcos

Technological tools are widely used in physics education. Many researchers have examined student learning gains associated with activities utilizing technology. Less attention has been given to the role of tools in shaping classroom practices and student interactions. By emphasizing the mediating role tools play, activity theory is ideally suited for examining the impact of tools on

2:45 pm **(TP-E) Broadening Our Lens: Socio-Cultural Perspectives in PER (Part II: communities & social interaction)**

Noah Finkelstein, University of Colorado at Boulder, Department of Physics, noah.finkelstein@colorado.edu

Chandra Turpen, University of Colorado

Research in physics education has conducted significant work at understanding student ideas and applying such understanding to the design of curricular reforms and evaluation instruments. Studies of classroom practices are beginning to appear more frequently and suggest that we, as a community, may benefit from a broader theoretical lens. This session focuses on applications of socio-cultural theories to education research in physics and physics teacher preparation. It includes studies that examine: introductory college classrooms and after-school programs as cultural systems, building a learning community related to becoming and being a physics teacher, educational tools as mediating artifacts in student learning and engagement, and the creation of contexts supportive of all students in learning physics. In Part 2 of this session, we will focus on the role of communities and participation within a community as mediating artifacts in student learning.

TP1. Our Classrooms as Cultural Systems: an Examination of Social and Cultural Influences in Two Educational Environments

Noah Finkelstein, Chandra Turpen, and Laurel Mayhew, University of Colorado

This inter-active poster seeks provides case studies of two educational environments, one, a formal introductory college level course that implements several PER-based innovations, the other, an informal afterschool educational program for children 6-18 years old. Each is considered from two different cultural historical activity theoretic perspectives, which provide the opportunity make sense of both the theory and the educational environments by triangulating among both the theories and the environments. An activity theoretic lens frames the classroom and afterschool program as activity systems where we delineate variation in roles, rules, and distribution of labor surrounding the use of similar tools (physics concepts). A Communities of Practice and Apprenticeship lens frames these environments as allowing or constraining various forms of participation by members both within the classroom community and within the institutional setting. The authors will share tools that will provide participants and opportunity to apply these perspectives to their own work and compare with our two case studies.

TP2. Building a Professional Learning Community of Physics Teachers

Eugenia Etkina, Rutgers University

This poster will describe how a group of physics teachers built a professional learning community without ever knowing about this theoretical construct. The community was born to address the needs of seven pre-service physics teachers while supporting each other during student teaching in the Fall of 2003. Since then it has transformed into a living organism that nurtures new members (now more than 40 in-service teachers), cares for the needs of everyone, provides timely advice for every-day problems, communicates passion to teaching, and provides natural professional development for all of its members. The discussion will focus on the elements of a professional learning community that are absolutely necessary to maintain it, specific features of a physics teachers learning community, and the role of faculty responsible for teacher preparation in helping sustain such a community.

TP3. Moving beyond the Classroom: Socio-Cultural Motivation for Expanding the Unit of Analysis

Eric Brewe, Laird Kramer,Vashti Sawtelle, Idaykis Rodriguez and George O'Brien,
Florida International University

Efforts to document the complex learning community established by the Center for High Energy Physics Research and Education Outreach (CHEPREO) initially focused on classroom based measures of Modeling Instruction. Classroom-based measures alone are insufficient to understand complex phenomena such as participation, retention, and persistence shown by our students. The underlying Vygotskian perspective on learning in Modeling Instruction motivated a shift in unit of analysis, moving beyond standard measurements of physics classes toward understanding the patterns of interactions and participation in learning communities. Changing the unit of analysis from the class to the learning community allows us to consider the roles of social and cultural influences on participation, persistence and retention. In this poster we re-frame the CHEPREO reform efforts through an ecological framework [Aubusson] and describe how this framing supports students especially given the cultural makeup of FIU's student body.

TP4. Promoting Conceptual Change and Development of Collective Responsibility

Elizabeth S. Charles, Dawson College, Montreal
Nathaniel Lasry, John Abbott College, Montreal
Chris Whittaker, Dawson College, Montreal

Socio-cultural approaches view learning as a social phenomenon, situated in the course of human activities. Thus, student learning and conceptual change is enhanced by instruction that creates opportunities for students to interact socially with others while engaged in appropriate learning activities. Models of instruction that promote social-interactions include Peer Instruction and community of learners (Brown&Campione,1994). This poster presents results from a case study of an introductory physics course using Peer Instruction. Audio recordings were made of small group conversations where students explained and justified their choices to peers. Discourse analyses of recordings show that students expend greater effort over time, build more rigorous arguments and regulate their discourse using both individual and collective processes of monitoring (e.g. in time, peers use as well as demand more precise definitions and justifications before accepting arguments). Our results show changes in individual student's attitudes toward their personal and collective responsibility to classmates.

Descriptions of Contributed Roundtable Discussions

Thursday, July 30th

2:45 PM **CANCELLED**

(RTD- 1) Where do the Student Conceptions Come from? Light and Optics Case (Dennison 130)

Derya Kaltakci, kaderya@metu.edu.tr,

Physics Education Group, Department of Physics Box 351560

Ali Eryilmaz, eryilmaz@metu.edu.tr

Several studies in physics and science education research have revealed that students have difficulty in understanding some introductory light and optics concepts. Nowadays, more emphasis is given to using appropriate methodologies to eliminate these difficulties, and to understanding the nature of acquisition of scientific conceptions fully. However, in addition to identification of these difficulties in students' minds, the possible sources of these difficulties should be determined and eliminated. Students experiences, textbooks, language used, teachers can be listed among several possible sources of students unscientific conceptions in physics. In the present study examples of these possible sources will be provided with related unscientific conception from light and optics.

1:30 PM **(RTD -2) Cognition of an Expert Tackling an Unfamiliar Conceptual Physics Problem (Dennison 120)**

David Schuster, Western Michigan University, david.schuster@wmich.edu

Adriana Undreiu, University of Virginia's College at Wise, Department of Natural Sciences

We have investigated and analyzed in detail the cognition of an expert tackling a qualitative conceptual physics problem of an unfamiliar type. The basic but non-trivial task was to find qualitatively the acceleration direction of a pendulum bob at various stages of its motion, originally studied by Reif and Allen. Methodology included introspection, retrospection and self-reported metacognition. Different reasoning was used for different points on the motion path, revealing multiple facets of cognition, including its context- and background-dependence. An account will be given of the zigzag thinking paths and interplay of various reasoning modes and knowledge elements invoked. We interpret the cognitive processes using theoretical ideas such as: case-based, principle-based and experiential-intuitive reasoning; general strategies; schemata; association and transfer; cueing and interference; metacognition and epistemic frames. The rich microcosm of cognition brought out in this case study contrasts with the tidy systematic problem solutions we usually present to students. We discuss implications for instruction in problem-solving.

Descriptions of Contributed Posters (including posters presented at the TPS)

IMPORTANT: In order to provide an opportunity for the attendees to view all the posters, the posters presented at the Targeted Poster Sessions are invited to be presented at the Contributed Poster Sessions.

Wednesday, July 29th (Michigan League Hussey and Vandenburg)

8:00 pm - 10:00 pm:

8:00 pm - 9:00 pm (odd- numbered posters) and 9:00 pm – 10:00 pm (even- numbered posters)

Thursday, July 30th (Michigan League Hussey and Vandenburg)

10:00 am - 10:25 am (odd- numbered posters) and 10:30 am – 10:55 am (even- numbered posters)

Primary Author	*Poster ID*	*Title*
Alarcon	***23***	*Influence of Scientific Reasoning on College Students' Physics Learning*
Alhadlaq	***24***	*Measuring StudentsBeliefs about Physics in Saudi Arabia*
Allen	***25***	*The RIPLEffect on Learning Gains in Lecture at Appalachian State*
Ambrose	***156***	*Learning about Student Learning in Intermediate Mechanics: Using Research to Improve Instruction*
Antimirova	***26***	*The Effect of Classroom Diversity on Conceptual Learning in Physics*
Aubrecht	***27***	*Newton's Third Law in middle school*
Baily	***28***	*Understanding and Teaching Quantum Interpretations in Modern Physics Courses*
Bartiromo	***29***	*Seeing Inquiry in the Classroom From Multiple Perspectives*
Barrantes	***149***	*What do A students learn that D Students don't?*
Barrantes	***150***	*What Do Seniors Remember from Freshman Physics?*
Bartley	***30***	*Reaching Students through Informal Science Education*
Beach	***73***	*Examining Change Strategies in University STEM Education*
Black	***32***	*Modeling the Creation of Procedural Resources*
Blue	***33***	*Resilience of Astronomy Misconceptions*

Blue	***34***	*Student Perceptions of an Introductory Laboratory Course*
Brahmia	***35***	*PUM: Developing Reasoning Skills in the First Physics Courses*
Brewe	***36***	*Investigating Student Communities with Network Analysis of Interactions in a Physics Learning Center*
Brewe	***159***	*Moving beyond the Classroom: Socio-Cultural Motivation for Expanding the Unit of Analysis*
Camp	***37***	*Nonlinear Development of Newtonian Concepts*
Carmichael	***38***	*Comparing the Effect of Simulations and Hands on Activities on Student Learning*
Carvalho	***39***	*Maple as a Learning Tool in an Introductory Physics Course*
Charles	***160***	*Promoting Conceptual Change and Development of Collective Responsibility*
Chasteen	***40***	*Tapping into Juniors' Understanding of E&M: The CO Upper-Division Electrostatics (CUE) Diagnostic*
Chini	***41***	*Does the Teaching/Learning Interview Provide an Accurate Snapshot of Classroom Learning?*
Cochran	***42***	*Probing Student Understanding of Cosmology*
Coletta	***43***	*Addressing Barriers to Conceptual Understanding in IE Physics Courses*
Crema	***44***	*Revising Lab Materials to Address Difficulties with Electric Circuits*
Dancy	***45***	*Knowledge, Attitudes, and Practices of College Physics Instructors: Results of a National Survey*
D'Angelo	***46***	*The Effect of Representations on Student Understanding of Motion*
de Guzman Corpuz	***47***	*The Relative Effectiveness of an Interactive Teaching Approach Using PDAs as Interaction Tool*
de Guzman Corpuz	***48***	*Students' Perceptions about PDAs as Interaction Tool in a Predominantly Hispanic Classroom*
Demaree	***49***	*Promoting Productive Communities of Practice: An Instructor's Perspective*
Didis	***147***	*Active Learning of Physics by Modelin*
Ding	***83***	*Conceptually Scaffolded Problem Solving*

Docktor	***51***	*Assessment of Student Problem Solving Processes*
Dubson	***52***	*Faculty Disagreement about the Teaching of Quantum Mechanics*
Etkina	***53***	*Searching for "Preparation for Future Learning" Transfer in Physics*
Etkina	***144***	*Building a Professional Learning Community of Physics Teachers*
Finkelstein	***158***	*Our Classrooms as Cultural Systems: an Examination of Social and Cultural Influences in Two Educational Environments*
Goertzen	***54***	*How do Tutorial TAs Set the Tone for their Students?*
Goldhaber	***55***	*Transforming Upper-Division Quantum Mechanics: Learning Goals and Their Assessment*
Gray	***56***	*Analysis of Former Learning Assistants Views on Teaching and Learning*
Guelman	***57***	*The Influence of Tablet PCs on Students Use of Multiple Representations in Lab Reports*
Haghanikar	***58***	*Protocol for Analysis of Content Questions*
Harlow	***59***	*Developing Pedagogically-Relevant Physics Content Knowledge through Asynchronous Online Discussions*
Hawkins	***60***	*Exploring Student Consistency in Vector Addition Method Choices*
Henderson	***61***	*The Impact of Physics Education Research on the Teaching of Introductory Quantitative Physics*
Henderson	***145***	*Quiz corrections: Improving learning by encouraging students to reflect on their mistakes*
Henderson	***105***	*The Impact of Physics Education Research on the Teaching of Introductory Quantitative Physics*
Hull	***62***	*Undergraduate Engineers' Sense-making of Mathematics*
Hunt	***63***	*Effects of Single Sex Lab Groups on Physics Self-efficacy, Behavior, and Academic Performance*
Ibrahim	***64***	*Effect of Peer Instruction on Student Conceptual Understanding: a Systematic Review of Literature*
Iverson	***65***	*Instructional Innovations in Physics and their Effects on Student Learning*

Jaffer	***66***	*Moving Towards PBL & PI - A Canadian-Indian Partnership*
Kahn	***67***	*PER in Early Grades: Introducing the Tools of Physicists to Young Children*
Kaltakci	***68***	*Diagnosing Student Conceptions with a Cross Paradigm Method*
Kapon	***141***	*Activities that Foster Learning from Public Physics Lectures*
Kohl	***69***	*Introductory Physics Gender Gaps: Pre- and Post-Studio Transition*
Kost	***70***	*Unpacking Gender Differences in Students' Perceived Experiences in Introductory Physics*
Kuo	***71***	*PER Community Enhancing Network for Teaching, Research and Learning*
Lasry	***72***	*When Talking is Better than Keeping Quiet*
Li	***50***	*Relationships across Communities of Practice Pertaining to Student Physics Learning*
Libarkin	***74***	*Communicating across Paradigms: Boundary-Crossing in an Interdisciplinary World*
Lin	***75***	*Locus of Authority in Learning, Teaching, and Research.*
Lin	***76***	*Categorization of Quantum Mechanics Problems by Professors and Students*
Loverude	***77***	*Student Understanding of Basic Probability Concepts in an Upper-Division Thermal Physics Course*
Maier	***78***	*Usage of the Term Force, Reasoning Ability, and FCI Performance*
Manoque	***153***	*Cognitive Development at the Middle-division Level*
Martinuk	***79***	*Research Projects in Introductory Physics: Impacts on Student Learning and Attitudes*
Marx	***80***	*Development of an Assessment of Textbook Problem-Solving Ability*
Mason	***81***	*Do Advanced Students Learn from their Mistakes without Explicit Intervention?*
Mason	***140***	*Self-diagnosis, Scaffolding and Transfer: A Tale of Two Problems*
Mateycik	***82***	*Using Similarity Rating Tasks to Assess Case Reuse in Problem Solving*
Mayhew	***31***	*Learning to Teach Science through Informal Science Education Experiences*

McBride	***84***	*Applying Knowledge in New Contexts: A Comparison of Pre- and Post-Instruction Students*
Meltzer	***157***	*Observations of General Learning Patterns in an Upper-Level Thermal Physics Course*
Mestre	***151***	*Methods and Experimental Designs in Cognitive Studies*
Milner-Bolotin	***85***	*Technology as a Lens for Examining Instructors Pedagogical Content Knowledge*
Mountcastle	***86***	*Conceptual Difficulties with Binomial Distributions in Statistical Physics*
Moyer	***87***	*Identifying Student Difficulties with Pressure in a Fluid*
Murphy	***88***	*Probing Student Understanding of Resonance**
Nagle	***89***	*Joint Engineering and Physics Education Research Projects Should there be more of them?*
Nakamura	***90***	*Online Data Collection and Analysis in Introductory Physics*
Neakrase	***91***	*The Examination of Beginning Secondary Physics Teachers PCK through Two Different Research Lenses*
Nguyen	***92***	*Facilitating Student Transfer of Problem Solving Across Representations**
Otero	***146***	*Evolution of Socio-Cultural Perspectives in My Research*
Paulson	***93***	*PhET Simulations: Should we Show the Invisible?*
Pawl	***142***	*Modeling Applied to Problem Solving*
Perkins	***94***	*Using Clickers in Upper-division Physics Courses: What do students think?*
Podolefsky	***95***	*Student Choices when Learning with Computer Simulations*
Podolefsky	***105***	*Computer Simulations to Classrooms: Cultural tools for learning physics*
Pollock	***96***	*Longer Term Impacts of Transformed Courses on Student Conceptual Understanding of E&M*
Pollock	***152***	*A Research-Based Approach to Transforming Upper-Division Electricity & Magnetism I*

Price	***162***	*How Tools Shape Classroom Practices and Collaboration: Examples from Introductory Physics Classes Using Tablet PCs*
Pritchard	***97***	*Addressing the Shortcomings of a Textbook with a Supplemental Wiki*
Pritchard	***148***	*What Else (Besides the Syllabus) Should Students Learn in Introductory Physics?*
Pritchard	***154***	*Foundations of Course Reform for Introductory Physics*
Pyper	***98***	*PER in Polynesia*
Ramlo	***99***	*In-Service Science Teachers' Newtonian Conceptual Understanding before & after a One-Week Workshop*
Rebello	***100***	*Can We Assess Efficiency and Innovation in Transfer?*
Rodriguez	***101***	*Impact of the FIU PhysTEC Reform of Introductory Physics Labs*
Rosenblatt	***102***	*Modeling Student Conceptual Understanding of Force, Velocity, and Acceleration*
Rosengrant	***103***	*Comparing Experts and Novices in Solving Electrical Circuits Problems with the Help of Eye Tracking*
Sadaghiani	***106***	*The Effect of Inquiry-Based Early Field Experience on Pre-Service Teachers Understanding & Attitudes*
Sadaghiani	***107***	*Using Multimedia Learning Modules (MLM) as Part of a Hybrid Course in Electricity and Magnetism*
Sadaghinai	***108***	*Computational Physics Undergraduate Research Experience (A Case Study)*
Samuels	***109***	*Take My Survey, Please!: Comparison of Survey Response Rates Across Four Administration Factors*
Safadi	***139***	*Students' Perceptions of the Self-Diagnosis Task*
Sande	***110***	*Open Online Physics Homework Forums*
Sawadthaisong	***111***	*Using Quantitative Demonstrations to Improve Student Understanding of Collisions*
Sawtelle	***112***	*I Think I Can: Investigating the Impact of Physics Problem Solving on Student Self-efficacy**

Sayre	***113***	*Student Understanding of Vector Products*
Sayre	***114***	*Tracking Epistemological Changes throughout a Three-Course Sequence*
Scaife	***115***	*Student Difficulties with the Direction of Magnetic Force on a Charged Particle*
Schmitt	***116***	*Long-term observation in middle school astronomy*
Sharma	***117***	*The Use of Design-Based Research and Practitioner (Action) Research in Physics Education Research*
Shaw	***118***	*Relations between Cognitive and Affective Factors in Predicting Performance in Introductory Science*
Shekoyan	***119***	*Using Cognitive Apprenticeship Framework and Multiple-Possibility Problems to Enhance Epistemic Cog*
Shubert	***120***	*Describing Student Approaches to Laboratory Activities: Epistemology in a Reformed Lab Setting*
Singh	***121***	*Comparing Problem Solving Attitudes of Introductory Students, Physics Graduate Students and Faculty*
Singh	***143***	*Categorization of Problems to Assess and Improve Student Proficiency as Student and Learner*
Singh	***155***	*Cognitive Issues and Appraoches to Improving Students' Understanding of Quantum Mechanics*
Smith	***122***	*Addressing student difficulties considering entropy and heat engines*
Smith	***123***	*How Do Students Process a Worked Example?*
Spike	***124***	*A Study of Undergraduate and Graduate Student Conceptions of Teaching*
Springuel	***125***	*Using Cluster Analysis to Group Student Responses on the FMCE*
Springuel	***104***	*Comparing Cluster Analysis and Traditional Analysis Methods in PER: More Data*
Talbot III	***126***	*Measuring Science Teacher Knowledge: Domain-General or Domain-Specific?*
Teodorescu	***127***	*Pedagogical Approaches for Enhancing Cognitive Development in Introductory Physics*
Turpen	***128***	*Towards Understanding Classroom Culture: StudentsPerceptions of Tutorials*

Van Wieren	***161***	*Using Item Response Models to Build a Hierarchy of Concepts and Gauge Instructional Effectivenes*
Wagner	***129***	*Identifying Student Difficulties with Density and Buoyancy*
Wampler	***130***	*An Assessment Design Rubric for a Reformed Introductory Physics Curriculum*
Warren	***131***	*Time-Series Analysis: Detecting & Measuring Structural Changes in Knowledge*
Winters	***132***	*Why Must Bulb Touch Battery? Interpretations of Fourth Graders' Thinking*
Wittmann	***133***	*Comparing Three Methods for Teaching Newton's Second Law*
Wutchana	***134***	*Are Students' Responses to Surveys and Their Behaviors Consistent?*
Yerushalmi	***135***	*Self-Diagnosis, Scaffolding and Transfer in Introductory Physics*
Yerushalmi	***163***	*Negotiating Meaning: Rethinking and Re-Interpreting Knowledge*
Zavala	***136***	*Investigation of Students' Alternative Conceptions of Vector Direction with Mexican Students*
Zavala	***137***	*Understanding Graphs with and without Context: Testing an Instrument*
Zhu	***138***	*Improving Student Understanding of Stern Gerlach Experiment*

Contributed Posters Abstracts

CP.23: **Influence of Scientific Reasoning on College Students' Physics Learning**

Hugo Alarcon and Jorge de la Garza

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Modeling instruction has been successfully implemented in colleges and high schools in the United States. In this work a preliminary implementation of modeling instruction in an introductory physics course of Mechanics in a Mexican university is analyzed. The Lawson's Test of Formal Reasoning and the Force Concept Inventory (FCI) were applied in the beginning of the semester, while the FCI was administered again at the end of the period in order to assess the concept learning of students. The students in modeling courses gained the double of concept learning than students in traditional courses. A stepwise correlational study was established between scientific reasoning, initial concepts and concept learning. The concept learning gain just exhibited correlation with the scientific reasoning, $R = .454$ ($p < .001$) for modeling instruction and $R = .319$ ($p < .001$) for traditional instruction, which proves to be one of the reasons for the observed difference in the concept learning gain.

CP.24: **Measuring Students Beliefs about Physics in Saudi Arabia**

Hisham A. Alhadlaq, The Excellence Center of Science and Mathematics Education, King Saud University, h.alhadlaq@gmail.com
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Over the last decade, science education researchers in the US have studied students beliefs about science and learning science and measured how these beliefs change in response to classroom instruction in science. In this work, we present an Arabic version of the Colorado Learning Attitudes about Science Survey (CLASS) which was developed to measure students beliefs about physics at King Saud University (KSU) in Riyadh, Saudi Arabia. We will describe the translation process, which included review by four experts in physics and science education and ten student interviews to ensure that the statements remained valid after translation. We have administered the Arabic CLASS to over 300 students in introductory physics courses at KSU s men s and women s campuses. We will present a summary of students beliefs about physics at KSU and compare these results to similar students in the US.

CP.25: **The RIPL Effect on Learning Gains in Lecture at Appalachian State**

Patricia E. Allen, Appalachian State University, allenpe@appstate.edu
John E. Cockman, Appalachian State University
Jon M. Saken, Appalachian State University

The main goal for the Redesigned Introductory Physics Lab (RIPL) project at Appalachian State is to improve student performance and attitudes in the algebra sequence. An additional goal is to affect student performance in the lecture portion, independent of the instructor s pedagogical approach. Preliminary results indicate a large positive difference (8 to 10 points on 100-point scale) in all course measures (exams, homework,

etc.) for students in the redesigned lab compared to those in the standard lab offered by the department. On the other hand, FCI and other diagnostic scores show little difference between the two groups. While these measures indicate a discrepancy in the redesigned lab impact, an item-by-item analysis of the diagnostics reveals a rich story, one that can be used to improve both lecture and lab activities. Some examples, and their implications, will be discussed.

CP.26: **The Effect of Classroom Diversity on Conceptual Learning in Physics**

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Introductory physics is taken annually by hundreds of undergraduates at Ryerson University. The diversity of our students (a large Canadian urban university) reflects the diversity of Toronto. Their educational backgrounds also vary substantially. Since students learning outcomes in the introductory science courses have a significant impact on their success in the science programs, we decided to investigate how student demographic and educational diversity affects their success in introductory physics. As expected, we found that the completion of a senior high school physics course positively impacts students success in the course. The unexpected result was that gender remained a predictor of the students success even when the completion of high school physics was accounted for. Interestingly, other demographic characteristics, (mother tongue, immigration, parental education) seem not to matter. The results suggest that the impact of completing high school physics may extend far beyond the first year, significantly hindering girls success in SMET disciplines.

This study has been supported by the Ryerson SSHRC Internal Grant.

CP.27: **Newton's Third Law in Middle School**

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Eleanor C Sayre (Both Ohio State University)

Newton's Third Law is a difficult concept to teach well, and middle school students' ideas are mediated by their teachers' conceptions as well as their lived experiences. As part of a school-year course for in-service middle school using inquiry techniques with teachers, eighth-grade science teachers studied Newton's Third Law and how to facilitate their students' learning of it, and taught their students. In this study, we self-assessed the teachers' learning of Newton's Third Law, and they assessed their students using a similar instrument. From student gains, we compare teachers' ideas and their students' learning.

CP.28: **Understanding and Teaching Quantum Interpretations in Modern Physics Courses**

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While expert physicists may agree on how to apply the mathematical formalism of quantum mechanics, instructors often hold different views regarding the role of interpretation of quantum phenomena when teaching an introductory course on modern physics. There has been relatively little research in the physics education community on the variation in student perspectives in interpreting quantum phenomena, and how these instructional choices impact student thinking. We investigate two modern physics courses taught at the University of Colorado where the instructors held markedly different views on how to teach students about quantum processes, and find significant differences in how students from these two courses responded

to end-of-term surveys designed to probe their attitudes and beliefs about quantum mechanics.

CP.29: **Seeing Inquiry in the Classroom From Multiple Perspectives**

Tara Bartiromo tmfinley1@yahoo.com
Eugenia Etkina (Both Rutgers University)

This study investigates the implementation of scientific inquiry practices in the classroom in the context of the new Physics Union Mathematics curriculum. Extensive field notes and Reformed Teaching Observation Protocol (RTOP) scores from classroom observations and interview transcripts from a small sample of teachers form the data by which we conduct this investigation. These different sources provide us with multiple perspectives and rich qualitative and quantitative data for our study. From them, we construct a picture of what inquiry looks like in a PUM classroom, how teachers use the materials to implement inquiry-based approach in the classroom, what the roles are of both teachers and students, and how we can better prepare teachers to implement inquiry-oriented instruction using PUM. The teachers that participated in the study have varying years of teaching experience and experience practicing inquiry-oriented teaching.

CP.30: **Reaching Students through Informal Science Education**

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Jessica Bartley, Laurel Mayhey, Noah Finkelstein (All University of Colorado at Boulder)

We present findings from the University of Colorado's Partnership for Informal Science Education in the Community (PISEC) [1,2,3]. This model of university-community partnerships brings together primary school students with university educators in Math, Engineering, and Science Achievement (MESA) sponsored after school programs. The elementary students worked through flexible inquiry based circuit activities based on the Physics and Everyday Thinking (PET) curriculum [4] with physics graduate and undergraduate students learning about education in the community. We document the interactions that these informal science education (ISE) environments support and present findings on conceptual learning gain and attitude shifts of the children who participated.

[1] N.D. Finkelstein and L. Mayhew, Acting in Our Own Self-Interest: Blending University and Community, Proceedings of the 2008 Physics Education Research Conf, AIP Press, Melville NY, 1064, (2008).
[2] L. Mayhew and N.D. Finkelstein, New Media and Models for Engaging Under-Represented Students in Science, Proceedings of the 2008 Physics Education Research Conf, AIP Press, Melville NY, 1064, (2008).
[3] PISEC, http://spot.colorado.edu/~mayhew/PISEC/Program Description.html
[4] S. Robinson, F. Goldberg, and V. Otero, "Physics and Everyday Thinking," http://petproject.sdsu.edu/

CP.31: **Learning to Teach Science through Informal Science Education Experiences**

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Noah D. Finkelstein, University of Colorado, Physics Education Research finkelsn@Colorado.EDU

Teaching experiences, as part of the University of Colorado Partnerships for Informal Science Education in the Community (PISEC) [1] K12 after school program, provide university students with an opportunity to learn how to speak about science in everyday language. Formative and summative evaluations included pre, post, and in situ video taping of student teaching, surveys of student attitudes about science and teaching, observations, and ethnographic field notes. This poster focuses on case studies which demonstrate the impact of informal science teaching opportunities and

particularly on the abilities of university students to communicate about science in everyday language. We find that students with more interactive experiences post larger gains than students whose experiences were less interactive.

1. PISEC, Partnerships in Informal Science Education in the Community, http://per.colorado.edu

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CP.32: **Modeling the Creation of Procedural Resources**

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Michael Wittmann (Both University of Maine)

A problem in resource theory is to describe the creation of new, high-level resources. We give an example of resource creation by analyzing four student groups separating variables in a group quiz setting. The task was to solve an air resistance problem with uncommon initial conditions. The fluency of each group is described by three observables: use of overt mathematical language (such as divide, subtract, or equals), use of covert mathematical language (such as moving, bringing, or pulling over), and use of accompanying gestures (such as circling, grabbing, or sliding). For each group, the type of language and gesture used corresponds to how easily they carry out separation of variables. We create resource graphs [1,2] for each group to organize our observations and use these graphs to describe a potential reification process [3] for the procedural resources grouping and separate variables.

[1] Wittmann, 2006
[2] Black, Wittmann, 2007
[3] Sfard, 1991

CP.33: **Resilience of Astronomy Misconceptions**

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Before we can develop new techniques in teaching astronomy in a way that effectively dismisses misconceptions, we must first find which are most prevalent and resilient. A study was performed by giving the same astronomy survey to both eighth grade students and introductory physics university students. Some questions from the Astronomy Diagnostic Test were used, along with a longer question about the phases of the moon. We found that some misconceptions are held by both eighth graders and university students, while some were more common among the university students. With the results from this study, new curricula and teaching strategies can be formed to counter these alternate conceptions.

http://solar.physics.montana.edu/aae/adt/
Keeley, Eberle, & Farrin (2005). Uncovering Student Ideas in Science. NSTA.

CP.34: **Student Perceptions of an Introductory Laboratory Course**

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We surveyed students taking an introductory university physics laboratory course over the summer. These students are science majors, but not physics majors. 47 students completed a written questionnaire, and 18 of those students were interviewed. Student perceptions of the purpose of the lab course and about what they liked and did not like about the course will be shared. These lead to implications for instruction and implications for improving communication among faculty, teaching assistants, and students.

CP.35: **PUM: Developing Reasoning Skills in the First Physics Courses**

Suzanne White Brahmia,

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Physics Union Mathematics (PUM) is a new physics curriculum spanning from middle to high school. The physics curriculum is based on the successful college-level Investigative Science Learning Environment (ISLE) curriculum in which students engage in the thought processes physicists use to construct new knowledge. An important feature of PUM is the development of mathematical reasoning skills from the outset in the context of learning physics. PUM is infused with grade-appropriate mathematical tools, and activities in which students use those tools to reason about physics. Starting in September 2008, 40 New Jersey teachers field-tested modules of the curriculum. In this poster we focus on the development of specific mathematical tools used in scientific reasoning integers and zero, graphs and rates of change, bar charts, proportional reasoning, and algebraic descriptions- and how students at this level use them to reason. We will share the results of the implementation of 4 modules.

CP.36: **Investigating Student Communities with Network Analysis of Interactions in a Physics Learning Center**

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Dept. of Curr. & Inst.,(all - Florida International University)

We describe our initial efforts at implementing social network analysis to visualize and quantify student interactions in Florida International University s Physics Learning Center. Developing a sense of community among students is one of the three pillars of an overall reform effort to increase participation in physics, and the sciences more broadly, at FIU. Our implementation of a research and learning community, embedded within a course reform, has led to increased recruitment and retention of physics majors. Finn and Rock [1997] link the academic and social integration of students to increased rates of retention. To identify these social interactions, we have initiated an investigation that utilizes network diagrams to identify primary community participants. Community interactions are then characterized through the network s density and connectivity, shedding light on learning communities and participation. Preliminary results, further research questions, and future directions utilizing social network analysis will be presented.

Work supported by NSF #PHY-0802184.

CP.37: **Nonlinear Development of Newtonian Concepts**

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Learning by Design (TM) follows a tight spiral approach with multiple passes through the same Newtonian principles in a project based curriculum. This afforded a time series measurement of understanding to explore conceptual development. Such a measurement, based on the FMCE, was conducted in two years of middle school. Data is presented from each of these years that demonstrates a temporary degradation of performance during that development. By comparison with early childhood data on U-shaped development, a possible explanation is advanced, but further work is required to test that hypothesis as this particular experiment has significant confounding variables.

CP.38: **Comparing the Effect of Simulations and Hands on Activities on Student Learning***

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Sadhana Puntambekar
Department of Educational Psychology, University of Wisconsin, Madison

Often computer simulation environments present students with an idealized version of the real world which can affect students conceptual understanding. Here we investigate the effects of completing an experiment in mechanics using this ideal world as compared to an identical experiment in the real world. Students in three of five conceptual physics laboratory sections completed the hands-on experiment while the other two sections performed the experiment virtually. Each section performed a pulley experiment. The experiments were conducted in the context of a unit on simple machines from the CoMPASS curriculum which integrates hypertext based concept maps in a design-based context. We will present at data from pre-, mid- and post-tests and written responses on worksheets completed by the students during the activities.

* This work is funded in part by the U.S. Department of Education, Institute of Education Sciences Award R305A080507.

[1] S. Puntambekar, A. Stylianou, and R. Hübscher, Improving navigation and learning in hypertext environments with navigable concept maps. Human-Computer Interaction, 2003. 18: p. 395-428.

CP.39: **Maple as a Learning Tool in an Introductory Physics Course**

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Maple is a powerful programming software with the ability to handle mathematics symbolically. This feature together with the capability for 2D and 3D graphical display make this software an excellent tool to teach and learn physics concepts as well as to acquire problem solving skills. The purpose of this presentation is to show evidence of how creative students can be, in Physics, when they are given the opportunity to use an appropriate software.

CP.40: **Tapping into Juniors Understanding of E&M: The CO Upper-Division Electrostatics (CUE) Diagnostic**

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As part of an effort to systematically improve our junior-level E&M I course, we are developing a tool to assess the effectiveness of the course transformations. With a group of PER and non-PER faculty, we began by explicitly defining what students should be able to do at the end of the course (the learning goals). We established a list of 11 such goals, such as choose and apply the appropriate problem-solving technique and sketch the physical parameters of a problem. These goals, in conjunction with student observations and interviews, served as a guide for the working group to create the CUE assessment. The result is a 17-question open-ended post-test (with an optional 7-question pre-test) diagnostic, with an accompanying grading rubric. We present the preliminary validation of the instrument and rubric, plus results from 4 semesters at the University of Colorado, and 4 additional universities.

CP.41: **Does the Teaching/Learning Interview Provide an Accurate Snapshot of Classroom Learning?***

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The teaching/learning interview has been used to investigate student learning. The aim of the teaching/learning interview is to model a natural learning environment while allowing more direct access to a student s or group s thinking and reasoning. The interview typically involves one to four students working with a researcher/interviewer while being audio and video recorded. It has previously been reported [1] that the data collected in a teaching/learning interview is richer in detail than data collected in an actual classroom. We investigated the possibility that there were also other differences between these formats. We used the same instructional materials as well as pre-, mid- and post-tests in a teaching/learning interview and in a classroom laboratory setting. We will describe how the data collected in these two settings compare.

* This work is funded in part by the U.S. Department of Education, Institute of Education Sciences Award R305A080507.

[1] D. L. McBride, Concept Categorization Analysis: Comparing Verbal and Written Data in American Association of Physics Teachers Winter Meeting, Chicago, IL, 2009.

CP.42: **Probing Student Understanding of Cosmology**

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Donna Larrieu, Kim Coble; Chicago State University
Janelle Bailey, Roxanne Sanchez; University of Nevada Las Vegas
Lynn Cominsky, Kevin McLin; Sonoma State University

Recently, powerful new observations and advances in computation and visualization have led to a revolution in our understanding of the origin, evolution and structure of the universe. These gains have been vast, but their impact on education has been limited. At Chicago State (CSU), we are implementing new inquiry-based instructional materials in our astronomy lab course. We are researching the effectiveness of these materials, focusing on student understanding of cosmology. As part of a collaborative effort with the University of Nevada Las Vegas and Sonoma State (SSU) to develop a cosmological subject inventory, we administered an open-ended survey prior to instruction and conducted student interviews using the survey. Students taking the CSU course were also required to write a guided essay on their beliefs about cosmology. We have collected open-ended post-test data through student exams. Preliminary results regarding student misconceptions in cosmology and student attitudes toward inquiry will be presented.

CP.43: **Addressing Barriers to Conceptual Understanding in IE Physics Courses**

Vincent Coletta, Loyola Marymount University, *vcoletta@lmu.edu*, *Jeffrey Phillips*

We report on an NSF sponsored intervention, Thinking in Physics (TIP), which we have developed to help students with weak scientific reasoning skills, as measured by low preinstruction scores on the Lawson Test of Scientific Reasoning Ability. Without such special help, such students are unlikely to achieve a good conceptual understanding of introductory mechanics.

CP.44: **Revising Lab Materials to Address Difficulties with Electric Circuits**

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We explored students understanding of electric circuits in an introductory, non-science-major physics class (Science 201) at Grove City College. Differentiating between and understanding current, voltage, and resistance is quite difficult and confusing for many students. We identified the common misconceptions held by students before, during, and after their class and lab involvement with circuits. Students in Science 201 spend three lab sessions working with circuits. We videotaped students using the original laboratory materials, interviewed students about their understanding of circuit concepts after each lab activity, and analyzed diagnostic test data to identify specific problem areas. We re-wrote the laboratory materials in the hopes of improving student learning. This poster will present the difficulties students were encountering, describe how we modified the lab materials to better address those difficulties, and summarize the changes in diagnostic data we saw after introducing the modified materials.

CP.45: **Knowledge, Attitudes, and Practices of College Physics Instructors: Results of a National Survey**

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During the Fall of 2008 a survey, designed to collect information about pedagogical knowledge and practices, was delivered to a representative sample of physics faculty across the United States. In this poster we present results from the survey related to faculty goals, satisfaction with teaching, perceptions of their teaching environment, and self-reported teaching techniques.

CP.46: **The Effect of Representations on Student Understanding of Motion**

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Doug Clark, Vanderbilt University

Students intuitive ideas and tacit understandings about forces and motion are usually at odds with normative physics knowledge. In this project, we have developed a video game to increase students understanding of Newtonian mechanics by giving them an opportunity to explore and articulate their tacit understandings, while retaining the strong motivational components of current commercial game design. The game play involves students manipulating the motion of an object to navigate mazes or hit projectile targets. Different forms of representations of motion (such as vector arrows and motion maps) are utilized in the game. This study examines how visual and position-based aspects of the representations help or hinder students in gaining understanding of the concepts and articulating them in a context outside of the game. Specifically, we are looking at how students are able to coordinate multiple representations and use them to make sense of the physics concepts involved.

CP.47: **The Relative Effectiveness of an Interactive Teaching Approach Using PDAs as Interaction Tool***

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Using a quasi-experimental pretest-posttest comparison group research design, the relative effectiveness of an interactive teaching approach using personal digital assistants (PDAs) as interaction tool (experimental group) was compared with a similar teaching approach which used flashcards as the interaction tool (comparison group). Two introductory algebra-based physics classes were purposely selected as participants of the study. The descriptive analysis of the mean gain scores in the Force Concept Inventory (FCI) showed that there is a significant difference on the mean gain scores between the experimental and comparison groups. Furthermore, the calculated Cohen s index of effect size (d=0.6988) indicates that the average gain scores in the experimental group exceeds 76% of the gain scores of the comparison group. Our data suggest that the interactive teaching approach using PDAs as classroom interaction device is more effective in promoting conceptual understanding compared to an interactive teaching approach using flashcards.

*This work is in part funded by the National Science Foundation-DUE-CCLI 0737375.

CP.48: **Students' Perceptions about PDAs as Interaction Tool in a Predominantly Hispanic Classroom***

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An interactive teaching approach using personal digital assistants (PDAs) as classroom interaction devices was implemented in two (2) algebra-based physics and two (2) physical science classes in a predominantly Hispanic institution. The preliminary investigation was focused on implementation issues and perceptions of students towards the use of PDAs in the classroom. A 25-item Likert scale survey was developed to determine students perception about the use of the PDAs as classroom interaction devices. A one-way analysis of variance (ANOVA) showed that there is no significant difference in the degree of agreement of the different group of students in almost all of the items in the survey. Overall, majority of the students surveyed indicated a positive attitude towards the use of PDAs in physics/physical science classroom, irrespective of their educational background and major.

*This work is funded in part by NSF grant DUE-CCLI- 0737375

CP.49: **Promoting Productive Communities of Practice: An Instructor's Perspective**

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Sissi Li

At Oregon State University, we are undergoing curriculum reform in large-enrollment introductory calculus-based physics. We are integrating course goals and materials borrowed from ISLE (Investigative Science Learning Environment) at Rutgers and California State University, Chico. ISLE has been found to help students develop scientific abilities through processes practiced as authentic scientists. Using Peer Instruction to engage students in these practices, our curricular reforms are in part aimed at having students be able to justify their own knowledge, and develop ownership of that knowledge, moving into roles of authority with respect to their physics learning. The instructor works to develop a productive community of practice (Wenger, 1998) enabling students to participate in social interactions and make meaning of their experiences to build a shared repertoire of knowledge. This poster reports on strategies the instructor uses, challenges faced, and present evidence of both successes and failures in terms of achieving this aim.

CP.50: **Relationships across Communities of Practice Pertaining to Student Physics Learning**

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Dedra N. Demaree

At Oregon State University, we are undergoing curriculum reform in our large-enrollment introductory calculus-based physics sequence. As part of this reform, we are integrating materials borrowed from the ISLE (Investigative Science Learning Environment) at Rutgers and California State University, Chico. ISLE has been found to help develop scientific abilities through processes practiced as authentic scientists. Using Peer Instruction to engage students in these practices, our curricular reforms assist the development of a community of practice (Wenger, 1998) which enables students to participate in social interactions and make meaning of their experiences in class to build a shared repertoire of knowledge. Additionally students develop practice beyond our physics community as they participate in other academic as well as non-academic communities of practice throughout their daily lives. This poster will describe the development of students doing physics in the network of communities of practice and how we can support it.

CP.51: **Assessment of Student Problem Solving Processes**

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At Minnesota we have been developing a rubric to evaluate students' written solutions to physics problems that is easy to use and reasonably valid and reliable. The rubric identifies five general problem-solving processes and defines the criteria to attain a score in each (useful description, physics approach, application of physics, math procedures, and logical progression). An important test of the instrument is to check whether these categories represent the actual processes students engage in during problem solving. We will report an analysis of problem-solving interviews conducted with students enrolled in an introductory physics course and discuss the implications of these results for the rubric.

CP.52: **Faculty Disagreement about the Teaching of Quantum Mechanics**

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At our school, there is a strong consensus among faculty on how to teach junior-level E&M. In particular, faculty agree that E&M should be taught on an axiomatic basis (Maxwell s equations) and they agree on the essential concepts in the course (fields and potentials). In contrast, we find a range of opinions about how to teach first-semester, junior-level quantum mechanics (QM). We surveyed over 15 faculty about their approaches to teaching QM, and reviewed several popular textbooks. Although there is broad agreement on the list and order of topics (Schrodinger equation to matrix methods and spin), we find substantial disagreement in several pedagogical aspects, including (1) the importance of presenting QM on an axiomatic basis (i.e. the postulates); (2) the treatment of measurement in QM (in particular, the collapse of the wave function); and (3) the physical interpretation of the wave function (matter wave vs. information wave vs. something else).

CP.53: **Searching for "Preparation for Future Learning" Transfer in Physics**

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Preparation for future learning is a term describing a new approach to transfer. In addition to focusing on the learning environments that help students better apply developed knowledge in new situations researchers are searching for the educational interventions that better prepare the students to learn new information on their own. First PFL studies were conducted by J. Branford and D. Schwartz in psychology and statistics. They found that students who engaged in innovation before being exposed to new material, learned better. We attempted to replicate their experiments in the field of physics, specifically in the area of conductivity. Using two experimental conditions and one control in terms of doing lab work prior to reading we compared student learning of thermal and electrical conductivity from the written text afterwards. We present the results of groups performance on 7 conceptual questions.

CP.54: **How do Tutorial TAs Set the Tone for their Students?**

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Andrew Elby, Department of Physics,
(All from the University of Maryland, College Park)

Tutorial students learn how to "do tutorial" primarily from the explicit and implicit messages that they get from their TAs. These messages are most clearly evident in the first few weeks of the semester, as students and TAs negotiate their expectations regarding what kinds of answers are acceptable, who leads the conversation, and what the TA's and students' roles are during their conversations. We present a case study of a TA's interaction with a group of students during the first three weeks of the semester as they "set the tone" by communicating and negotiating their expectations.

CP.55: **Transforming Upper-Division Quantum Mechanics: Learning Goals and Their Assessment**

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In order to help students overcome documented difficulties learning quantum mechanics (QM) concepts, we have transformed our upper-division QM I course using principles of learning theory and active engagement. Key components of this process include learning goals and a valid, reliable conceptual assessment tool to measure the extent to which students achieve these learning goals. The course learning goals were developed with broad faculty input, and serve as the basis for the design of the course assessment tool. The development of the assessment tool has included significant faculty input and feedback, over 21 student interviews, review of PER literature, and administration of the survey to two semesters of QM I students as well as to a cohort of graduate students. Here, we discuss this ongoing development process and present initial results from our quantum mechanics class for the past two semesters.

CP.56: **Analysis of Former Learning Assistants Views on Teaching and Learning**

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We are currently working to categorize middle and high school teachers views on students, knowledge construction, group interactions, and assessment. This poster will compare the views of teachers who were formerly involved in the Learning Assistant (LA) program to a similar group of teachers who did not participate in this program. This analysis will allow us to reflect on the effects that this program has had on its graduates teaching. The LA Program is intended to recruit promising science and math majors to become secondary science and math teachers. LAs are hired to assist in science and math courses at the university and are required to take an education seminar focused on teaching methods. Previous work has already shown that the LA program has improved the learning of students in the introductory science and math courses and has increased the number of science and math majors earning teacher certifications.

CP.57: **The Influence of Tablet PCs on Students Use of Multiple Representations in Lab Reports**

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It is often hoped that, as students are enculturated into the practice of physics, they will begin to use multiple representations for problem solving, sense making, and communication. This study examined how different tools influenced students choice of representations when communicating with the instructor in a written lab report. In one section of an introductory physics laboratory course, every student had a Tablet PC that served as a digital-ink based lab notebook. With digital labbooks, students could seamlessly create hand-drawn graphics and equations, and write lab reports on the same computer used for data acquisition, simulation, and analysis. In another laboratory section, students used traditional printed lab guides, kept paper notebooks, and then wrote lab reports on regular laptops. Analysis of the lab reports showed differences between the sections use of multiple representations, including an increased use of diagrams and equations by the tablet users.

CP.58: **Protocol for Analysis of Content Questions**

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As a part of a study of the science preparation of elementary school teachers, we are investigating students abilities to apply scientific concepts to unfamiliar situations. The objective is to construct a method which will enable us to compare how students use their reasoning and their content knowledge across different disciplines. To analyze students answers we developed a rubric based on the hierarchies of knowledge and cognitive processes cited in a two dimensional revision of Bloom s taxonomy (1). In this poster we will present the structure of some content questions and the rubric. In addition we will demonstrate the method of analysis for few example questions.

Supported by National Science Foundation grant ESI-055 4594

(1) A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, L.W. Anderson & D.R. Krathwohl, D.R. New York: Longman (2001).

CP.59: **Developing Pedagogically-Relevant Physics Content Knowledge through Asynchronous Online Discussions**

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Helping pre-service teachers develop physics knowledge that is useful in the tasks of teaching is a growing responsibility of physics education researchers. Prior research has documented that analyzing video of children learning science aids pre-service teachers in developing their physics knowledge and deepens their understanding of the learning process. Research on video analysis in teacher education suggests that the primary value of such tasks comes not from watching the video, but from the subsequent discussions. We questioned whether similar advantages would be evident when participants watched and analyzed video clips via online threaded discussions. We found that participants used the video clips as a mediating tool to position their own current ideas about physics topics with respect to their prior understandings as well as to ideas articulated by the students in the video clips. We discuss the study findings and affordances and limitations of online discussion formats.

CP.60: **Exploring Student Consistency in Vector Addition Method Choices**

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The mathematical operation of two-dimensional vector addition arises in multiple physics contexts. The vectors are presented with different features (axes, grids, etc.) depending on the values and physical contexts. As part of a larger survey developed by Van Deventer in 2007, we asked four two-dimensional vector addition questions, with different contextual features, in both a math and a physics context. Consistent with the previous results of Meltzer and Nguyen (2003) we find that changing the graphical presentation of vectors may affect the methods students use to add vectors. We also conducted interviews consisting of two sets of five different two-dimensional vector addition questions with a distracter task between sets. We expected that during the interviews students would change methods of vector addition based on the presentation of the vectors. However, students used the method they used on the first representation, right or wrong, for all following representations.
Footnote: Supported in part by NSF grant DRL-0633951.

CP.61: **The Impact of Physics Education Research on the Teaching of Introductory Quantitative Physics**

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During the Fall of 2008 a survey, designed to collect information about pedagogical knowledge and practices, was delivered to a representative sample of physics faculty across the United States. In this poster we present information about the survey design and implementation. Additionally, we present results related to faculty knowledge and use of specific products from Physics Education Research, as well as an analysis of the reasons faculty give for not using more of these products.

CP.62: **Undergraduate Engineers' Sense-making of Mathematics**

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We are investigating what facilitates or impedes mathematical sense-making -- seeking for meaning and coherence between mathematics and the physical system-- by students in their introductory physics and engineering courses. As such, we have administered epistemological surveys and conducted clinical interviews with students in introductory physics and basic circuits courses. A comparison of clinical interviews of two students, Matt and Emily, illustrates a trend: the tendency to hook up mathematical formalism to the physical intuition facilitates conceptual understanding and problem-solving. Although Matt and Emily both possess the needed basic math skills and physical ideas, Matt solves problems more fluidly and successfully for two reasons: (1) he has formed cognitive units, called symbolic forms [1], in which an algebraic template is tied to a conceptual interpretation, and (2) his epistemological beliefs about math, unlike Emily's, support his using these symbolic forms as a central part of his problem solving.

[1]Cognition and Instruction, 19(4), pgs 479-541, 2001

CP.63: **Effects of Single Sex Lab Groups on Physics Self-efficacy, Behavior, and Academic Performance**

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The purpose of this study was to investigate the relationships between the gender composition of a laboratory group and student behaviors, self-efficacy, and quiz performance, within the college physics laboratory. A student population was chosen and subdivided into two groups, which were assigned either same-sex or coed laboratory teams while executing identical laboratory activities and instruction. Assessments were carried out prior to instruction, during the course, and at the end of one semester worth of instruction and laboratory activities. Students were assessed in three areas: behaviors exhibited during laboratory activities, self-efficacy, and scores on laboratory quizzes. Analyses considered the differences in outcomes after a single semester of physics laboratories that differed only in team gender organization.

In an analysis of the individual behaviors data, it was noted that there is present a practical difference in the individual behaviors exhibited by males and females. This difference implies a difference in how males and females successfully engage in the lab activities.

CP.64: **Effect of Peer Instruction on Student Conceptual Understanding: a Systematic Review of Literature**

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Peer Instruction is an interactive pedagogical method that has shown positive effects on students conceptual understanding of subject matter as well as problem solving skills. The purpose of the current study is to present a systematic review of the literature relating to Peer Instruction. We searched databases, journals and other relevant data sources from 1991 to 2009. Selection criteria included physics education and peer instruction. The study reports the number of studies found, the types of experiments done, and the effects of each study. The results of the review present a strong evidence base to the effectiveness of the Peer Instruction method. The study will be extended in the future to include other subject matter. This study is the first to conduct a comprehensive systematic review of the published literature of the Peer Instruction method.

CP.65: **Instructional Innovations in Physics and their Effects on Student Learning**

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This paper presents results of an NSF project in which the goal is to provide a synthesis of research on instructional innovations that have been implemented in undergraduate courses in physics. The research questions guiding the project are: What constitutes the range of principal course innovations that are being implemented in undergraduate science courses? To what extent are different course innovation approaches associated with differences in student learning? What issues are critical to the effective implementation of course innovations? The paper will describe: (1) the procedures followed to analyze the studies described in 118 journal articles, (2) the literature search procedures, (3) the characteristics of the studies reported, and (4) the results from synthesizing the quantitative results of those studies that met our criteria for inclusion. The paper concludes with recommendations for strengthening programs of research that focus on evaluating the effectiveness of instructional innovations in physics.

CP.66: **Moving Towards PBL & PI - A Canadian-Indian Partnership**

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PAC Ramsamy Raja Polytechnic College (Pacrpoly), a member of the Canada India Institutional Cooperation Project (CIICP), offers Engineering programs targeted towards local needs. Upon invitation, 2 faculty members from the Physics Department at John Abbott College in Quebec visited Pacrpoly and provided guidance and training in Problem Based Learning and Peer Instruction, teaming with selected faculty members at Parcpoly to create relevant examples for the Tamil Nadu region. Funding for this project was provided by both partners, and from Cegep International.

CP.67: **PER in Early Grades: Introducing the Tools of Physicists to Young Children**

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This research turns the PER lens back in the developmental timeline, asking how early instruction using microcomputer-based laboratories (MBL) and interactive lecture demonstrations (ILD) can teach second and third graders motion concepts, using motion graphs as representational tools. Seventeen children in a mixed-age second and third grade classroom participated in the study. In the first session the children explored MBL materials in a semi-structured manner. The second session followed the structure of ILDs (a structured prediction/observation/report approach). Each session lasted one hour. Qualitatively, the children demonstrated understanding slope (both direction and speed), and the graph as a narrative of motion. Qualitatively, children revealed that they were extending their understanding of the motion graph representation beyond the target instruction. This research summarizes an encouraging first step that PER has applications when working with much younger students, not only in teaching motion concepts but also in promoting the use of abstract tools.

CANCELLED

CP.68: **Diagnosing Student Conceptions with a Cross Paradigm Method**

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Identification of student conceptions is one of the main topics for both qualitative and quantitative paradigms in physics and science education research. There are invaluble studies in literature based on both of these paradigms, and all provide us with important information about how students conceptualize nature. However, both paradigms have advantages as well as limitations compared to one another. In this study, a need for a cross paradigm to diagnose student conceptions will be discussed, and an example of a cross paradigm method to diagnose conceptions will be proposed.

CP.69: **Introductory Physics Gender Gaps: Pre- and Post-Studio Transition**

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Like many science and engineering programs, the Colorado School of Mines physics department is interested in improving its gender balance. In this poster, we present preliminary results from our studies of the gender-based performance gaps that exist in our introductory physics population. We analyze eight semesters of data from the second-semester calculus-based course, Introduction to Electromagnetism. Four semesters came from a semi-traditional classroom environment, and four semesters followed a transition to a hybrid Studio physics model (total N = 2577). Our data include CSEM results, DFW rates, course grades, and background information such as ACT scores. As has been found in other environments, gender gaps exist but are reduced as we implement research-based course reforms, with the most persistent gaps residing in the CSEM normalized gains. We also find striking semester-to-semester variations in all measures, despite the same instructors handling the courses for much of the study period.

CP.70: **Unpacking Gender Differences in Students' Perceived Experiences in Introductory Physics**

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Prior research has shown: 1) males outperform females on conceptual assessments (a gender gap) at our institution, 2) the gender gap persists despite the use of research-based reforms, and 3) the gender gap is correlated with students physics and mathematics background and prior attitudes and beliefs [Kost, et. al. PRST-PER, 5, 010101]. We next begin to explore how males and females experience the introductory course differently and how these differences relate to the gender gap. In a survey to students in the introductory course we investigated students physics identity and sense of belonging, epistemology, and self-efficacy. We find there are significant gender differences in each of these three areas, and further find that these measures are weakly correlated with student conceptual performance, and moderately correlated with course grade.

CP.71: **PER Community Enhancing Network for Teaching, Research and Learning**

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PER-CENTRAL is a cataloged, vetted, and free online collection designed specifically to serve as an informational touch-point and online community for producers and consumers of physics education research. Along with a database of PER articles and dissertations, there are links to research groups, PER-based curricular materials, news and events, and many other things of interest to our community. The latest additions feature the PERWiki, intended to provide a collaborative space for works of interest, and volume two of the reviews in PER, a collection of articles that provides an accessible overview of basic issues related to conducting Physics Education Research. This poster presents both featured content and the tools available to users of PER-CENTRAL.

PER-CENTRAL is part of the ComPADRE network of physics and astronomy resource communities. ComPADRE is part of and supported by grants from the National Science Foundation's National Science Digital Library.

CP.72: **When Talking is Better than Keeping Quiet**

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The effectiveness of Peer Instruction is often associated to the importance of in-class peer-discussions. Reflection or time-on-task may also explain this effectiveness because students answering ConcepTests reflect more and spend more time thinking about concepts. An identical sequence of conceptual questions was given to three groups of students. All groups were polled twice on each question. Between polls, the first group was asked to discuss their choice with a peer, the second group was asked to reflect for a minute (no discussion), and the third group was given a distraction task (sequence of cartoons: no discussion and no reflection). All three groups displayed gains between the first and the second polls. The Distract group had less gain (3.4%) than the Reflect group (9.7%) while the Discuss group had most (21.0%). All groups show gains, potentially because of a testing effect although peer-discussions clearly yield greatest changes.

CP.73: **Examining Change Strategies in University STEM Education**

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Yuhfen Lin, Charles Henderson, Noah D Finkelstein

Calls for change in STEM education have been made for over a decade. Yet change is hard to initiate, and difficult to sustain. In order to gain a better understanding of the mechanisms that facilitate change in instruction in higher education, we surveyed existing literature that describes reform in STEM education. Through examining the strategies that researchers adopted, two dimensions of change strategies emerged: 1) change strategies either seek to impact individuals or the environments and structures; 2) the intended change outcome is either prescribed or emergent. With the aid of extra coding categories, we were able to better study the differences and similarities of the approaches adopted by researchers in three different fields: STEM education, higher education, and faculty development. In this talk we will present some of the results and discuss some implications for how to effectively promote change in STEM education.

CP.74: **Communicating across Paradigms: Boundary-Crossing in an Interdisciplinary World**

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Interdisciplinary knowledge is becoming increasingly important in a world where scientists, politicians, and the general public are expected to make informed and reasoned decisions about unpredictable phenomena ranging from global

climate change to economic bubbles. The ability to reason about complex and non-intuitive systems is a fundamental objective of higher education learning, and necessary for the development of scientific literacy. We argue that interdisciplinary communication is a necessary prerequisite for the effective communication of scientific principles to non-scientists. While evident in traditional sciences, communication between disciplines is less common in the learning and cognitive science domains. We present: 1) an analysis of boundary crossing as represented in disciplinary science education, science education, and cognitive science journals; 2) a discussion of limitations to communication imposed by traditional venues; and 3) solutions offered by familiar technologies and trends in online publication.

CP.75: **Locus of Authority in Learning, Teaching, and Research.**

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David T. Brookes

From prior research we know that the majority of college freshmen view knowledge as an object, emanating from an external authority such as a professor or a textbook. By the time graduate students complete their degree they are expected to have shifted from recipients of knowledge to creators of knowledge. To distinguish these two different scenarios, we will introduce the idea of locus of authority. If students are to view knowledge as constructed by themselves rather than an object received from an authority figure, they need to start viewing themselves as an authority. Thus the locus needs to shift from external sources to within themselves. We will discuss the theoretical implications of this idea for the activities of learning, teaching, and research. Here, we will apply the locus of authority idea to examine how graduate students face the difficult task of being both student and teacher at the same time.

CP.76: **Categorization of Quantum Mechanics Problems by Professors and Students**

Shih-Yin Lin, University of Pittsburgh, hellosilpn@gmail.com
Chandralekha Singh

We discuss the categorization of 20 quantum mechanics problems by physics professors and students in honors-level quantum mechanics course. Professors and students were asked to categorize the problems based upon similarity of solution. We find that while faculty members' categorization was overall better than students' categorization, the categories created by faculty members were more diverse compared to the uniformity of the categories they create when asked to categorize introductory mechanics problems. We will discuss the findings. This work is supported by National Science Foundation.

CP.77: **Student Understanding of Basic Probability Concepts in an Upper-Division Thermal Physics Course**

Michael Loverude, California State University Fullerton, mloverude@fullerton.edu

As part of an ongoing study of student understanding in upper-division thermal physics, we developed a number of simple diagnostic questions designed to probe understanding of basic probability concepts. As reported in 2007, many students had difficulty in distinguishing the concepts of microstate and macrostate, and in applying mathematical relationships for multiplicity of simple systems. We have tested a tutorial sequence designed to address some of the difficulties. In this poster we will briefly summarize previous results, show post-test results from the target courses, and describe aspects of the tutorial sequence that are likely in need of modification.

CP.78: **Usage of the Term Force, Reasoning Ability, and FCI Performance**

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Will students achieving greater FCI gains be less likely to use force synonymously with other terminology following instruction? Can reasoning ability or demonstrated conceptual understanding of force be used as a predictor of accuracy in the usage of the term force ? For this particular study, 230 participants completed Force Concept Inventory (FCI) pre- and post-tests, Lawson s Classroom Test of Scientific Reasoning (TSR) and Mechanics Language Usage (MLU) pre- and post-tests. The conventional expected result was not strongly supported. Although individuals with greater FCI gains had greater TSR scores, these students did not necessarily use force more discerningly. That is, regardless of FCI gains and reasoning ability, there is a noted tendency for students to continue using force equivalently with other colloquial terms like power, energy, strength and momentum. The data for this study were collected in large enrollment lecture based algebra physics classes, first semester.

CP.79: **Research Projects in Introductory Physics: Impacts on Student Learning and Attitudes**

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Over the last two years UBC has completely revamped their introductory course for non-physics majors to present physics in terms of everyday situations and real-world issues of energy and climate change. These changes attempt to reinforce connections between classroom physics and real-world phenomena through the lecture examples, weekly context-rich tutorials, and incorporation of real-world model problems in lab experiments. A key change was the incorporation of a final project where groups of students research and present on a topic of their choice related to the course. Students were asked to quantitatively model a real-world situation to make a choice or settle a dispute. Near the end of the second year of implementation students were surveyed to examine the project s impact on their attitudes towards physics and were tested for transfer using novel real-world problems. This poster will present the results of these assessments and discuss their implications for the course.

CP.80: **Development of an Assessment of Textbook Problem-Solving Ability**

Jeff Marx, McDaniel College, jmarx@mcdaniel.edu
Karen Cummings
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Development of students problem-solving ability is commonly cited as one of the primary goals in introductory physics courses. However, there is no broadly agreed upon definition of what is meant by problem solving. Most physicists want students to be able to successfully apply a logically yet flexible approach to solving real-world problems significantly different from any they have seen before. Still, many introductory instructors are primarily concerned with how successfully and thoughtfully students solve standard textbook-style problems. In this poster, we will present our progress on the development of a multiple-choice survey, the function of which is to reasonably characterize the problem-solving ability of introductory, undergraduate physics students in the realms of dynamics, energy, and momentum. Specifically, we will discuss our particular motivations and goals for this project, share some specific examples of items we have developed, and invite interested faculty to participate in the testing of our instrument.

CP.81: **Do Advanced Students Learn from their Mistakes without Explicit Intervention?**

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Chandralekha Singh, University of Pittsburgh Department of Physics and Astronomy

One attribute of physics experts is that they learn from their own mistakes while solving physics problems. Experts are unlikely to make the same mistakes when asked to solve a problem a second time especially if they had access to the correct solution after their initial unsuccessful attempt. Here, we discuss a case study which explores if advanced physics students use the opportunity to learn from their mistakes. The performance on the final exam shows a wide distribution of students' performance on problems administered a second time, which suggests that many advanced students may not automatically exploit their mistakes as an opportunity for learning, and repairing, extending, and organizing their knowledge structure. We also conduct individual interviews with a subset of students to obtain a better insight into students' attitude towards problem-solving and learning and to understand how well students are able to retrieve knowledge relevant for solving the problems.

This study is supported by the National Science Foundation.

CP.82: **Using Similarity Rating Tasks to Assess Case Reuse in Problem Solving***

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Case-reuse strategies involve extracting the conceptual schema from previous cases and adapting them to new problems. Recognizing the deep structure differences and similarities between problems is essential for productive case reuse. We report on a semester-long study with students participating in weekly focus group learning interviews to facilitate case reuse strategies. At the mid and end points of the study, students were interviewed individually to ascertain the effect of these strategies. During these interviews students were asked to rate the similarities between problem pairs, identify the underlying principles of these problems and determine which problems from the collection might be most or least helpful as worked out examples to solve a new challenging problem. We will report on the results from these interviews as well as present a comparison with expert responses to these questions.
* This work is supported partly by the U.S. National Science Foundation grant 06185459.

CP.83: **Conceptually Scaffolded Problem Solving**

Lin Ding, Department of Physics, The Ohio State University, ding.65@osu.edu
Neville Reay, Albert Lee, Lei Bao

Conceptual learning has long been a primary component of introductory physics education. However, educators agree that problem solving is equally important. Building on our conceptually-based clicker methodology, we conducted pilot studies to seek possible ways of promoting student problem solving skills through guided conceptual scaffolding. We created several question sequences, each consisting of two relevant conceptual questions plus one quantitative problem. Both questions and the problem synthesized concepts widely separated in the textbook. Synthesizing concepts is particularly difficult for students, and generally is not required for solving end-of-chapter problems. Participating students were divided into three groups: the first answered the conceptual questions before being asked to solve the problem. The second received cueing on underlying concepts before attempting the problem. The third was simply asked to solve the problem. Small-scale interviews and a large-scale written test were conducted. We report pilot results and discuss future work.

CP.84: **Applying Knowledge in New Contexts: A Comparison of Pre- and Post-Instruction Students**

Dyan L. McBride, Kansas State University, dyanm@ksu.edu, Dean A. Zollman

For several years, our research group at Kansas State has been studying how students apply knowledge in new contexts. One such study focuses on how students apply knowledge of light and basic geometric optics to the context of wavefront aberrometry. In one aspect of this study we compared the application of previous knowledge of students who had studied light and basic geometric optics in a physics course with those who had not and thus could only apply knowledge obtained in an informal way. We sought to examine what differences exist in the way they construct an understanding of wavefront aberrometry. The data showed that students with no formal instruction tended to rely on experiential knowledge as one would expect. However, the students with formal instruction relied on textbook knowledge and tended to discount or ignore their everyday experiences. We will discuss what this difference in knowledge types might imply about the knowledge construction process

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CP.85: **Technology as a Lens for Examining Instructor's Pedagogical Content Knowledge**

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The relationship between instructors content knowledge and the chosen pedagogical approach (Pedagogical Content Knowledge - PCK) and its impact on student learning have been a focus of many studies. Usually they employ interviews, observations and surveys. We propose to analyze the instructor s choice of educational technologies and corresponding pedagogical-technological decisions to investigate her PCK. For example, the instructor s use of clickers can allow the researchers to gain significant information about her PCK even without observing the classes, just by inspecting such teaching materials as lecture notes. The analysis of the types of questions included in lectures, sequencing of the material covered, etc. should also reveal information about the instructor's Subject Matter Content Knowledge (SMCK). We propose the framework for doing such an analysis as applied to clicker technologies implemented by science and mathematics instructors. One of the biggest advantages of such an analysis compared to an interview is its objectivity.

CP.86: **Conceptual Difficulties with Binomial Distributions in Statistical Physics**

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As part of our continuing research on the teaching and learning of concepts in upper-division thermal physics at the University of Maine, we report on student responses to questions about binomial distributions and the changes in those distributions with an increasing number of trials (N). We have administered questions before and after traditional instruction and guided-inquiry activities that probe understanding of multiplicities, probabilities, and their distributions over N, covering more than 6 orders of magnitude in N. Preliminary results indicate some positive learning outcomes, along with some persistent problems; e.g., confusion over the dependence of macrostate probability on multiplicity, and whether the probability of a single (N/2) macrostate emerges at large N to dominate the distribution, or not. Results are discussed in the context of the term overwhelming probability, commonly used to describe the connections with equilibrium thermodynamic (very large N) systems.

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CP.87: **Identifying Student Difficulties with Pressure in a Fluid**

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This study is part of an effort to develop an FCI-style diagnostic test assessing student understanding of fluids. In particular, this poster addresses questions which involve pressure, one of which is modified from McDermott s <i>Tutorials</i>. This particular question, which asks students to rank pressures in an N-shaped tube and explain their reasoning, has been administered to hundreds of students in three different introductory courses at Grove City College for the past six years. As might have been expected, students have provided a seemingly endless range of answers. We have sorted the responses into categories relating to similar interpretations of the question. We are using the commonly-occurring difficulties to develop a series of multiple-choice questions which probe the various facets of student understanding of pressure. By analyzing the data from the resulting questions, instructors will be able to tailor instruction to address the identified difficulties.

CP.88: **Probing Student Understanding of Resonance***

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Dyan L. McBride, and Dean A. Zollman

The study of how students apply knowledge in new contexts is a currently being researched at Kansas State University. Resonant phenomena play a crucial role in magnetic resonance imaging (MRI), a widely used medical tool in today s society and a part of the larger modern miracle medical machines project. The basics of MRI can be taught by looking at the resonance of a compass driven by an electromagnetic field. However, this is not a system that is familiar to most students, making it beneficial to start by first introducing resonance in the context of a pendulum before shifting over to a system involving magnetism. We present a case-study on students ability to apply the knowledge learned in the traditional resonant system to the novel system.
*Supported in part by NSF Grant DUE 04-27645

CP.89: **Joint Engineering and Physics Education Research Projects   Should there be More of them?**

Katie Nagle, Engineering, College of DuPage, naglek@cod.edu , Tom Carter

The majority of students in many introductory calculus-based physics classes are not majoring in physics, but instead are engineering students. The engineering discipline has its own education research community and its own conceptual evaluations. This poster introduces one of those evaluations, the Statics Concept Inventory (SCI). Some concepts probed by the SCI are similar to those in the Force Concept Inventory (FCI) with only surface features changed (e.g. drawing style). We will compare the initial results of a joint research project involving engineering and physics faculty. We show results from students who took both the SCI and FCI in both introductory engineering and physics courses at a two-year college.

CP.90: **Online Data Collection and Analysis in Introductory Physics**

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Kansas State University Physics Department

Online implementation of physics learning materials may present a powerful method of data collection, in addition to being useful for supplemental instruction. This may have implications for composite instruction and research designs. We have developed three lessons on Newton s laws and implemented them on the Internet. The lessons ask students to make observations and measurements using video clips, perform calculations and answer open-ended questions. Responses can be collected via an online response system. 110 university students enrolled in an algebra-based physics course and 30 high school physics students worked through some or all of our lessons, and their responses were collected. We present a qualitative and quantitative analysis of their responses and assess the implications for optimal design of online lesson materials for collecting meaningful data about student understanding of basic physics concepts. This work is supported by the U.S. National Science Foundation under grants REC-0632587 and REC-0632657.

CP.91: **The Examination of Beginning Secondary Physics Teachers PCK through Two Different Research Lenses**

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This study examines the pedagogical content knowledge (PCK) of beginning physics teachers through two different research lenses cognitive and teacher education research. The cognitive research lens examines PCK through the nature of expertise. Beginning physics teachers are considered novices, and therefore exhibit certain characteristics in terms of knowledge structure and pedagogies specific to teaching physics. The teacher education research lens examines PCK as one element within the necessary knowledge for teaching. All teachers move through a continuum of professional development, where beliefs about teaching interact with different types of knowledge (content, pedagogical, context, and pedagogical content knowledge) and classroom practice. Each of these areas develops with time spent in the profession of teaching. Data collected from four beginning secondary physics teachers over their first two years of teaching are used to illustrate similarities and differences between these two research lenses, within the characterization and development of PCK for teaching physics.

CP.92: **Facilitating Student Transfer of Problem Solving Across Representations***

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Studies indicate that the use of multiple representations in teaching helps students become better problem solvers. Students who learn in representation-rich environments are able to construct representations to help them solve problems. We report on a study to investigate students difficulties with multiple representations and strategies to help students overcome those difficulties. We conducted teaching/learning interviews with 20 students in a first semester calculus-based physics course. Each student was interviewed four times during the semester, each time after they had completed an exam in class. During these interviews students were first asked to solve a problem they had seen on the exam, followed by problems that differed in context and type of representation from the exam problem. Students were provided verbal scaffolding to solve

the new problems. We present the interview protocols, common difficulties that students encountered and scaffolding that we provided students to help them overcome those difficulties.

* This work is supported in part by the U.S. National Science Foundation grant 0816207.

CP.93: **PhET Simulations: Should we Show the Invisible?**

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During hundreds of student interviews, we have seen students engage in productive scientific exploration with PhET Interactive Simulations (sims). Recently we have been working to determine what specific features of PhET sims are necessary to make them effective learning tools. In this study, we compare differences in student learning and sim investigation when the sim either shows or hides representations of abstract or invisible phenomena such as a magnetic field or electron flow in a wire. Specifically, we conducted individual interviews with introductory-level university physics students, some of whom were using Faraday's Electromagnetic Lab as designed and others who used a version of the same sim but without the invisible representations. Preliminary results indicate that students who saw the representation of electron flow and the magnetic field are more ready to learn about Lenz's Law compared to students who did not see these representations.

CP.94: **Using Clickers in Upper-division Physics Courses: What do Students Think?**

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A growing number of faculty are using clicker questions and peer instruction in introductory physics courses at institutions across the US; however, this approach is rarely used in upper-division physics courses. At the University of Colorado at Boulder, an increasing number of faculty are incorporating clicker questions in upper-division courses clickers have been used 24 times in 10 different upper-division courses by 14 different faculty. Here, we report on the results of a survey administered to over 250 students in 12 classes. We find that 79% of the students recommend using clickers in upper-division courses. In all classes, a majority of students favor clickers and there are few negative responses. We also analyze students responses as to why and how clickers support their learning, and report on how students recommend that faculty implement clickers in their courses (e.g. 2-5 questions interspersed with lecture). For upper-division clicker questions see http://www.colorado.edu/physics/EducationIssues/cts/index.htm.

CP.95: **Student Choices when Learning with Computer Simulations**

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We examine student choices while using PhET computer simulations (sims) to learn physics content. In interviews, students were given questions from the Force Concept Inventory (FCI) and were allowed to choose from 12 computer simulations in order to answer these questions. We investigate students choices when answering FCI questions with sims. We find that while students initially choose sims that match problem situations at a surface level, deeper connections may be noticed by students later on. These results inform us on how people may choose education resources when learning on their own.

CP.96: **Longer Term Impacts of Transformed Courses on Student Conceptual Understanding of E&M**

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We have measured upper-division physics majors' performance using two research-based conceptual instruments in E&M, the BEMA [1] and the CUE (Colorado Upper Division Electrostatics assessment [2].) The BEMA has been given pre/post in freshman E&M (Physics II) courses, and the BEMA and CUE have been given as a pre/post-test in several upper-division E&M courses. Some of the data extends over 10 semesters. We used PER-based techniques to transform the introductory and upper-division courses starting in Fall 2004 and 2007, respectively [2,3]. Our longitudinal data allows us to measure "fade" on BEMA performance between freshman and junior year. We investigate the effects of curricula on students by comparing juniors who were enrolled in traditional vs transformed physics as freshmen, as well as those who were enrolled in transformed or traditional upper-division E&M I, using both BEMA and CUE measures. We find that while freshman reforms significantly impact BEMA scores, junior-level reforms affect CUE but not BEMA outcomes.

[1] L. Ding et al., Phys Rev ST:PER 2, 010105 (2006)
[2] N. Finkelstein and S. Pollock, Phys Rev ST:PER 1, 010101 (2005)
[3] S. Chasteen, S. Pollock, "Transforming Upper-Division Electricity and Magnetism", PERC proceedings, Edmonton, 2008

CP.97: **Addressing the Shortcomings of a Textbook with a Supplemental Wiki**

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PER has shown the benefit of transitioning teachers from a "sage on the stage" to a "guide on the side". The e-Book will enable a similar shift in the role of the textbook[1] from authoritative serial repository to a modular, searchable and customizable hub that provides a clear overview of the domain, short summaries of key content, and links to more detailed resources. Our Wiki will incorporate these features naturally, and allow for student feedback. Our open-source wiki for introductory mechanics uses ideas from modeling physics to encourage strategic, concept-based problem solving. This resource can serve as a customizable supplement to any existing course using any mechanics text. We invite collaborators to help us reinvent the textbook!

[1] P. Bierman, "Initial Workshop Summary", NSF Workshop Reconsidering the Textbook May 24-26, 2006 (National Academy of Sciences, WA). <http://serc.carleton.edu/textbook>

CP.98: **PER in Polynesia**

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I spent the last semester teaching at BYU-Hawaii in Laie, Oahu, among one of the most diverse student bodies in America. Cross-correlating student responses to surveys, including the FCI or CSEM, the Lawson test, and the EBAPS, I hoped to see if cultural differences would affect interactive engagement efforts. Both statistical analyses and anecdotal experiences yield some very interesting conclusions.

CP.99: **In-Service Science Teachers' Newtonian Conceptual Understanding before & after a One-Week Workshop**

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Out of field teaching, when teachers are assigned to teach subjects that do not match their training or education, is an issue across the country but is especially prevalent in subjects such as physics. Yet even for those with undergraduate course work in physics, they may not possess Newtonian conceptual understanding of force and motion, especially if they experienced traditional physics courses. Thus, effective professional development is necessary to correct conceptual understanding in our science teachers to prevent perpetuating these misunderstandings. This presentation investigates the effects of a one week workshop for in-service teachers on the teachers conceptual understanding of force and motion using the Force and Motion Conceptual Evaluation as the pretest and posttest. Teacher feedback was also used to gauge the effectiveness of the workshop, including improving the teachers classroom strategies for teaching force and motion.

CP.100: **Can We Assess Efficiency and Innovation in Transfer?***

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Schwartz, Bransford and Sears [1] propose a two-dimensional model that describes transfer in terms of efficiency and innovation. Efficiency is the ability to apply prior knowledge to new situations quickly and accurately. Innovation is the ability to question assumptions, let go of prior knowledge and generate new ideas. Schwartz et. al. argue that most educational assessments focus on efficiency at the expense of innovation. We suggest that this perspective does not adequately reflect the challenges that our students face while problem solving. For instance, while faculty may find end-of-chapter physics problems to be routine and overly focused on efficiency, our students, who lack prior knowledge and experience may find these problems to be novel and innovative. We propose an operational meaning of efficiency and innovation and development of criteria to measure these constructs in ways that reflect both students challenges as well as faculty expectations.

* This work is supported in part by the U.S. National Science Foundation grants 0816207.

[1] D. Schwartz, J. D. Bransford, and D. Sears, in Transfer of Learning from a Modern Multidisciplinary Perspective, edited by J.P. Mestre (Information Age Publishing, Greenwich, CT, 2005).

CP.101: **Impact of the FIU PhysTEC Reform of Introductory Physics Labs**

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A previous study of the impact of the FIU PhysTEC Project s reform of introductory physics labs reported significant differences in normalized FCI gain and common exam questions in reformed labs versus traditional labs [1]. We have extended the study to investigate gender and ethnicity as well as TA effects. Reformed lab sections incorporated Learning Assistants and implemented University of Maryland tutorials [2]. We will present results on normalized FCI gain and common exam questions. We find no significant difference in student performance when comparing TAs, an 18% improvement in exam scores for females and a 9% improvement on the FCI raw gain for underrepresented students in the reformed labs.

[1] Wells et al., AIP Conf.Proc. 1064:227 (2008).

[2] Scherr, et al., Physics 122: Tutorials and Laboratories, Wiley Custom Press (2007).

Work supported by PhysTEC and NSF PHY-0802184.

CP.102: **Modeling Student Conceptual Understanding of Force, Velocity, and Acceleration**

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We have developed a multiple choice test designed to probe students conceptual understanding of the relationships between force, velocity, and acceleration. The test was administered to more than 800 students in standard or honors introductory physics courses or a second-year physics majors course. We report on several validity and reliability measures for the test including correlations with grade, course level, and the Force Concept Inventory. Results indicate that students are much more likely to respond that the velocity of an object can be zero or opposite to the acceleration than the velocity can be zero or opposite to the net force. The data also indicates a possible evolution from the common misconception, that velocity must be in the direction of the acceleration or net force, through an intermediate model where velocity can be opposite to or in the direction of the acceleration or net force but not zero.

CP.103: **Comparing Experts and Novices in Solving Electrical Circuits Problems with the Help of Eye Tracking**

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In order to help introductory physics students understand and learn to solve problems with circuits, we must first understand how they differ from experts. This preliminary study focuses on problem solving dealing with electrical circuits. We investigate difficulties novices have with circuits and compare their work with those of experts. We incorporate the use of an eye-tracker to investigate any possible differences or similarities on how experts and novices focus on graphics or multimedia usually used in analyzing circuits and their components. Our results show similarities in gaze patterns among all subjects on the components of the circuit. Yet, we found differences in how they solve the problems. For example, experts simplified circuits when appropriate as opposed to novices who did not. We also found that novices were confusing additive properties of capacitance with those of resistance. They also had difficulties identifying when resistors are in parallel or in series.

CP.104: **Comparing Cluster Analysis and Traditional Analysis Methods in PER: More Data**

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(all from Univirsity of Maine)

Previous work with applying cluster analysis to free response questions about two-dimensional motion has shown suggestive similarities between the groups found by the cluster analysis and the traditional classifications of student responses [1]. To check this relationship more carefully, we have carried out a

[1] R. P. Springuel, M. C. Wittmann, and J. R. Thompson, Applying clustering to statistical analysis of student reasoning about two-dimensional kinematics, Physical Review Special Topics - Physics Education Research 3, 020107 (2007).

CP.105: **Computer Simulations to Classrooms: Cultural Tools for Learning Physics**

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The PhET computer simulations (sims) have been demonstrated as successful tools for teaching and learning physics. In this poster we situate PhET sims in a socio-cultural-historical context, focusing on the Wave Interference sim as an example. Sims are cultural tools designed to embody certain norms and practices of the physics community, particularly learning through exploration. This poster focuses on the interaction between three scales of cultural tools: representations (graphs, pictures, etc.), learning tools (sims), and learning environments. Sims can strongly influence the nature of student engagement in the classroom, but they are not magic pills. Classroom environments can drive certain types of activity, but we are not fated to recapitulate traditional educational practices. We will examine critical features of tools across these three scales which support student learning through engaged exploration.

CP.106: **The Effect of Inquiry-Based Early Field Experience on Pre-Service Teachers Understanding & Attitudes**

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As part of a pre-service science course for teachers at California Polytechnic University, Pomona we provided an early field inquiry-based teaching experience. A K-12 science specialist and Cal Poly faculty member worked together to help students develop a formal standards-based lesson plan and present to a class of 4th grade students in a local elementary school. Data will be presented to demonstrate the effect of the field experience in student content knowledge, science reasoning skills, ability to teach inquiry-based science lessons, as well as their attitudes towards teaching.

CP.107: **Using Multimedia Learning Modules (MLM) as Part of a Hybrid Course in Electricity and Magnetism**

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As part of a hybrid course in a calculus-based introductory E&M at California State Polytechnic University, Pomona, we have implemented Multimedia Learning Modules [1] through the blackboard learning management system. The integration of the web-based Multimedia Learning Modules introduces students to basic physics content prior to class and allows instructors to focus on more in-depth application of the concepts. We will describe the research project and discuss the impact it had on student preparation, exam performance, and their attitude towards online material.

[1] https://online-s.physics.uiuc.edu/courses/phys212/gtm/No_Login/page.html

CP.108: **Computational Physics Undergraduate Research Experience (A Case Study)**

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There is a growing trend of inclusion of more research programs into undergraduate education. In spite of that, the assessment of undergraduate-research experience in physics is very limited. This presentation describes the case study for undergraduate research experience for two upper division physics students. The analysis of data suggests more gains on research methodologies and skills than actual physical concepts underling the research project. We also discuss the change in student attitude as measured by Maryland Physics Expectations (MPEX) survey and interviews.

CP.109: **Take My Survey, Please!: Comparison of Survey Response Rates Across Four Administration Factors**

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This poster identifies modes of assessment administration which produce the highest response rates. The analysis compares the response rates of students who answered both the Sources of Self-Efficacy in Science Courses and CLASS surveys administered at Florida International University between Fall 2008 and Spring 2009. The survey administrations, given as both a pre- and post-course surveys, included four factors: two survey formats (paper or online), an incentive (extra credit from the professor or no extra credit), email notifications (two different versions), and follow-up reminders (email, in person, or none). We present findings of this analysis and make recommendations to help streamline their survey administration processes and maximize response rates.

Supported by NSF Grant #0802184

CP.110: **Open Online Physics Homework Forums**

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Open, online, homework help forums are websites where any student with Internet access can post questions from their coursework. By participating in these homework forums, students have access to more knowledgeable peers and experts who voluntarily provide help and encouragement. These forums provide a new context for studying help-seeking behavior, tutoring strategies, and can serve as a catalog of common student difficulties. In this poster, we focus on the two largest english-speaking physics forums: www.physicsforums.com and www.cramster.com. For PhysicsForums, we collected a month's worth of tutoring exchanges for introductory physics homework. We analyzed the participation structure of the exchanges by tabulating conversational turns, giving insight into the social interactions that occur. We also qualitatively analyzed the exchanges based on the quality of the instruction and the sophistication of the pedagogical approaches employed by the tutors. In addition, we conducted a much briefer analysis of Cramster. We conclude that effective tutoring can occur in this setting if tutors have the goal of encouraging active student learning.

CP.111: **Using Quantitative Demonstrations to Improve Student Understanding of Collisions**

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Ratchapak Chitaree, Department of Physics Faculty of Science, Institute for Innovation Development of Learning Process, Mahidol University, Bangkok

This study identifies student models underlying the difficulties which were affected by the student naïve understanding of collisions. Based on the identified student models, teaching models are developed to facilitate student learning. The results of the study show that most students have difficulty in identifying the appropriate system to qualitatively interpret the principles of energy conservation in an elastic collision and the principle of momentum conservation in both elastic and inelastic collisions, due to the difficulties in visualizing the energy and momentum transfer during collisions. The student reasoning can be grouped into three categories: correct models, incorrect models, and null models. Based on the student models, the teaching approach incorporating quantitative demonstrations has been developed to help students with their learning in the class. The study found that after this instruction, many students shift from incorrect to correct models and develop independent models consistent with the scientifically correct explanation.

CP.112: **I Think I Can: Investigating the Impact of Physics Problem Solving on Student Self-efficacy***

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Laird Kramer
(All from Florida International University)

Proximal goal setting has been strongly linked to self-efficacy and often occurs in successful problem solving. A qualitative study, using both observations and interviews, investigated the problem-solving processes and the self-efficacy of two students enrolled in an introductory physics course that implemented Modeling Instruction at Florida International University. We found that the problem solving process could be divided into two main themes: the goal setting process and the self-efficacy feedback loop. Further, the goal setting process could not be isolated from its impact on the self-efficacy of the students. This relationship between the goal setting strategies within the problem-solving process and self-efficacy may be linked to the retention of students in physics. We present results of the study and its possible link to student retention.

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CP.115: **Student Difficulties with the Direction of Magnetic Force on a Charged Particle**

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In a series of tests administered to introductory physics students, we examine how students answer questions about the direction of the magnetic force on a charged particle. Data were taken over a period of 17 weeks using differing representations of magnetic field. Following instruction, a significant proportion of answers (approximately 30% given a magnetic pole representation of field and 20% given field line) coincided with an overall sign error. Potential sources of sign error (e.g. "left-hand-rule," physical discomfort, non-commutativity of cross products) were investigated via additional test questions and student interviews. Evidence from these additional experiments suggests that the sign errors are not systematic within students, but vary randomly. For example, students using the "left-hand-rule" would consistently answer with a sign error, while students who believe the cross product is commutative would answer with either the correct force or an overall sign error.

CP.116: **Long-Term Observation in Middle School Astronomy**

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Gordon Aubrecht, Ohio State University

AAAS has noted that middle-school students may think experiments are a way to produce a desired outcome, rather than of testing ideas." Last school year, OSU Marion collaborated with the entire Grant Middle School (Marion) science faculty to improve science teaching and learning systemically. We developed an astronomy unit that would address major parts of Ohio standards to address this problem by instituting an investigation that would occur over the school year. We asked students to observe and infer these motions without telling them what was expected. Only part of what we planned was implemented because few Moon observations (done at home) were made. Sun shadows were observed roughly monthly by students; a daub of paint on a wood platform indicated the tip of the shadow. We present the results of the yearlong investigation and speculate on whether this could be a useful way to address the AAAS's concern.

CP.117: **The Use of Design-Based Research and Practitioner (Action) Research in Physics Education Research**

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As educators working within the context of research focused universities, we are encouraged to undertake scholarly inquiry into our teaching and learning practices. In this paper we demonstrate how practitioner (action) research and design-based research integrate to enable the scholarship of teaching as modelled by Boyer (1990) and Trigwell, Martin, Benjamin and Prosser (2000). A teaching development initiative, the workshop tutorials, will be used to exemplify both research methodologies. An overlying interpretive theoretical perspective will be used to reflect on the evolution of the workshop tutorials. The perspective allows us to propose five key features that explain why design-based research offers a methodological framework for the broad description and conduct of scholarly inquiry into teaching and learning in physics and other disciplines.

Boyer, E. L. (1990). Scholarship reconsidered: Priorities of the professoriate. Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.
Trigwell, K., Martin, E., Benjamin J., & Prosser, M. (2000). Scholarship of teaching: a model. Higher Education Research & Development, 19 (2), 155-168.

CP.118: **Relations between Cognitive and Affective Factors in Predicting Performance in Introductory Science**

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Understanding factors related to student performance in introductory science courses is necessary for helping a growing number of students who have difficulties with STEM courses to learn and succeed. After conducting a pilot study focusing on Lawson s Classroom Test of Scientific Reasoning (CTSR), the authors designed a study to ascertain affective and cognitive factors (as well as social and classroom factors) that may provide predictive power for success in science as measured by course grade. Data from this study indicate that although both SAT/ACT and CTSR scores correlate with course grade, the CTSR provides no additional predictive power of grade than the SAT/ACT score does. Data also indicates that Science Self-efficacy is correlated with course grade, and provides additional predictive information about student success.

CP.119: **Using Cognitive Apprenticeship Framework and Multiple-Possibility Problems to Enhance Epistemic Cog**

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Eugenia Etkina

Epistemic cognition occurs when a person is solving a problem that does not have one right answer (a multiple-possibility problem), and thus she/he has to examine different possibilities, assumptions, and evaluate the outcomes. Epistemic cognition is an important part of thinking in real life. Physicists routinely engage in epistemic cognition when they solve problems. But in educational settings we polish problems and make them single-possibility problems. Thus students rarely get a chance to engage in epistemic cognition while working on problem-solving tasks. We introduced multiple-possibility physics problems in recitation sections of an algebra-based introductory physics course at Rutgers University. In this poster we describe how we incorporated the cognitive apprenticeship framework in the course and evaluated its effectiveness as a method of enhancing students' epistemic cognition level.

CP.120: **Describing Student Approaches to Laboratory Activities: Epistemology in a Reformed Lab Setting**

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Traditional introductory physics laboratories serve as validation of material presented in lectures; however, reformed laboratory activities stress the active construction of understanding through a student's lab experience. Our reformed labs, informed by Modeling Instruction, are adapted to our lecture course, which covers algebra-based content motivated by biological applications. Our question probes student buy-in: How are students approaching knowledge construction in reformed lab activities? We videotape groups of students as they work through our reformed lab activities. We then interview members of the video taped lab groups individually, seeking deeper insight into selected clips from their in-lab videos. The videos are transcribed and then coded, using a semi-open coding. This coding is guided by the framework of epistemic resources. Codes are validated through comparison within individual's interviews and across interviewees with respect to written materials. We will present key aspects of our methodology and initial descriptions of individual student epistemologies.

CP.121: **Comparing Problem Solving Attitudes of Introductory Students, Physics Graduate Students and Faculty**

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Andrew Mason, University of Pittsburgh

Cummings et al.[1] developed a survey related to attitudes towards problem solving partially based upon the Maryland Physics Expectations Survey (MPEX)[2]. We expand upon this survey to include questions related to students' approaches to problem solving and examine how students in the introductory courses, graduate students and physics faculty compare with each other. Graduate students answered the survey questions twice: once about problem solving in the graduate courses and second time about solving introductory physics problems. Results will be discussed. Supported by NSF.

1. Cummings, K., Lockwood, S., & Marx, J. Attitudes Toward Problem Solving as Predictors of Student Success. In 2003 Physics Education Research Conference Proceedings, edited by J. Marx, S. Franklin , and K. Cummings, 133-136, (2004).

2. Redish, E., Saul, J., & Steinberg, R. Student Expectations in Introductory Physics. Am. J. Phys. 66, 212-224, (1998).

CP.122: **Addressing Student Difficulties Considering Entropy and Heat Engines**

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In an ongoing investigation of student understanding of thermodynamics and statistical mechanics concepts in the upper division, we have uncovered several student difficulties with the topic of entropy. Based on the results of our research we have developed and implemented a three-tutorial sequence designed to guide students to develop a robust understanding of entropy and its applications. We present the rationale behind, and the design intent of, the third tutorial in this sequence, dealing primarily with entropy considerations of heat engines. We also present pre- and post-instruction data from the first implementation of this tutorial showing evidence of its effectiveness at improving student understanding. Supported in part by NSF Grants REC-0633951 and DUE-0817282.

CP.123: **How Do Students Process a Worked Example?**

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Our physics instruction for under-prepared engineering students often incorporates worked examples. We are therefore interested in how students process a worked example in order to learn from it. We used an eye tracker to record the eye movements of 43 introductory physics students as they read worked examples to aid them in solving difficult physics problems. Our examples are presented in a two-column format with symbolic manipulations and corresponding text explanations in adjacent columns. Two experimental conditions are employed: In one condition students were shown a specific target problem followed by worked examples to help them solve it; in the other they were told a problem to solve would follow some preparatory worked examples. Both global trends and effects of the task will be presented.

CP.124: **A Study of Undergraduate and Graduate Student Conceptions of Teaching**

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We examine the impact of teaching environment and preparation on the conceptions of teaching and learning expressed by our graduate Teaching Assistants (TAs) and undergraduate Learning Assistants (LAs). Since these instructors spend the most time directly interacting with introductory physics students, their beliefs regarding the nature of instruction may play a critical role in the success of reformed teaching methods. In this study, we examine our instructors beliefs through post-semester interviews in which they describe their self-perceived role in the classroom and comment on two different videos of TAs interacting with students. Comparisons are then made between TAs and LAs, and across teaching environments. As part of this study, we also seek to understand where changes in pedagogical conceptions and attitudes originate, in order to improve our overall method of preparing physics instructors.

CP.125: **Using Cluster Analysis to Group Student Responses on the FMCE**

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Michael C. Wittmann, University of Maine

Previous work with applying cluster analysis to free response questions about two-dimensional motion has shown suggestive similarities between the groups found by the cluster analysis and the traditional classifications of student responses [1]. A comparison of cluster analysis and traditional classifications over a single class, however, was unable to make any hard and fast conclusions because the cluster analysis results were unreliable for that population size (N = 106) [2]. In this poster we present the results of making the same kind of pivot table comparison over a larger data set (N = 677) which served to reduce the amount of noise in the cluster analysis results.

[1] R. P. Springuel, M. C. Wittmann, and J. R. Thompson, Applying clustering to statistical analysis of student reasoning about two-dimensional kinematics, Physical Review Special Topics - Physics Education Research 3, 020107 (2007).
[2] R. P. Springuel, M. C. Wittmann, and J. R. Thompson, Comparing cluster analysis and traditional analysis methods in PER, AAPT Summer National Meeting (2007).

CP.126: **Measuring Science Teacher Knowledge: Domain-General or Domain-Specific?**

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The development of reliable and valid measures of science teacher knowledge is essential for the evaluation of teacher education programs. A particular challenge is that most programs serve pre-service teachers with a range of disciplinary specialties. Is it best to measure science teacher knowledge within individuals' science specialty, or can this be measured domain-generally for the sciences? In this research, we investigated this question by developing a physics-specific measure of science teacher knowledge. We then conducted an experiment in which we randomly administered a domain-general measure or the parallel physics-specific measure to a population of pre-service science teachers. We also interviewed and observed the teaching practices of two subsets of participants in order to contribute to our understanding of what is being measured. The empirical evidence gathered serves to further develop the Flexible Application of Student-Centered Instruction (FASCI) instrument, and contributes to our understanding of science teachers pedagogical content knowledge.

CP.127: **Pedagogical Approaches for Enhancing Cognitive Development in Introductory Physics**

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Cornelius Bennhold
Gerald Feldman
Larry Medsker
(All from The George Washington University)

We will present the approach we used to reform the first semester of the introductory algebra-based physics course at The George Washington University. The reform methodology sought to enhance students cognitive development and improve their attitudes towards learning physics. The pedagogical approaches we developed include: 1) classification schemes that organize physics problems according to features related to physics principles; 2) learning progressions that combine traditional and research-based physics problems such that students gradually experience a new type of thinking as they learn a new topic; and 3) GW-ACCESS problem-solving protocol that builds on existing protocols but is accompanied by a specific teaching methodology and assessment. The instructional environment that we designed allows for explicit monitoring, control and measurement of the cognitive processes exercised during the instruction period. We will discuss the course objectives, the teaching methodology and the results that show improvement in student attitudes and their problem-solving abilities.

CP.128: **Towards Understanding Classroom Culture: Students Perceptions of Tutorials**

Chandra Turpen, Chandra.Turpen@colorado.edu
Noah D. Finkelstein, Steven J. Pollock
(All from the University of Colorado at Boulder)

While research on educational transformation has traditionally focused on studying student learning outcomes, little work has examined students perception of the tools and classroom culture associated with transformed pedagogies. We present analyses of students perceptions of the Tutorials spanning five years at the University of Colorado in hopes of understanding the meaning students are making of this reform. We share results based on two types of data: 1) data from a Student Assessment of their Learning Gains (SALG) style instrument, designed to identify students broad perceptions of the utility and enjoyment of Tutorials, and 2) more detailed survey data that targets students perceptions of peer interactions and student-TA interactions in the Tutorials, as well as the coordination of the Tutorials with other course components. We find themes that are consistent across Physics 1 & 2 as well as certain semester-by-semester (or instructor dependent) differences.

CP.129: **Identifying Student Difficulties with Density and Buoyancy**

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This study is part of an effort to develop an FCI-style diagnostic test assessing student understanding of fluids. In particular, this poster addresses questions which involve density and buoyancy, one of which is modified from McDermott s <i>Tutorials</i>. The McDermott floating blocks question, which asks students to predict the final location of blocks released from rest when submerged and explain their reasoning, has been administered to hundreds of students in three different introductory courses at Grove City College for the past six years. We used the common student responses to craft a multiple-select version of the floating blocks problem and added a question about the definition of density in 2008. In addition to discussing the development of the multiple-choice questions, this poster will show the effects that changing workshop activities have had on student performance on the floating block question.

CP.130: **An Assessment Design Rubric for a Reformed Introductory Physics Curriculum**

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Matter and Interactions (M&I) is an introductory physics course that ventures beyond pedagogical innovation by altering course content and emphasis, thus defining new learning goals. For example, one of the central learning goals of M&I emphasizes the construction of models of physical systems starting from fundamental principles. It follows that new learning goals necessitate new assessments. In this paper we present a rubric developed to inform the design of test problems and assess not only content knowledge but also students approach to problem solving. In addition, we present research findings that informed the development of our rubric includingthe scaffolding of student learning of the new approach to problem solving. Although our focus is on assessment of the M&I curriculum, our work has implications for assessment design in general.

CP.131: **Time-Series Analysis: Detecting & Measuring Structural Changes in Knowledge**

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Time-series designs are an alternative to pretest-posttest methods that are able to identify and measure the impact of multiple educational interventions. In this study, we use an instrument employing standard multiple-choice conceptual questions (e.g., from CSEM) to collect data from students at regular intervals. The questions are modified by asking students to distribute 100 confidence points among the options in order to indicate which options they think are more likely to be correct. Tracking the class-averaged confidence ratings for each option produces a set of time-series. Intervention ARIMA (autoregressive integrated moving average) analysis can then be used to test for, and measure, structural changes in each series. In particular, it is possible to discern which interventions (lectures, labs, etc.) were able to produce significant and sustained changes in class performance. Cluster analysis can also identify groups of students whose ratings evolve in similar ways. Methods and preliminary findings are presented.

CP.132: **Why Must Bulb Touch Battery? Interpretations of Fourth Graders' Thinking**

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This paper continues a presentation given at the AAPT conference, providing further discussion of theoretical conjectures about and implications of our findings. Previous work suggests college students have more difficulty lighting a bulb with a single wire and a battery than with two wires (Slater et al., 2000), results that have informed the design of activities (Schaffer & McDermott, 1992). I present some unexpected findings from two 4th grade classes engaged in a 15-hour inquiry module on electric circuits. Students successfully lit the bulb with a single wire in a variety of ways, but students from both classes showed and expressed the view that the bulb must be in direct contact with a battery in order for it to light. I offer an interpretation of this in terms of a resources perspective (diSessa, 1993; Hammer et al., 2005), where spontaneously generated explanations and actions are contextually sensitive. (NSF Grant #0732233)

CP.133: **Comparing Three Methods for Teaching Newton's Second Law**

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Mindi Kvaal Anderson, University of Maine

As a follow-up to a study comparing learning of Newton's Third Law when using three different forms of tutorial instruction [1], we have compared student learning of Newton's Second Law (NSL) when students use the Tutorials in Introductory Physics [2], Activity-Based Tutorials [3], or Open Source Tutorials [4]. We split an algebra-based, life sciences physics course into 3 groups and measured students' pre- and post-instruction scores on the Force and Motion Conceptual Evaluation (FMCE) [5]. We look at only the NSL-related clusters of questions on the FMCE [6] to compare students performance and normalized gains. Students entering the course are not significantly different, and students using the Tutorials in Introductory Physics show the largest normalized gains in answering questions on the FMCE correctly. These gains are significant in only one cluster of questions, the Force Sled cluster.

CP.134: **Are Students' Responses to Surveys and Their Behaviors Consistent?**

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Narumon Emarat and Eugenia Etkina

In our project we attempted to find out whether students whose beliefs about physics are more expert-like and less expert-like, as judged by the CLASS survey, are different in terms of their approaches to learning physics and whether their behaviors in the classroom are consistent with their responses to the surveys. All students, enrolled in the second semester of an introductory course, took the CLASS survey. We used survey results to identify expert-like and non-expert like students to participate in the study. We selected 4 highest scoring and 4 lowest scoring students. We then observed those students in laboratories and recitations during the whole semester and interviewed them at the end of the semester. We found some inconsistencies between students responses to the survey and their actual behaviors as well as several significant differences in behaviors of more expert-like and less expert-like students.

CP.135: **Self-Diagnosis, Scaffolding and Transfer in Introductory Physics**

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Andrew Mason, Chandralekha Singh, University of Pittsburgh, clsingh@pitt.edu

Previously we discussed how well students in an introductory physics course diagnosed their mistakes on a quiz problem with different levels of scaffolding support. In this case, the problem they self-diagnosed was unusually difficult. We also discussed issues related to transfer, particularly the fact that the transfer problem in the midterm that corresponded to the self-diagnosed problem was a far transfer problem. Here, we discuss a related intervention in which we repeated the study methodology with the same students in the same groups, using a new quiz problem which was more typical for these students and a near transfer problem. We discuss how these changes affected students' ability to self-diagnose and transfer from the self-diagnosed quiz problem to a transfer problem on the midterm exam.

CP.136: **Investigation of Students Alternative Conceptions of Vector Direction with Mexican Students**

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In this work we investigate the more common alternative conceptions and difficulties of university Mexican students with the concept of direction of a vector before instruction.
We present students difficulties with the vector direction concept due to the use of two conventions in the Mexican system. The common direction conception in the American system conflicts with a convention of this property as it is composed of two separate properties: direction as the line of action and sense as which way it points. Both conventions are regularly used in the Mexican educational system.
Additionally, based on the work of Nguyen and Meltzer [1], we designed questions in which students are asked for direction of a vector without indicating any particular convention, and questions indicating the line of action convention. We compare responses of students in the two types of problems, we analyze alternative conceptions of direction in the first type (investigating in depth the ones detected in [1]), and alternative conceptions of direction and sense in the second type of problems.

[1] Ngoc-Loan Nguyen and David E. Meltzer, Initial understanding of vector concepts among students in introductory physics courses, Am. J. Phys. 71, 630-638 (2003).

CP.137: **Understanding Graphs with and without Context: Testing an Instrument**

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This is an ongoing study where the objective is to design a concept test to evaluate the understanding and interpretation of calculus graphs. The instrument is based on a modified version of the Test of Understanding Graphs in Kinematics (TUG-K) [1]. The modified version has the intention to obtain more accurate results in its assessment of student understanding, i.e. a complete taxonomy of the student state in kinematics [2]. A new context-free version (TUG-C) was created to evaluate student interpretation of calculus graphs. A total of 365 students participated in the study from two courses in a university level: Introductory Physics and Introductory Calculus. A total of 158 students were administered the kinematics test and 207 of them the context-free test. This work will present data showing preliminary results of the test and a study on how the context affects students understanding of graphs.

[1] Robert, J. Beichner, Testing student interpretation of kinematics graphs, American Journal of Physics, 62 (8), 750-762 (1994).
[2] Genaro Zavala, Santa E. Tejeda, Juan J. Velarde & Hugo Alarcon, Assessing student understanding of graphs in kinematics: Improving the tool, Foundations and Frontiers of Physics Education Research. Bar Harbor, Maine (2007).

CP.138: **Improving Student Understanding of Stern Gerlach Experiment**

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Stern-Gerlach experiment is a classic experiment which has played a central role in quantum mechanics. Our group is investigating the difficulties that students have in learning Stern-

Gerlach experiment and developing and evaluating Quantum Interactive Learning Tutorials (QuILTs) and Peer Instruction tools to improve students' understandingof these concepts. We will discuss common difficulties with these topics and iterative development and evaluation of learning tools to help improve student understanding.

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CP.139: **Students' Perceptions of a Self-Diagnosis Task**

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Teachers frequently make sample solutions available to their students, and expect them to identify mistakes they have made and realize deficiencies in their solution, assisted by the sample solution. However many teachers are concerned that so few of their students engage in such an activity. What happens when students are required to engage in a self-diagnostic activity; namely, are given time and credit for identifying mistakes they have made by referring to the sample solution?

- What do students believe qualifies as "diagnosis" in this setting?
- How do students perceive the sample solution as a resource for self-diagnosis?

We answer these questions using data collected from 180 high school students studying for the matriculation physics exam in the Arab sector in Israel, and with 30 college students taking a pre-med introductory algebra based course in the USA. The findings indicate that college students' diagnostic statements focused on the weaknesses of their solutions, whereas the high school students also reflected on their personal involvement in the solution process, their opinion as to the adequacy of the problem statement, etc. The high school students used the sample solution as a template and identified as deficiency any external deviation of their solution from that template. We will discuss the possible interpretations of these results, and their implications for the design of self-diagnosis tasks.

CP.140: **Self-diagnosis, Scaffolding and Transfer: A Tale of Two Problems**

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Helping students learn from their own mistakes can help them develop habits of mind while learning physics content. Based upon cognitive apprenticeship model, we asked students to self-diagnose their mistakes and learn from reflecting on their problem solution. Varying levels of scaffolding support were provided to students in different groups to diagnose their errors on two context-rich problems that students originally solved in recitation quizzes. The level of scaffolding necessary for successful self-diagnosis and performance on the transfer task was strongly dependent on the difficulty in invoking and applying physics principles to solve the problems and how far the transfer was. Moreover, a high level of sustained scaffolding may be necessary to teach students problem-solving skills. This targeted poster will summarize our findings from self-diagnosis and near and far transfer associated with two context-rich problems that students self-diagnosed such that one self-diagnosed problem was unusually difficult.

CP.141: **Activities that Foster Learning from Public Physics Lectures**

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Uri Ganiel, and Bat Sheva Eylon
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Public scientific lectures are often considered by physics educators to be intellectual entertainment rather than a venue for learning physics. We present empirical evidence suggesting that such lectures can be utilized as a useful instructional resource, particularly for students who lack the prior knowledge needed for formal learning of contemporary physics topics.

Fourteen graduates of a pre-academic physics course took part in the study. Two public web-lectures were used, one on quantum mechanics and one on astrophysics. The intervention included a collaborative phase that followed the lecture and focused on the scientific argumentation and analogical reasoning presented in it. The impact of the guided discussions that followed the lectures emerged clearly from tests of long term memory and transfer. The contribution of the guided discussions was also manifested in the transcripts of the discussions, which revealed processes of negotiating meaning and knowledge integration.

CP.142: **Modeling Applied to Problem Solving**

Andrew Pawl, MIT, aepawl@gmail.com
Analia Barrantes, David E. Pritchard

Modeling[1] Applied to Problem Solving (MAPS) is a pedagogy that helps students transfer instruction to problem solving in an expert-like manner. Declarative and Procedural syllabus content is organized and learned (not discovered) as a hierarchy of General Models. Students solve problems using an explicit Problem Modeling Rubric that begins with System, Interactions and Model (S.I.M.). System and Interactions are emphasized as the key to a strategic description of the system and the identification of the appropriate General Model to apply to the problem. We have employed the pedagogy in a three-week review course for students who received a D in mechanics. The course was assessed by a final exam retest as well as pre and post C-LASS surveys, yielding a 1.2 standard deviation improvement in the students' ability to solve final exam problems and a statistically significant positive shift in 7 of the 9 categories in the C-LASS.

1. M. Wells, D. Hestenes, and G. Swakhamer, "A Modeling Method for High School Physics Instruction", Am. J. Phys. 63, 606-619 (1995).

CP.143: **Categorization of Problems to Assess and Improve Student Proficiency as Teacher and Learner**

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The ability to categorize problems is a measure of expertise in a domain. In order to help students learn effectively, instructors and teaching assistants (TAs) should have pedagogical content knowledge. They must be aware of the prior knowledge of students, consider the difficulty of the problems from students' perspective and design instruction that builds on what students already know. In this targeted poster, we discuss the response of graduate students enrolled in a TA training course to categorization tasks in which they were asked to group problems first from their own perspective, and later from the perspective of introductory physics students. A majority of the graduate students performed an expert-like categorization of physics problems. However, when asked to categorize from the perspective of introductory students', most students expressed dismay, claiming that either the task was either impossible or pointless. We will discuss how categorization can be a useful tool for scaffolding and improving pedagogical content knowledge of instructors.

CP.144: **Building a Professional Learning Community of Physics Teachers**

Eugenia Etkina, Rutgers University,
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This poster will describe how a group of physics teachers built a professional learning community without ever knowing about this theoretical construct. The community was born to address the needs of seven pre-service physics teachers while supporting each other during student teaching in the Fall of 2003. Since then it has transformed into a living organism, that nurtures new members (now more than 40 in-service teachers), cares for the needs of everyone, provides timely advice for every-day problems, communicates passion to teaching, and provides natural professional development for all of its members. The discussion will focus on the elements of a professional learning community that are absolutely necessary to maintain it, specific features of a physics teachers learning community, and the role of faculty responsible for teacher preparation in helping sustain such a community.

CP.145: **Quiz corrections: Improving learning by encouraging students to reflect on their mistakes**

Charles Henderson, Western Michigan University,
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Kathleen A. Harper, Denison University

Most introductory physics instructors are disheartened that students typically view tests and quizzes as summative evaluations and, therefore, miss the tremendous opportunity to learn from their mistakes. One way to address this problem is for the instructor to assign and collect written student assessment corrections. We have experimented with methods for dealing with this sort of assessment correction that require minimal instructor time. In this poster we i) provide some theoretical arguments supporting this practice, ii) describe several variations of assessment corrections that we have used, and iii) provide some data related to its effectiveness.

CP.146: **Evolution of Socio-Cultural Perspectives in My Research**

Valerie Otero, University of Colorado,
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Over the past 10 years I have been using socio-cultural theoretical perspectives to understand how people learn physics in a highly interactive, inquiry-based physics course such as Physics and Everyday Thinking. As a result of using various perspectives (e.g. Distributed Cognition and Vygotsky's Theory of Concept Formation), my understanding of how these perspectives can be useful for investigating students' learning processes has changed. I will illustrate changes in my thinking about the role of socio-cultural perspectives in understanding physics learning and describe elements of my thinking that have remained stable. Finally, I will discuss pitfalls in the use of certain perspectives and discuss areas that need attention in theoretical development for PER.

CP.147: **Active Learning of Physics by Modeling**

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Ali Eryilmaz, Middle East Technical University

Models are important elements to explain scientific ideas. Physics makes explanations about nature with different type of models. In educational context, Modeling is an instructional methodology which students being physically and mentally active . Modeling cycle aims students construction of mathematical model(s) of a given physical situation by analyzing, discussing, exploring and experimenting with cooperative learning groups. Including different type of active learning activities makes modeling is an effective instructional methodology in learning of physics at different levels- high school and university levels (Wells, Hestenes, & Swackhamer, 1995). This study explains a model of modeling cycle for a physics concept in terms of active learning elements. The roles of students and teacher in a lesson are mentioned in detail. Richness of this methodology with active learning elements provides teachers and instructors active and effective learning environments.

CP.148: **What Else (Besides the Syllabus) Should Students Learn in Introductory Physics?**

David E. Pritchard, MIT, dpritch@mit.edu
Brian Belland, Utah State University
Analia Barrantes, MIT

Course reform begins with a set of objectives. We started with a Delphi Study based on interviews with experts, developed orthogonal responses to "what should we teach non-physics majors besides the current syllabus topics?" AAPT attendees, atomic researchers, and PERC08 attendees were asked for their selections. All instructors rated "sense-making of the answer" very highly and expert problem solving highly. PERers favored epistemology over problem solving, and atomic researchers "physics comes from a few principles". Students at three colleges had preferences anti-aligned with their teachers, preferring more modern topics, and the relationship of physics to everyday life and to society (the only choice with instructor agreement), but not problem solving or sense-making. Conclusion #1: we must show students how old physics is relevant to their world. Conclusion #2: significant course reform must start by reaching consensus on what to teach and how to hold students' interest (then discuss techniques to teach it).

CP.149: **What do A students learn that D Students don't?**

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We have compared performance of students scoring 1 standard deviation below average (D group) with students scoring 1 standard deviation above average (A group) on final exam problems requiring analytic solutions and written plans. While the D group received 38% fewer total points than the A group, the differences were more dramatic with respect to getting an entire problem correct: for both analytic solutions and plans of attack the A group relative to the D group gave ~ 3.6 times more good answers, and failed to identify all of the physical principles about 3.8 times less often. We found that students' written plans of attack closely correlated with their analytic solutions in both groups. We suggest that the typical "one topic per week" organization of introductory courses does not prepare students to identify the physical principles that apply to problems that might involve any of the concepts in the course.

CP.150: **What Do Seniors Remember from Freshman Physics?**

Analia Barrantes, MIT, dpritch@mit.edu
Andrew Pawl and David E. Pritchard, MIT

We have given a group of 56 MIT Seniors who took mechanics as Freshmen a written test similar to the final they took at that time, plus the MBT and C-LASS standard instruments. Students unlikely to have reviewed the material in the interim scored half as well as they did as Freshmen on the written part of the test. Their facility with energy and kinematics was comparable to D-level Freshmen. They were less able than D-level Freshmen to construct simultaneous equations describing a dynamics problem, but more able to recognize a two-stage problem and develop subgoals. Their mean score on the MBT was essentially unchanged from the post-test taken as Freshmen, though there were significant shifts in responses to ten of 26 questions. Attitudinal surveys indicate that half the Seniors believe the mechanics course content will be useful to them, while the vast majority believe physics teaches valuable problem solving skills.

CP.151: **Methods and Experimental Designs in Cognitive Studies**

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Michael I. Posner, University of Oregon

Whereas PER focuses on how students learn and perform physics tasks (especially those we are interested in teaching them), cognitive psychology research (CPR) focuses more broadly on how the mind works when engaged in cognitive tasks. This talk will review some of the approaches to experimental design and methodology in CPR and PER, ranging from garden variety behavioral studies, to studies using eye-tracking devices functional Magnetic Resonance Imaging (fMRI), electroencephalography (EEG), magnetoencephalography (MEG) and transcranial magnetic stimulation (TMS). The strengths and weaknesses of each method will be addressed in terms of what can, and cannot be learned about human learning, cognitive performance, and ultimately teaching. The session will conclude with views of what PER and CPR can learn from each other.

CP.152: **A Research-Based Approach to Transforming Upper-Division Electricity & Magnetism I**

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Stephanie Chasteen
(Both from the University of Colorado at Boulder)

We are transforming an upper-division electricity and magnetism course for physics and engineering majors using principles of active engagement and learning theory. The teaching practices and new curricular materials (homeworks, interactive lectures with clickers, and after-class help sessions and tutorials) were guided by the results of observations, interviews, and analysis of student written work to identify common student difficulties with the content, and were informed by explicit learning goals established in collaboration with faculty. In parallel, we are developing a conceptual test, the CUE (Colorado Upper-division Electrostatics instrument), to assess some of the impacts and ongoing evolution of the new curriculum. We present key elements of our research base for these course transformations, including instances where interactive engagement techniques, and our assessment tools and observations, help elucidate student difficulties at this level. Our work underlines the need for further investigation into the nature of student difficulties and appropriate instructional interventions for complex physical problem solving at the upper division level.

CP.153: **Cognitive Development at the Middle-division Level**

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Elizabeth Gire,
(Both from the Oregon State University)

One of the primary goals, as students transition from the lower-division
to upper-division courses is to facilitate the cognitive development
needed for work as a physicist. The Paradigms in Physics curriculum
(junior-level courses developed at Oregon State University) addresses this goal by coaching students to coordinate different modes of reasoning, highlighting common techniques and concepts across physics topics, and setting course expectations to be more aligned with the professional culture of physicists. This poster will highlight some of the specific ways in which we address these cognitive changes in the context of classical mechanics and E&M courses.

This work is supported in part by NSF grant DUE 0618877.

CP.154: **Foundations of Course Reform for Introductory Physics**

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At the heart of course reform lies the question "What do we want the students to learn?" and its complement "What do the students want to get from our course?". Each question has two parts: what skills should students master for the final examination, and what skills should they retain at some later point in their lives, for example at graduation? This targeted poster session reports a series of studies exploring these questions and shows the use of various PER-based diagnostic instruments to evaluate an approach to problem solving inspired by the answers we found. Since the posters represent work in progress, audience opinion and suggestions will be solicited.

CP.155: **Cognitive Issues and Appraoches to Improving Students' Understanding of Quantum Mechanics**

Chandralekha Singh, clsingh@pitt.edu
Guangtian Zhu
(Both from the University of Pittsburgh)

Learning quantum mechanics is challenging. Our group is investigating cognitive issues in learning quantum mechanics and developing quantum interactive learning tutorials (QuILTs) and tools for peer-instruction based upon cognitive task analysis. Many of the tutorials employ computer-based visualization tools to help students take advantage of multiple representations and develop better intuition about quantum phenomena. We will discuss the aspects of the cognitive design of the quantum mechanics curriculum that are similar or different from introductory courses and discuss why the analysis of cognitive issues is important for bridging the gap between quantitative and conceptual aspects of quantum mechanics.

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CP.156: **Learning about Student Learning in Intermediate Mechanics: Using Research to Improve Instruction**

Bradley Ambrose, Grand Valley State University,
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Ongoing research in physics education has demonstrated that physics majors often do not develop a working knowledge of basic concepts in mechanics, even after standard instruction in upper-level mechanics courses.[1] A central goal of this work has been to explore the ways in which students make--or do not make--appropriate connections between physics concepts and the more sophisticated mathematics (e.g., differential equations, vector calculus) that they are expected to use. Many of the difficulties that students typically encounter suggest deeply-seated alternate conceptions, while others suggest the presence of loosely or spontaneously connected intuitions. Analysis of results from pretests (ungraded quizzes), written exams, and informal classroom observations will be presented to illustrate specific examples of these difficulties. Also to be presented are examples of particular instructional strategies (implemented in Intermediate Mechanics Tutorials2) that appear to be effective in addressing these difficulties.

1. B.S. Ambrose, "Investigating student understanding in intermediate mechanics: Identifying the need for a tutorial approach to instruction,"
Am. J. Phys. 72, 453 459 (2004).
2. Supported by NSF grants DUE-0441426 and DUE-0442388.

CP.157: **Observations of General Learning Patterns in an Upper-Level Thermal Physics Course**

David E. Meltzer, Arizona State University,
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I will discuss some observations from using interactive-engagement instructional methods in an upper-level thermal physics course over a two-year period. From the standpoint of the subject matter knowledge of the upper-level students, there was a striking persistence of common learning difficulties previously observed in students enrolled in the introductory course, accompanied, however, by some notable contrasts between the groups. More broadly, I will comment on comparisons and contrasts regarding general pedagogical issues among different student sub-populations, for example: differences in the receptivity of lower- and upper-level students to diagrammatic representations; varying receptivity to tutorial-style instructional approach within the upper-level population; and contrasting approaches to learning among physics and engineering sub-populations in the upper-level course with regard to use of symbolic notation, mathematical equations, and readiness to employ verbal explanations.

CP.158: **Our Classrooms as Cultural Systems: an Examination of Social and Cultural Influences in Two Educational Environments**

Noah Finkelstein, noah.finkelstein@colorado.edu
Chandra Turpen and Laurel Mayhew
(All from the University of Colorado at Boulder)

This inter-active poster seeks provides case studies of two educational environments, one, a formal introductory college level course that implements several PER-based innovations, the other, an informal afterschool educational program for children 6-18 years old. Each is considered from two different cultural historical activity theoretic perspectives, which provide the opportunity make sense of both the theory and the educational environments by triangulating among both the theories and the environments. An activity theoretic lens frames the classroom and afterschool program as activity systems where we delineate variation in roles, rules, and distribution of labor surrounding the use of similar tools (physics concepts). A Communities of Practice and Apprenticeship lens frames these environments as allowing or constraining various forms of participation by members both within the classroom community and within the institutional setting. The authors will share tools that will provide participants and opportunity to apply these perspectives to their own work and compare with our two case studies.

CP.159: **Moving beyond the Classroom: Socio-Cultural Motivation for Expanding the Unit of Analysis**

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Laird Kramer,Vashti Sawtelle, Idaykis Rodriguez, George O'Brien
(All from Florida International University)

Efforts to document the complex learning community established by the Center for High Energy Physics Research and Education Outreach (CHEPREO) initially focused on classroom based measures of Modeling Instruction. Classroom-based measures alone are insufficient to understand complex phenomena such as participation, retention, and persistence shown by our students. The underlying Vygotskian perspective on learning in Modeling Instruction motivated a shift in unit of analysis, moving beyond standard measurements of physics classes toward understanding the patterns of interactions and participation in learning communities. Changing the unit of analysis from the class to the learning community allows us to consider the roles of social and cultural influences on participation, persistence and retention. In this poster we re-frame the CHEPREO reform efforts through an ecological framework [Aubusson] and describe how this framing supports students especially given the cultural makeup of FIU's student body.

CP.160: **Promoting Conceptual Change and Development of Collective Responsibility**

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Socio-cultural approaches view learning as a social phenomenon, situated in the course of human activities. Thus, student learning and conceptual change is enhanced by instruction that creates opportunities for students to interact socially with others while engaged in appropriate learning activities. Models of instruction that promote social-interactions include Peer Instruction and community of learners (Brown&Campione,1994). This poster presents results from a case study of an introductory physics course using Peer Instruction. Audio recordings were made of small group conversations where students explained and justified their choices to peers. Discourse analyses of recordings show that students expend greater effort over time, build more rigorous arguments and regulate their discourse using both individual and collective processes of monitoring (eg. in time, peers use as well as demand more precise definitions and justifications before accepting arguments). Our results show changes in individual student's attitudes toward their personal and collective responsibility to classmates.

CP.161: **Using Item Response Models to Build a Hierarchy of Concepts and Gauge Instructional Effectiveness**

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We analyze FCI data from three different instructors using an approach based on standard tools of IRT (Item Response Theory) using variables such as student proficiency, question difficulty, and a concept's 'learning probability' after instruction. Results allow us to hierarchically classify concepts by their 'difficulty', find the likelihood a concept will be acquired at a given proficiency level and find how strongly a question discriminates between proficiency levels. We also demonstrate the potential of such deeper statistics to illuminate differences between classrooms by decomposing instructional effectiveness into appropriate vectors. The result is a visual and intuitive portrait that informs us about the FCI, and how students acquire concepts in different instructional settings.

CP.162: **How Tools Shape Classroom Practices and Collaboration: Examples from Introductory Physics Classes Using Tablet PCs**

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Technological tools are widely used in physics education. Many researchers have examined student learning gains associated with activities utilizing technology. Less attention has been given to the role of tools in shaping classroom practices and student interactions. By emphasizing the mediating role tools play, activity theory is ideally suited for examining the impact of tools on classroom culture. This poster uses activity theory to explore two examples where Tablet PCs were used in introductory physics classes. In one example, every student used a Tablet PC to collaborate in small groups during a laboratory course. In a second example, groups of students in an active learning-based course used one Tablet PCs for group work, which the instructor projected during whole class discussions. Use of the Tablet PCs is identified with changes in the nature of student collaboration and in the classroom practices required to support desired class norms.

CP.163: **Negotiating Meaning: Rethinking and Re-Interpreting Knowledge**

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Teachers frequently make sample solutions available to their students, expecting them to learn from their mistakes. However many teachers are concerned that only few of their students engage in such an activity. What happens when students are given time and credit for identifying mistakes they have made by referring to the sample solution? What do students believe qualifies as "diagnosis"? Our data consists of diagnosis work by 180 Arab-Israeli high school physics students, and 30 American students taking introductory algebra based physics. The findings indicate that while the instructor expected students to focus on the weaknesses of their solutions, many reflected also on their personal involvement in the solution process, their opinion as to the adequacy of the problem statement, etc. Students used the sample solution as a template and identified as deficiency any external deviation of their solution from it.