Physics Education Research Conference

Connecting Physics Education Research (PER) to Teacher Education at All Levels: K-20

August 10-11, 2005
University of Utah, Salt Lake City, UT

PROGRAM

http://web.phys.ksu.edu/perc2005/

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About PERC

Description

The Physics Education Research Conference (PERC) provides an opportunity for those in the field of physics education research and allied fields to share their research, obtain feedback, explore diverse perspectives and discuss issues relevant to the community. Various session formats afford the opportunity for maximum interaction. The focus at PERC is on feedback and discussion with others engaged in physics education research, rather than on dissemination.

Theme

This year's theme is "***Connecting Physics Education Research (PER) to Teacher Education at All Levels: K-20***." Participants will explore diverse perspectives on how physics education research informs the training, preparation and professional development of teachers at all levels ranging from elementary teachers to university faculty. While all of the presentations and activities at PERC will not explicitly focus on this theme *per se*, participants are urged to reflect and discuss ways in which their own research can relate to to the preparation and training of teachers at all levels. A variety of session formats will provide opportunities for multiple perspectives in our discussion of the conference theme and/or general issues related to methodology of physics education research.

Registration

The registration form for the 2005 Summer Meeting of the American Association of Physics Teachers (AAPT) includes a line to register for PERC 2005. The cost for registration is $80 and includes lunch and a copy of the Conference Proceedings.

The PERC dinner on Wednesday evening is ticketed separately ($30). Please purchase dinner tickets and register for the PERC on the AAPT website linked above since on-site registration is limited.

Participation

A variety of session formats are available to participants in PERC 2005. These include Invited Talks & Panel Discussions, Targeted Poster Sessions, Workshops, and Contributed Posters.

Previous Physics Education Research Conferences

- **2004 -** "Transfer of Learning," Sacramento, CA
- **2003 -** "The Practice of Analysis as a Window on Theory," Madison, WI
- **2002 -** "Alternative Approaches to Assessment in Physics Teaching and Research in Physics Learning," Boise, ID
- **2001 -** "Research at the Interfaces," Rochester, NY
- **2000 -** "Teacher Education," Guelph, Canada
- **1999 -** "The Underlying Assumptions of Physics Education Research," San Antonio, TX
- **1998 -** University of Nebraska, Lincoln, NE
- **1997 -** University of Denver, Denver, CO

Schedule

WEDNESDAY, AUGUST 10

When	Where	What
5:45 - 6:45	OSH Auditorium	**Keynote Address:** *Lillian C. McDermott* Presider: *Rebecca Lindell*
6:50 - 8:00	Union Ballroom	**Dinner Banquet** (**$30 Ticket Needed**)
8:00 - 10:00	Union Ballroom	**Contributed Poster Session** (Refreshments Provided) *Posters will remain up all day through Thursday, August 11*

THURSDAY, AUGUST 11

When	Where	What
8:00 - 8:15	OSH Auditorium	**Orientation**
8:15 - 9:45 (Parallel Sessions)		**Workshops , Targeted Poster Sessions & Roundtable Discussions- I**
	Union Parlor A	**Workshop W-A: Important Issues in Preparing Graduate Teaching Assistants** *Kathleen Harper*, The Ohio State University
	OSH 234	**Workshop W-B: Model Analysis: Theoretical Basis and Methodology for Developing Effective Assessment** *Lei Bao & Neville Reay*, The Ohio State University
	Union Collegiate	**Targeted Poster Session TP-A: Goals & Assessment in the PhysTEC Project: Drawing from Research and Systematic Self-assessment to Promote Inquiry-Oriented Teacher Education** *Laura Lising*, Towson University, *Noah Finkelstein*, University of Colorado *Bob Poel*, Western Michigan University, *Ted Hodapp*, American Physical Society
	Union Saltair	**Targeted Poster Session TP-B: Research on Improving Content and Pedagogical Knowledge of Science Teachers** *Chandralekha Singh*, University of Pittsburgh
	Union Panorama East	**Combined Workshop & Targeted Poster Session W&TP: Title: Forthcoming** *Organizer*, University of Washington
	OSH 232	**Roundtable Discussion RT-A Title To be Announced** *Organizer*, Institution
	OSH 231	**Roundtable Discussion RT-B: Title To be Announced** *Organizer*, Institution
9:45 - 10:15	Union Ballroom	**Break** (Refreshments provided)
10:15 - 12:15 (Parallel Sessions)	OSH Auditorium	**Invited Talks & Panel Discussion** Discussant: *Kastro M. Hamed*
		10:15 — **Repositioning ourselves from "knowers" to "learners:" Formative Assessment, Vygotsky, and Teacher Preparation**, *Valerie Otero*, University of Colorado
		10:45 — **The Physics Teacher Education Coalition: Results, Directions, Initiatives**, *Ted Hodapp*, Hamline University
		11:15 — **Evaluating Activity-based Teacher Workshops**, *Ron Thornton*, Tufts University
		11:45 — **Panel Discussion** Discussant: *Kastro M. Hamed*
12:15 - 1:45	Union Ballroom	**Luncheon Banquet** Speaker**: *Dr. Harold Himmelfarb*,** U.S. Department of Education Presider: *Kastro M. Hamed*, University of Texas at El Paso

THURSDAY, AUGUST 11

Post Lunch Session

When	Where	What
1:45 - 3:15 (Parallel Sessions)		**Workshops , Targeted Poster Sessions & Roundtable Discussions - II**
	Union Parlor A	**Workshop W-A: Important Issues in Preparing Graduate Teaching Assistants** *Kathleen Harper*, The Ohio State University
	OSH 233	**Workshop W-C: Piaget's Workshop** *Dewey Dykstra*, Boise State University
	Union Collegiate	**Targeted Poster Session TP-A: Goals & Assessment in the PhysTEC Project: Drawing from Research and Systematic Self-assessment to Promote Inquiry-Oriented Teacher Education** *Laura Lising*, Towson University, *Noah Finkelstein*, University of Colorado *Bob Poel*, Western Michigan University, *Ted Hodapp*, American Physical Society
	OSH 235	**Targeted Poster Session TP-C: The Changing Face of Teacher Training: Creating Well-Qualified Physics and Astronomy Educators in the Age of No Child Left Behind** *Rebecca Lindell*, Southern Illinois University Edwardsville
	Union Panorama East	**Combined Workshop & Targeted Poster Session W&TP: Title: Forthcoming** *Organizer*, University of Washington
	OSH 232	**Roundtable Discussion RT-A: Title To be Announced** *Organizer*, Institution
	OSH 231	**Roundtable Discussion RT-C: Title To be Announced** *Organizer*, Institution
3:15 - 3:45	Union Ballroom	**Break** (Refreshments provided)
3:45 - 5:15 (Parallel Sessions)		**Workshops , Targeted Poster Sessions & Roundtable Discussions - III**
	OSH 233	**Workshop W-C: Piaget's Workshop** *Dewey Dyskstra*, Boise State University
	Union Saltair	**Targeted Poster Session TP-B: Research on Improving Content and Pedagogical Knowledge of Science Teachers** *Chandralekha Singh*, University of Pittsburgh
	OSH 235	**Targeted Poster Session TP-C: The Changing Face of Teacher Training: Creating Well-Qualified Physics and Astronomy Educators in the Age of No Child Left Behind** *Rebecca Lindell*, Southern Illinois University Edwardsville
	OSH 231	**Roundtable Discussion RT-B: Title To be Announced** *Organizer*, Institution
	OSH 238	**Roundtable Discussion RT-C: Title To be Announced** *Organizer*, Institution

Keynote Address

5:45 pm - 6:45 pm, Wednesday, August 10

Where: OSH Auditorium
Presider: *Rebecca Lindell*, Southern Illinois University Edwardsville

Lillian C. McDermott,
(lcmcd@phys.washington.edu) University of Washington

How can physics education research contribute to K-12 teacher preparation?

Abstract: The recent history of reform in K-12 science education indicates that there is a significant gap between the science curriculum that teachers are taught as undergraduates and the curriculum that they are expected to teach in elementary, middle, and high school. In particular, research has shown that many teachers lack a basic understanding of K-12 physics and physical science, both content and process. Unless this gap is successfully bridged, the current efforts of physics faculty to improve the preparation of teachers are unlikely to have a lasting impact. Results from research and many years of experience in teaching teachers have contributed to the development of an instructional approach that has been shown to be effective in meeting this challenge.

Invited Talks

10:15 am - 12:15 pm, Thursday, August 11

Where: OSH Auditorium
Presider : *Kastro M. Hamed*, University of Texas at El Paso

10:15-10:45 ***Valerie Otero***,
(valerie.otero@colorado.edu) University of Colorado, Boulder

Repositioning ourselves from "knowers" to "learners:" Formative Assessment, Vygotsky, and Teacher Preparation

Abstract: Learning to be an effective teacher is an ongoing process of inquiry. Understanding teaching as the process of inquiry entails a repositioning of oneself from a traditional notion of "teacher as knower," an expert who provides information for learners, to a contemporary notion of "teacher as learner," one who continuously collects, interprets, and analyzes information in real-time and over longer periods of time. Formative assessment is a mechanism used by those who position themselves as teacher-learners. In this presentation, I argue using both data and theory that the notion of repositioning ourselves from "teacher" to "learner" is a single thread that underlies theoretical and practical research associated with reform pedagogy, cognitive theory, socio-cultural theory, formative assessment, and professional development. My argument also applies to *what* teacher educators should teach and *how* they should teach it. In addition, I will discuss the role that theoretical and practical research in PER has played in my thinking and research. Data from several studies involving pre-service elementary teachers, university science faculty, pre-service secondary science teachers, and practicing teachers will be presented and compared.

10:45-11:15 ***Ted Hodapp***,
(thodapp@hamline.edu) Hamline University

The Physics Teacher Education Coalition: Results, Directions, Initiatives

Abstract: The Physics Teacher Education Coalition is an NSF/FIPSE/APS funded project to help produce more, better prepared physics and physical science teachers. The project began over four years ago as a joint effort between the AAPT, AIP and APS to address a nationally recognized need in the preparation of future science teachers. The project's

goals include a) establishing a network of institutions that are deeply engaged in the science preparation of future teachers, b) providing compelling evidence of the importance and success of ideas and components central to preparing science teachers, c) engaging physics and education faculty in collaborating in the preparation of these teachers, and d) using the joint resources of the AAPT, AIP and APS to promote and disseminate these ideas and programs.

At its heart, this project is about how we engage physics departments in this critical mission. This presentation will highlight some of the results, directions, and initiatives of the project. PER faculty and the research products they have developed are critical to success of this venture, and their roles in this project will be highlighted..

11:15-11:45 ***Ron Thornton***,
(ronald.thornton@tufts.edu) Tufts University

Evaluating Activity-Based Teacher Workshops

Abstract: The research of the Center for Science and Mathematics Teaching at Tufts University and that of others has shown that teachers (and students) are more likely to achieve fundamental understandings of science in workshops or classes that provide activity-based learning environments. Our research also shows that such workshops can be effective in providing teachers with new pedagogical resources. In the past 18 years I have taught, with others, over 100 teacher workshops. These workshops have lasted from one day to two weeks and have involved teachers of students in grades 5 through 12 and college and university professors. All of these workshops enhance teachers' pedagogical skills to include the effective use of guided inquiry, peer collaboration and technology in teaching basic science concepts while improving teacher understanding of those same concepts. Participants engage in active, inquiry-driven learning experiences, suitable for their students, in which they often use real-time data collection to explore the physical world by collecting and analyzing physical data. We have used a number of different methods to evaluate the efficacy of the workshops including self reported data by teachers on the effect of the workshop, evaluations of teacher content knowledge and longer term studies of pedagogical change and student learning in courses taught by workshop teachers. The results of two studies will be presented. The first involves changes in pedagogy by college and university professors attending a two-week workshop. The second evaluates a series of short workshops for high school teachers that resulted in changed instruction for 90% of the participants. A *Teacher Education Module* we developed may help others implement this program.

For more information contact:
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Telephone: 617-627-2825
Fax: 617-627-3253
Email: csmt@tufts.edu
Web: http://ase.tufts.edu/csmt/

11:45-12:15 **Panel Discussion**
Discussant : *Kastro M. Hamed*, University of Texas at El Paso

Luncheon Banquet Talk

12:15 pm - 1:45 pm, Thursday, August 11

Dr. Harold Himmelfarb, U.S. Department of Education

Where : Union Ballroom
Presider: *Kastro M. Hamed*, University of Texas at El Paso

Teacher Quality Issues in Science Education and Research Opportunities

Abstract: Dr. Himmelfarb will address the nature of the issues facing U.S. Schools with regard teacher preparation in the sciences with implications for Physics, the types of research that Institute for Education Sciences in the U.S. Department of Education is soliciting to build an evidenced-based field, and promising ideas for interventions.

Targeted Poster Session: TP-A

Goals and Assessment in the PhysTEC project: Drawing from Research and Systematic Self-assessment to Promote Inquiry-Oriented Teacher Education

Organizers:
Laura Lising (llising@towson.edu), Towson University, *Noah Finkelstein,* University of Colorado, *Bob Poel,* Western Michigan University *Ted Hodapp,* American Physical Society

Where: Union Collegiate

When: 8:15 – 9:45 & 1:45 – 3:15, Thursday, August 11

Theme: The Physics Teacher Education Coalition (PhysTEC) is a national effort aimed at improving and promoting the education of future physics and physical science teachers. One of the main goals is to develop programs that are capable of producing more better-prepared elementary, middle, and high school teachers, committed to interactive, inquiry-based approaches to teaching. This involves collaboration between physics and education faculty, establishing a network of institutions, and assessing the success of various ideas, methods, and program elements, which can then be disseminated. The project, overseen through the American Physical Society, and funding by the APS, NSF, and a national campaign, currently consists of eight Primary Program Institutions and a number of institutions forming a Coalition that are deeply engaged in teacher preparation. The eight primary institutions have been drawing from PER and other educational research and the expertise of local practicing teachers (who spend a year as a teacher-in-residence at each institution) to develop programs to meet the project goals.

Goals: In working toward more inquiry-focused teacher preparation, each institution must develop or adopt various types of assessments to evaluate the successes and challenges they are having. During this session, several of the primary program institutions will discuss their programs, the assessment instruments they are using, their results so far, and the questions that are being raised for future work. One of the strengths of this project and our assessment efforts is that the various institutions, while focusing on the same clearly articulated goals, are taking approaches that vary widely in some aspects and in other aspects are quite similar, with just a few key differences. This allows us to communicate, compare, and learn from each other, gaining insights into subtleties of our results that might be less accessible in a smaller, less varied project context. With this poster session, we hope that by sharing our results and current questions with the PER community, we can further broaden the dialogue.

Individual Poster Abstracts

TP-A1
Promoting science as inquiry in Towson University s preservice elementary teacher education program

Laura Lising (llising@towson.edu), *Lisa Tirocchi,* Baltimore Public Schools & Towson University
Cody Sandifer, Towson University

Abstract: PhysTEC at Towson is focused on improving the preparation of elementary teachers for teaching science as inquiry. We had the following primary goals for 2004-2005: building a community of schools for science teaching internships; improving and integrating the internship course and the concurrent physical science/science methods course; and assessing the science teaching and mentoring that occurs during student teaching. To work on these goals we drew from many research findings from within PER and the larger educational research community. For instance, our courses use video teaching tools from the Case Studies in Elementary Inquiry in Physical Science, developed at Maryland, and draw from the work of the San Diego group and from the Powerful Ideas curriculum. To make the assessments we needed as starting points for our work, and to assess the effectiveness of our activities, we collected a wide variety of qualitative and quantitative data. We have notes from teacher discussions, journals of students from their student teaching and internships, and results of extensive teaching observations (done using a protocol we developed and tested based on the National Science Education Standards). We also developed several surveys, which have been administered in several rounds. These instruments help us measure pre-post course shifts as well as changes from semester to semester. Preliminary results will be presented..

TP-A2

Coupling research and pre-service teacher preparation: The Colorado PhysTEC program

Noah Finkelstein (finkelsn@colorado.edu), *Valerie Otero, S. Pollock, M. Dubson, C. Keller, C. Turpin*, University of Colorado

Abstract: The Colorado PhysTEC Initiative [1] is comprised of two fundamental components: i) a coordinated program for developing, preparing and supporting undergraduate (and graduate) physics majors for their roles as future educators, and ii) to research and document these efforts. The University of Colorado at Boulder builds on increasing attention to education in the physics department, strengthening ties between the school of education and the department, a new program in physics education research, and several initiatives on campus (particularly the STEM-Colorado program [2]) that bring significant resources and interest to this endeavor. We have implemented several proven reformed classroom approaches in our introductory large enrollment (500+) calculus based physics classes, including peer instruction with student response system in lecture[3], and Tutorials[4] with trained undergraduate learning assistants [2] in smaller recitations. To assess course transformations, we are collecting extensive survey data along with validated pre/post content- and attitude-surveys to investigate complementary effects of our multiple reforms. Here we present the impacts in terms of measured learning gains (e.g. median normalized gain on the FCI was 0.67) with special emphasis on isolating correlations with specific reform components, as well as with student attitudes and beliefs. We also focus on the impact of partnering undergraduate Learning Assistants with these reforms. Outcomes include increased student participation in teaching, enrollment in the School of Education, and improved pedagogical content knowledge. We also report on other course transformations, such as the implementation and assessment of Teaching and Learning Physics (an upper division / graduate physics course), the development of an active Teacher Advisory Group, and fundamental research studies on student learning, use of computer simulations in the classroom and replication of known reforms.

[1] Supported by APS and PhysTEC.
[2] Supported by NSF-STEMTP.

[3] Peer Instruction, E. Mazur Prentice Hall '97
[4] Tutorials in Introductory Physics, McDermott and Shaffer, Prentice Hall '02

TP-A3

Introductory Physics Course Reform at Western Michigan University

Charles Henderson (charles.henderson@wmich.edu), *Alvin Rosenthal, Norah Berrah, Lisa Paulius*, Western Michigan University

Abstract: The calculus-based introductory courses have been modified to include new curricula; a completely new set of laboratory experiences based on a predict-confront-resolve approach; small group work; a conceptual focus on homework and exam problems; interactive lectures and lecture demonstrations; reading questions; and recently, personal response systems. The effects of these reforms have been assessed using standardized instruments (FCI, CSEM) and compared (when possible) to regularly taught courses at the same time at our institution. Formative evaluations of student perceptions of some reform elements were also made. We have found that, after a start-up period, significantly improved normalized gains are obtained for the reformed courses as compared to the regularly taught courses. Data shows an increasingly good performance over time. Retention issues will be reported. Other issues such as faculty receptivity and student satisfaction for which hard data does not exist will also be addressed.

TP-A4

Physics Teacher Education Coalition Overview

Warren Hein (whein@aapt.org), American Association of Physics Teachers
John Layman, Professor Emeritus, University of Maryland

Abstract: The Physics Teacher Education Coalition is a program to improve physics and physical science preparation of future K-12 teachers. A collaboration between APS, AAPT and AIP, the program has two thrusts: PhysTEC and PTEC. PhysTEC (http://www.phystec.org) provides funding to institutions committed to building quality teacher preparation programs through a set of activities that include establishing bridges between physics and education departments and school districts, utilizing K-12 teachers in a university setting to connect the university to the schools, reforming undergraduate physics and education courses to emphasize interactive engagement and student-centered approaches to learning, and promoting institution involvement in the continuum of activities necessary to successfully educate, and engage physics and physical science teachers as an undergraduate and later in the classroom. PTEC

(http://www.phystec.org) is a coalition of institutions coming together to help explore, share, adapt, and disseminate creative ideas that advance physics and physical science teacher preparation. The coalition holds an annual conference, publishes information through a variety of venues, and runs programs aimed at supporting these efforts.

Targeted Poster Session: TP-B

Research on Improving Content and Pedagogical Knowledge of Science Teachers

Organizer: *Chandralekha Singh* (clsingh@pitt.edu), University of Pittsburgh

Where: Union Saltair

When: 8:15 – 9:45 & 3:45 – 5:15, Thursday, August 11

Theme: The theme of this targeted poster session is consistent with the theme of the conference because this session will highlight research on critical issues in pre-service and in-service teacher preparation. We will discuss the development and evaluation of interventions which are grounded in physics education research to alleviate the serious shortage of well-trained science teachers in the U.S. Topics in this session include research on increasing awareness, enthusiasm, and appreciation of the intellectual demands of physics teaching amongst science undergraduates, designing professional development and assessment for out-of-field teachers, teacher education using state-of-the-art digital video databases, and research and development on preparing teachers to deal with gender issues in classrooms.

Goals: This session will focus on research on important issues in pre-service and in-service teacher education to prepare qualified science teachers. We hope to convey to the participants how methods of physics education research can be used to design, implement and evaluate strategies to improve teacher preparedness. The participants will be given an opportunity to explore issues related to research on increasing awareness, enthusiasm, and appreciation of the intellectual demands of physics teaching amongst science undergraduates, designing professional development and assessment for out-of-field teachers, teacher education using state-of-the-art digital video databases, and research and development on preparing teachers to deal with gender issues in classrooms. The participants will have an opportunity to learn about various evaluation methods including pre/post-tests measures of attitude and expectations about science teaching before and after an intervention, self and peer evaluation of their own teaching after an intervention, content-based pre/post-tests given to students who received instruction from the teachers who went through a certain intervention, and audio-taped focus group discussions with the target audience.

Individual Poster Abstracts

TP-B1

Increasing interest and awareness about teaching in science undergraduates

Chandralekha Singh (clsingh@pitt.edu), *Laura Moin, Chris Schunn* University of Pittsburgh

Abstract: We discuss the development, implementation, and assessment of a course for science undergraduates designed to help them develop an awareness and a deeper appreciation of the intellectual demands of physics teaching. The course focused on increasing student enthusiasm and confidence in teaching by providing well supported teaching opportunities and exposure to physics education research. The course assessment methods include 1) pre/post-tests measures of attitude and expectations about science teaching, 2) self and peer evaluation of student teaching, 3) content-based pre/post-tests given to students who received instruction from the student teachers, and 4) audio-taped focus group discussions in the absence of the instructor and TA to evaluate student perspective on different aspects of the course and its impact. We will discuss how methods of physics education research were used in the development and assessment of the course.

Supported by NSF via a grant to the Learning and Research Development Center, University of Pittsburgh.

TP-B2

The challenges of designing and implementing effective professional development for out-of-field high school physics teachers

Lawrence T. Escalada (Lawrence.Escalada@uni.edu), *Juilia Moeller*, University of Northern Iowa

Abstract: With the existing shortage of qualified high school physics teachers and the current mandate of the No Child Left Behind Act required teachers to be "highly qualified" in all subjects they teach, there is a need for university physics departments to offer content courses and programs that would allow out-of-field high school physics teachers to meet this requirement. This paper will identify how the University of Northern Iowa Physics Department is attempting to address this need through its course offerings and the professional development experiences being provided for teachers. The effectiveness of one such physics professional development program, the UNI Physics Institute (UNI-PI), on secondary science teachers' and their students' conceptual understanding of Newtonian mechanics, and the teachers' instructional practices was investigated. Twenty-one Iowa high school and middle school science teachers participating in the program were able to complete the physics coursework required to obtain the State of Iowa 7-12 Grade Physics Teaching endorsement. Twelve of the participants completed a two-year program during the 2002 and 2003 summers. Background information, pre- and post-test physics conceptual assessments and other data was collected from participants throughout the Institute. Participants collected pre and post-test conceptual assessment data from their students during the 2002-2003 and 2003-2004 academic years. This comprehensive assessment data revealed the Institute's influence on participants' and students' conceptual understanding of Newtonian Mechanics. The results of this investigation, the insights we have gained, and our future directions for professional development will be shared.

TP-B3

Pathway: Using a State-of-the-Art-Digital Video Database for Research and Development in Teacher Education

Brian Adrian (badrian@phys.ksu.edu), *Dean Zollman*, Kansas State University
Scott Stevens, Carnegie Mellon University

Abstract: To demonstrate how state-of-the-art video databases can address issues related to the lack of preparation of many physics teachers, we have created the prototype Physics Teaching Web Advisory (Pathway). Pathwayýs Synthetic Interviews and related video materials are beginning to provide pre-service and out-of- field in-service teachers with much-needed professional development and well-prepared teachers with new perspectives on teaching physics. The prototype was limited to a demonstration of the systems. Now, with an additional grant we will extend the system and conduct research and evaluation on its effectiveness. This project will provide virtual expert help on issues of pedagogy and content. In particular, the system will convey, by example and explanation, contemporary ideas about the teaching of physics and applications of physics education research. The research effort will focus on the value of contemporary technology to address the continuing education of teachers who are teaching in a field in which they have not been trained.

Supported by the National Science Foundation under grants DUE-0226157, DUE-0226219, ESI-0455772 & ESI-0455813.

TP-B4

Seeing Gender: Research & Development on Gender Issues in Science Teaching

Jacqueline Spears (jdspears@ksu.edu), *Cecilia Hernandez*, Kansas State University

Abstract: A considerable body of research documents the existence of an inadvertent gender bias in science/mathematics classrooms. When made aware of this bias, teachers are able to introduce a number of changes to encourage girls' interest and participation in STEM fields. This poster presents a number of strategies for introducing this topic to pre-service and in-service teachers, including an interactive CD-ROM, short courses offered to teachers as part of workshops targeting middle- and high-school girls, and semester long graduate classes. Research on teachers' reactions to this information and the types of changes they make is also presented.

Supported in part by NSF grant HRD - 0225184.

Targeted Poster Session: TP-C

The Changing Face of Teacher Training: Creating Well-Qualified Physics and Astronomy Educators in the Age of No Child Left Behind

Organizers: *Rebecca Lindell* (rlindel@siue.edu), Southern Illinois University Edwardsville

Where: OSH 235

When: 1:45 – 3:15 & 3:45 – 5:15, Thursday, August 11

Theme: With the advent of the No Child Left Behind Act of 2001 (NCLB), states are now held to higher accountability standards for improving their elementary and secondary schools, as well as ensuring that no child is trapped within a failing school system. States have been mandated to implement statewide accountability systems based on challenging standards in mathematics and reading in addition to mandated statewide testing. States are also required to ensure that there is a highly qualified teacher in every public school classroom by the end of the 2005-2006 school year. By law a highly qualified teacher is now one who not only possesses a teaching certificate, but also has demonstrated competence in any subject area taught. To meet these new mandates, many states have had to make radical changes to their physics/ science certification programs. These changes have many implications for current and future physics and astronomy teachers, as well as challenges for the programs that train them. One of the greatest challenges of this legislature is the short timeline with which these changes must be implemented. In this targeted poster session, we will highlight the changes some programs have taken to adjust for NCLB, specifically ones that have utilized the results of PER to inform the best practices demonstrated to future and in-service teachers.

Goals: This session hopes to inform participants of the changing nature of physics teacher training as a result of NCLB. As many individuals hired in PER positions are also responsible for their schools physics teacher training programs, this poster session hopes to not only inform the community of the changes to teaching certification, but also highlight how several programs have utilized PER results to meet the needs of both future and in-service teachers. Because many of the changes have occurred within the last few years, many members of the community may also not be aware of the changing needs of these teachers and many programs may have been left at a loss on how to make these changes.

Individual Poster Abstracts

TP-C1
Development of a Standards-based Integrated Science Course for Elementary Teachers

Eric Malina (emalina@siue.edu), *Denise Plunk, Rebecca Lindell,* Southern Illinois University Edwardsville

Abstract: With the national mandates that science be an integral component of all levels of education, the importance of having courses for future elementary teachers designed to meet state and national standards is critical. This poster describes how three SIUE faculty, one from biology, chemistry, and physics, initiated, coordinated, and implemented curricular changes to our Foundations of Science course. The goals of this project were 1) to enhance the current content curriculum, 2) to revise current curricular modules and develop new modules to be inquiry-based, 3) to improve and expand upon the use of technology, and 4) to further articulate the interrelatedness of the sciences in the curriculum. Meeting these goals required the complete revision or creation of 25 hands-on inquiry-based modules. Evaluation of the project involved 1) determining the impact of the modules on student learning, 2) gathering students' perspective of the modules, and 3) collecting faculty feedback.

Supported by SIUE Excellence in Undergraduate Education Fund.

TP-C2
Professional Development for Standards-Based Physical Science Education Using Modeling Physics

Jason Cervenac (jason_cerv@earthlink.net), Worthington City School, *Kathleen Harper, Andrew Heckler,* The Ohio State University

Abstract: Ohio curricula have changed to address the new Ohio Graduation Test and state physical science standards. Consequently, teachers are looking for professional development opportunities that address the new standards. Ohio State

partnered with two school districts and the state to provide Modeling workshops in physical science. Participants represented a variety of teaching experiences. Teachers have learned content and methods to effectively prepare students for the relevant state standards and, working in small groups, designed Modeling-consistent units for other topics. Each unit explicitly indicates the state science standards it addresses. These units were disseminated to all participants in an effort to promote instructional practices that promote long-term retention, in-depth understanding, and knowledge transfer to novel situations. One message that is clear from current participants is that explicitly targeting the standards is valuable.

TP-C3

Meeting the Needs of Our Future and In-Service Teachers: The Development and Implementation of a PER-based Course to Teach Instructional Strategies in Astronomy

Rebecca Lindell (rlindel@siue.edu), Southern Illinois University Edwardsville, *Douglas Franke*, Knox College, *Elizabeth Peak*, Southern Illinois University Edwardsville, *Thomas Withee*, Collinsville High School & Southern Illinois University Edwardsville, *Thomas Foster*, Southern Illinois University Edwardsville

Abstract: To meet the requirements of the No Child Left Behind legislature, the State of Illinois radically changed its Science certification programs. This change resulted in the creation of a new certification in Earth and Space Science. To meet the requirements of this new program, the SIUE Department of Physics and Office of Science and Mathematics Education created a new course entitled "Instructional Techniques in Astronomy". Required for all students seeking Earth and Space Science certification, it is also ideal for meeting the needs of in-service teachers, who need additional astronomy courses to become "well-qualified". This poster will report on this unique course, which combines content and pedagogy along with both teacher-participant and instructor views on the effectiveness of this new course. In addition, teacher-participant lesson plans will be provided.

TP-C4

The Impact of Teacher Quality Grants (NCLB-based) on Long-Term Professional Development of Physical Science Teachers at the University of Texas at Dallas

Mary L. Urquhart (urquhart@utdallas.edu), University of Texas at Dallas, *Kendra M. Bober*, Evaluation Consultant

Abstract: The Texas Higher Education Coordinating Board Teacher Quality Grants (TQ Grants), supported in part through No Child Left Behind, are intended to ensure that secondary teachers of specific subjects are ³highly qualified². Now in their 3rd year, these grants have done much to shape long-term professional development for teachers in the physical sciences at the University of Texas at Dallas (UTD). The grants have also created a suite of challenges and benefits for the UTD Science Education M.A.T. program. TQ Grants are based on the No Child Left Behind framework that requires teachers to be ³highly qualified² as defined by the state. Recruitment is required to be targeted at teachers who are uncertified or teach one or more classes out of content area, and who work in high needs local school districts. Many of the students brought into are program through these grants have incoming content knowledge in physics similar to that typical of undergraduate non-majors, and a large percentage are uncomfortable with basic mathematics as well. How and what we teach has been dramatically impacted by the TQ Grants, as have our assessments and evaluations. An ongoing challenge has been to implement a PER-based course design while meeting the specific requirements of the TQ Grant program. The TQ Grants have also provided a great deal of opportunity to new and existing teachers in our program. A barrier to our teachers, rising tuition costs, has been removed, and as a result a mandate has become a doorway of opportunity for physical science teachers.

Workshops

Various Times & Rooms Listed Below
Workshop Presenters: Please follow the instructions provided here.

Workshop: W-A

Important Issues in Preparing Graduate Teaching Assistants

Organizer: *Kathleen Harper* (harper.217@osu.edu), The Ohio State University

Where: Union Parlor A

When: 8:15 – 9:45 & 1:45 – 3:15, Thursday, August 11

Theme: Graduate teaching assistants can have a profound effect on the students they teach, but often they are asked to do their job with little training or support. For those who will go on to be faculty in higher education, this also leaves them unprepared for the teaching component of their jobs. Traditionally, TAs go through a few days of intense initial training, then assuming they are doing a good job. Discussions among faculty development professionals have identified a baseline of issues that should be addressed with beginning TAs. Additionally, there are more efforts to go beyond the 'inoculation' model and develop programs of ongoing support throughout the TA's appointment. Several models will be shared with participants, who will have the opportunity to plan possible applications of these ideas to their own programs.

Goals: Participants will realize that TA preparation encompasses many areas beyond competency with content and extends beyond an 'inoculation' at the beginning of the academic year. Participants will leave having seen several models of TA preparation programs, some University-wide and some housed within specific departments. Participants will have ideas for implementing new elements as part of their TA preparation and support programs.

Activities: 1) Participants will list common complaints that they have either heard TAs make about their preparation or that faculty have made about TAs. 2) Participants will brainstorm about critical elements of TA preparation and support. These elements will be grouped into larger categories and each will be discussed. 3) Participants will be asked to think of a particular TA preparation program; this can be one they have experienced themselves, helped create, or have heard about. They will compare this program's characteristics against the elements identified in activity 1. Perceived strengths and deficiencies will be shared with the whole group. Additionally, as a group, connections between these deficiencies and the complaints in activity 1 will be explored. 4) Widespread deficiencies will be selected and smaller groups of participants will develop a list of possible activities for incorporating into existing programs to address these issues. These will be shared with the larger group. 5) The facilitator will share several examples of TA preparation and support programs, both University-wide and based within specific disciplines. 6) Participants will spend some time outlining a revised version of their TA preparation and support program.

Workshop: W-B

Model Analysis: Theoretical Basis and Methodology for Developing Effective Assessment

Organizers: *Lei Bao* (lbao@pacific.mps.ohio-state.edu)**,** *Neville Reay*, The Ohio State University

Where: OSH 234

When: 8:15 – 9:45, Thursday, August 11

Abstract: In this workshop, we first review some recent development in research on assessment methods. Specifically, we will discuss the context-dependence of cognitive process and its effects on teaching and learning. We then present a quantitative method to represent conceptual states and learning dynamics. The emphasis of the discussion is on the applications of the theoretical and mathematical models towards developing effective assessment methods for research and instruction. In particular, we will address issues in score-based assessment tools, and applications of Model Analysis to develop model-based multiple-choice instruments that combine both qualitative and quantitative methods. Examples will be given in tutorial forms. We will also demonstrate implementations of the assessment methods with technologies such as in-class polling systems. Application materials such as questions sets will be distributed.

Workshop: W-C

Reasoning, Piaget and Education

Organizer: *Dewey Dykstra*
(ddykstra@boisestate.edu), Boise State University

Where: OSH 233

When: 1:15 – 3:15 & 3:45 – 5:15, Thursday, August 11

Abstract: One of the pioneers in physics education research (PER) was Robert Karplus. He learned about the Swiss Genetic Epistemologist, Jean Piaget, from specialists in early childhood education in the Science Curriculum Improvement Study (SCIS) in the 1960's. Karplus saw value in Piaget's ideas in relation to learning science. Together with Robert Fuller, John Layman and others one of the first AAPT workshops was developed: Physics Teaching and the Development of Reasoning. Piaget's ideas are still relevant to understanding the learning process and we continue to use his research methods in PER. This small workshop will offer a taste of the essence of the original one with additions that have also grown from Piaget's work.

Combined Workshop & Discussion Session

Physics by Inquiry: Preparing K-12 teachers to teach physics and physical science

Organizers: *Donna Messina, Paula R. L. Heron, Peter S. Shaffer, and Lillian C. McDermott***,** Physics Education Group, Department of Physics, University of Washington

Where: Union Panorama East

When: 8:15 – 9:45 & 1:45 – 3:45, Thursday, August 11

Abstract: This combined workshop/discussion session will illustrate the type of instruction by guided inquiry that research has shown can help teachers develop a sound understanding of the physics and physical science that they are expected to teach. The workshop will feature excerpts from a WGBH video that was filmed during one of the intensive NSF Summer Institutes that our group conducts for K-12 inservice teachers. Workshop participants will be able to observe the types of interactions that take place among teachers as they work through the exercises and experiments in *Physics by Inquiry*. In another excerpt, a dialogue between a teacher and an instructor illustrates the nature of questions that are used to probe and assess the development of concepts and reasoning skills. The video will provide the basis for a discussion of the need for special physics courses for teachers, the benefits and challenges of instruction by guided inquiry, and some of the practical issues involved.

Contributed Posters

Wednesday, August 10
8:00 – 10:00pm
Union Ballroom

Posters will be set up between 6:00 – 8:00pm on Wednesday, August 10 and will remain up until the end of the conference.
Presenters are requested to put up their posters in the assigned spot as per the room layout at the end of this Program

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CP-01
Problem solving skills and evidence of their independence and transferability

Wendy Adams (wendy.adams@colorado.edu), *Carl Wieman* (wieman@jila.colorado.edu), University of Colorado

Abstract: Research in problem solving often presents categories of problem solving skills. The existing research describes many of these skills as higher level skills that develop only after other problem solving skills have been acquired. Building on prior work, we present a framework for categorizing problem solving skills, which emerge from interviews of individuals using the Colorado Problem Solving Survey. This new survey is designed to require a minimal amount of content knowledge in physics so as to address a broad range of problem solving skills. Analysis of results from 16 interviews and 8 written responses reveal that people can have expert-like skills in almost any area while their skills in all other problem solving categories remain quite novice. We also find that a person s problem solving skills can be carried not only across discipline but into the workplace as well.

Supported in part by funding from National Science Foundation DTS.

CP-02
Elementary education students' conecpts of force and motion

Rhett Allain (rallain@selu.edu), Southeastern Louisiana University

Abstract: The goal of this project is to examine the conceptual understanding of force and motion for pre-service elementary teachers. In particular, the study will explore the occurrence of the idea that the motion of an object is proportional to the force acting on that object. This investigation will use the Force Concept Inventory as well as responses to open ended questions to compare the understanding of pre-service elementary teachers to that of introductory algebra-based physics students.

CP-03
A comparison of student understanding of seasons using inquiry and didactic teaching methods

Paul Ashcraft (pashcraft@clarion.edu), Pennsylvania State University

Abstract: Student performance on open-ended questions concerning seasons in a university physical science content course was examined to note differences between classes that experienced inquiry using a 5-E lesson planning model and those that experienced the same content with a traditional, didactic lesson. The class examined is a required content course for elementary education majors and understanding the seasons is part of the university s state s elementary science standards. The two self-selected groups of students showed no statistically significant differences in pre-test scores, while there were statistically significant differences between the groups post-test scores with those who participated in inquiry-based activities scoring higher. There were no statistically significant differences between the pre-test and the post-test for the students who experienced didactic teaching, while there were statistically significant improvements for the students who experienced the 5-E lesson.

CP-04
Student Perceptions of Physics by Inquiry at Ohio State

Gordon Aubrecht, II (aubrecht@mps.ohio-state.edu), *Yuhfen Lin* (yflin@mps.ohio-state.edu), *Dedra Demaree* (ddemar1@mps.ohio-state.edu), The Ohio State University
Xueli Zou (xzou@csuchico.edu), California State University, Chico

Abstract: Students intending to become teachers may take Physics by Inquiry courses at Ohio State (the course is open to other non-science majors as well). We assess student perceptions of the Physics by Inquiry course using the Q-sort assessment. The assessment forces students to categorize the extent to which they think twenty-five descriptive statements characterize their laboratory class

experience. They sort the statements from most to least characteristic of the course into bins of successive size 2, 6, 9, 6, 2 (forcing a 'normal' distribution). We construct a matrix from the five categories and the twenty-five statements and examine the differences from the 'average' values. We find differences among different classes and between students and instructors. This poster will detail some of our most salient findings.

CP-05
Searching for Common and Optimum Knowledge Acquisition Paths in learning Lunar Phases

Joseph Beuckman (joe@beigerecords.com), *Rebecca Lindell* (rlindel@siue.edu), Southern Illinois University Edwardsville, *Andrew Heckler* (heckler@MPS.OHIO-STATE.EDU), The Ohio State University

Abstract: Preliminary qualitative work in determining a concept hierarchy among dimensions of the Lunar Phases Concept Inventory1 looks promising. The hierarchy proposed by Lindell, Hines and Heckler (AAPT WM04) was based on prerequisite mastery of each dimension. Here, we implement Ordering Theory2 to verify that such a hierarchy exists and attempt to build a concept hierarchy among individual correct and incorrect schema within and across the dimensions of the LPCI. This is quantitative work using pre- and post-instructional data from the national field test of the LPCI.

[1] Diognon, J. and Falmagne, J. 'Knowledge Spaces'
[2] Lindell, R. and Olsen, J., 'Development of Lunar Phases Concept Inventory'
[3] Airasian, P. and Bart, W. 'Ordering Theory'

CP-06
What is working in our introductory labs?

Jennifer Blue (bluejm@muohio.edu), Miami University

Abstract: A survey was conducted in the introductory physics laboratory class during the summer of 2005. Students were asked about their comfort with lab, their roles in their lab group, and their understanding of lab. Results will be reported, as will ideas for further research.

CP-07
Do our words really matter?: Case studies from Quantum Mechanics

David Brookes (dbrookes@physics.rutgers.edu), *Eugenia Etkina* (etkina@rci.rutgers.edu), Rutgers University

Abstract: To understand the role of language in learning physics, we will treat language as one possible representation of a physical model of the world. We will then present a theoretical framework that (a) enables us to identify physical models encoded in language, (b) enables us to describe the components of a linguistic representation of the model. The data shows that physicists use linguistic representations to reason productively about physical systems and problems. We will then present two case studies and supporting evidence to argue that these linguistic representations are being used and applied by physics students when they reason. Sometimes linguistic representations are being misapplied and overextended. This in turn, allows us to understand and account for many student ``misconceptions''. We will use the case studies to argue that students struggles with language is part of the process of learning physics.

CP-08
Physics Education Reseach: Making Inroads with an Entrenched Physics Teacher at Vacaville High School

Austin Calder (amcalder@ucdavis.edu), University of California, Davis

Abstract: In this paper I present an overview of a one-year teacher research orientated collaboration between graduate fellows at the University of California at Davis and high school science teachers in Vacaville High Schools. One goal of the collaboration was the presence of expertise in the classroom, in the form of an advanced graduate student. Along with this, there was the expectation of an information exchange and general teaching dialogue between graduate fellow and high school teacher. In this case, the teacher involved proved quite adamant in his traditional teaching views and often antagonistic toward the graduate fellow. Specifically, I detail the nature of the interactions and communications between the graduate fellow, whose focus is Physics Education, and a physics teacher with nine years of traditional teaching experience. Also given is an abridgment of the

actual Teacher Research project along with its sponsoring program.

CP-09
To Extract or Not To Extract? That Is The Question

Alice D. Churukian (churukia@cord.edu), Concordia College, Moorhead, Minnesota, *Paula V. Engelhardt* (Engelhar@tntech.edu), Tennessee Tech. University

Abstract: As a multitude of diagnostic instruments have been and are being developed to assess student understanding of various topics in physics, instructors are faced, more and more, with the dilemma of cost versus benefit. How many diagnostic instruments can effectively be administered in a single semester? Which instruments will give the most benefit? Why isn't there one instrument to assess the entire semester and still provide appropriate feedback? The Survey of Electricity, Magnetism, (DC) Circuits, and Optics (SEMCO) was initially created to assess the effectiveness of New Studio physics at Kansas State University. SEMCO is a conglomerate survey of questions selected from the CSE, the CSM, DIRECT, the LOCE, and the Optics ConcepTest. Do students taking SEMCO respond in a similar manner to students taking the full version of any one of the diagnostic instruments from which it was created? Other research suggests that changing the order of the questions can matter in terms of drawing students to different distracters. This poster will examine the effect of student performance between SEMCO and DIRECT for both calculus-based introductory students and algebra-based introductory students.

CP-10
Scaffolding Students' Microscopic Modeling of Friction in Teaching Interviews: A Case Study with Two Students

Edgar Corpuz (eddy@phys.ksu.edu), *N. Sanjay Rebello* (srebello@phys.ksu.edu), Kansas State University

Abstract: Our previous research [1] showed that students' mental models of microscopic friction are significantly influenced by their macroscopic ideas and experiences. We conducted teaching interviews to facilitate students' construction of a scientifically accepted model of microscopic friction and make them aware of the disparity between macroscopic and microscopic friction. We present the different scaffoldings provided to students during the teaching interviews and describe how these experiences influenced the model construction processes of two typical students.

[1] Corpuz, E.G. and N.S. Rebello (2005). Introductory College Physics Students Mental Models of Friction and Related Phenomena at the Microscopic Level.

Supported in part by NSF grant REC-0133621.

CP-11
College Students' Transfer from Calculus to Physics

Lili Cui (lili@phys.ksu.edu), *N. Sanjay Rebello* (srebello@phys.ksu.edu), *Andrew G. Bennett* (bennett@math.ksu.edu), Kansas State University

Abstract: This research investigated students' transfer of learning from calculus courses to an introductory physics course. We used semi-structured think aloud interviews to assess the extent to which students transfer their calculus knowledge when solving problems in a physics course. Results indicate that students do transfer their knowledge from calculus class to physics class. However, during the transfer process, they needed specific scaffolding to connect the calculus knowledge with the physics problem.

Supported in part by the NSF Grant DUE-0206943.

CP-12
Understanding change in physics education: Identifying old barriers and new directions

Melissa Dancy (mhdancy@uncc.edu), University of North Carolina, Charlotte, *Charles Henderson* (charles.henderson@wmich.edu), Western Michigan University

Abstract: While there are many calls for educational change, these calls often assume a common set of goals and pathways to change. Careful consideration of change in physics education indicates that the process is complex and often fraught with contradictory goals. In this poster, we will discuss our development of a set of dimensions to categorize practices and beliefs related to physics teaching and learning. We will then identify

practices that have been advocated by educational reformers in other disciplines, but are not generally found in PER-based curricula. Finally we will offer an analysis which connects our results with theories of change proposed by others.

CP-13
Gender in the student laboratory: An exploration of students experiences of doing laboratory work in physics

Anna Danielsson (anna.danielsson@fysik.uu.se), Uppsala University

Abstract: Laboratory work is generally seen as an important part of any science education, since it is here the students are given the chance to do science . This gives a unique opportunity to talk to the students about how they experience learning the doing of science and also to highlight (some) of the cultural norms of the physics student-community. In this spirit, I am conducting semi-structured interviews with physics majors, exploring how they experience learning in the student laboratory, taking into account the gendered norms of physics education. My main interest is how the students in the context of laboratory work create a physicist identity in relation to the cultural norms of the physics student-community.

CP-14
Is instructional emphasis on the use of non-mathematical representations worth the effort?

Charles De Leone (cdeleone@csusm.edu), California State University, San Marcos, *Elizabeth Gire* (egire@physics.ucsd.edu), University of California, San Diego

Abstract: A hallmark of physics is its rich use of representations. The most common representations used by physicists are mathematical representations such as equations, but many problems are rendered more tractable through the use of other representations such as diagrams or graphs. Examples of representations include force diagrams in mechanics, state diagrams in thermodynamics, and motion graphs in kinematics. Most introductory physics courses teach students to use these representations as they apply physical models to problems. But does student representation use correlate with problem solving success? In this poster we address this question as we report on student representation usage during the first semester of an introductory physics course for biologists taught in an active-learning setting.

Partially supported by NSF Grant #DUE-0410991

CP-15
Assessing ISLE labs as an enhancement to traditional large-lecture courses at the Ohio State University

Dedra Demaree (demaree.2@osu.edu), *Yuhfen Lin* (yflin@pacific.mps.ohio-state.edu), *Gordon Aubrecht II* (aubrecht.1@osu.edu), *Lei Bao* (lbao@pacific.mps.ohio-state.edu), The Ohio State University

Abstract: At the Ohio State University (OSU), some existing laboratory sections were replaced with Investigative Science Learning Environment (ISLE) labs during the 3-quarter calculus-based introductory physics sequence this past academic year. The ISLE labs have been developed by the PAER Group at Rutgers University and implemented at Rutgers and at California State University, Chico. A direct comparison is made of OSU students participating in the ISLE labs with students in the existing labs under the same large-lecture instruction. Assessment included diagnostic tests, attitude surveys, and feedback obtained from a Q-type instrument. The ISLE environment focuses on scientific abilities which are not directly tested in our large-lecture course or diagnostic tests. Therefore, we also solicited volunteers to participate in a lab 'practical exam' aimed at looking for differences in scientific abilities. The results of these assessments will be discussed.

CP-16
Designing an Assessment Tool for Matter & Interactions Mechanics Course*

Lin Ding (lding@ncsu.edu), *Ruth Chabay* (rwchabay@unity.ncsu.edu), *Bruce Sherwood* (Bruce_Sherwood@ncsu.edu), North Carolina State University

Abstract: Matter & Interactions [1] is a modern curriculum for calculus-based introductory physics. In the M&I mechanics course, the first semester of a two-semester sequence, a major goal is that students learn to use a small number of fundamental principles, in particular the momentum principle and the energy principle, to explain a broad range of

phenomena [2]. There is no published assessment tool that directly measures whether the M&I curriculum meets this goal. We designed an energy test for the M&I mechanics course, and administered a beta version to a class of 77 students. Some preliminary results will be reported.

This study is partially supported by NSF grant 5-33494.

[1] Matter & Interactions I: Modern Mechanics and Matter & Interactions II: Electric and Magnetic Interactions. Ruth Chabay & Bruce Sherwood, Wiley 2002, http//www4.ncsu.edu/~rwchabay/mi.
[2] Ruth Chabay & Bruce Sherwood, "Modern mechanics," Am. J. Phys. Vol. 72, 439, 2004.

CP-17
A Preliminary Study of the Effectiveness of Different Recitation Teaching Methods

Robert Endorf (robert.endorf@uc.edu), University of Cincinnati, *Kathleen Koenig* (kkoenig@fuse.net), *Greg Braun* (braung@xavier.edu), Xavier University

Abstract: We present preliminary results from a comparative study of student understanding for students who attended recitation classes which used different teaching methods. Student volunteers from our introductory calculus-based physics course attended a special recitation class that was taught using one of four different teaching methods. A total of 272 students were divided into approximately equal groups for each method. Students in each class were taught the same topic, Changes in Energy and Momentum , from Tutorials in Introductory Physics1. The different teaching methods varied in the amount of student and teacher engagement. Student understanding was evaluated through pretests and posttests given at the recitation class, and a posttest question on the final exam. Our results demonstrate the importance of the instructor s role in teaching the recitation. This poster addresses the conference theme by presenting evidence for which teaching methods should be emphasized in training future teachers and faculty members.

Supported by NSF grant DUE-0126919 1. L.C. McDermott, P.S. Shaffer and the Physics Education Group at the University of Washington, Tutorials in Introductory Physics, First Ed. (Prentice Hall, 2002).

CP-18
Design labs: Student s expectations and reality

Eugenia Etkina (etkina@rci.rutgers.edu), *Sahana Murthy* (sahana@physics.rutgers.edu), Rutgers University

Abstract: In a study reported in the 2004 PERC proceedings the authors described how introductory physics labs in which students design their own experiments help them develop scientific abilities such as an ability to design an experiment to solve a problem, an ability to collect and analyze data, and an ability to communicate the details of the experimental procedure. The goals of the present study are to investigate the social aspect of student learning in these labs: whether students expectations are consistent with the goals of the labs, whether student assessment of their learning in the labs matches the goals, and whether they perceive them as helping to learn useful skills. As all future science teachers enroll in introductory physics labs, restructuring the labs and changing students expectations about them is closely related to the improvement of teacher preparation.

CP-19
A Methodological Framework for Researcher and Teacher Professional Development

Peter R. Fletcher (fletcher@phys.ksu.edu), *N. Sanjay Rebello* (srebello@phys.ksu.edu), Kansas State University

Abstract: Whether you are training a junior researcher or working with a seasoned teacher, an appropriate methodological framework offers an ideal environment in which to conduct a program of professional development activities. The framework described here provides a forum and research setting allowing junior through experienced teachers and researchers to act in a variety of project management roles and perform a range of research activities. This presentation shows how a scaleable robust and flexible research framework is constructed by combining elements from Grounded Theory, Phenomenology and Action Research. In addition for larger projects an administrative framework based upon the three-level teaching experiment of Lesh and Kelly [1] is integrated to form a responsive, manageable research and professional development environment. We conclude the presentation with a discussion on a selection of professional development opportunities and activities possible within the framework.

[1] Lesh, R. and A.E. Kelly, Multitiered Teaching Experiments, in Handbook of Research Design in Mathematics and Science Education, R. Lesh and A.E. Kelly, Editors. 2000, Lawrence Earlbaum Associates: Mahwah, NJ. Supported in part by NSF grant REC-01336

CP-20
Science Teacher Self-Efficacy Beliefs and their Impact on Effective Teaching

Eric. A Hagedorn (ehagedorn@utep.edu),
University of Texas at El Paso

Abstract: A beginning science teacher may possess the knowledge and skills required to teach science, but if she does not believe that she can effectively do so, she is unlikely to do so. Similarly, if a teacher does not believe that her students can effectively learn science, this will also adversely affect her teaching. The first belief, which at first glance seems related to self-confidence, has been carefully defined and empirically validated as a "self-efficacy belief." The second belief relating to perceived student abilities has been carefully defined and empirically validated as an "outcome expectancy belief." The Science Teacher Efficacy Beliefs Instrument (STEBI) has been effectively used to measure teachers' self-efficacy and outcome expectancy beliefs for the past 15 years. This paper will review the literature on science teacher self-efficacy beliefs and provide an overview of the STEBI – including the interpretation of actual data taken before and after pre-service teachers participate in the second course of a physics course based on AAPT's Powerful Ideas in Physical Science [PIPS] curriculum.

CP-21
Making words work: The simultaneous construction of concepts and discourse

Danielle Harlow (Danielle.Harlow@colorado.edu),
Valerie Otero (Valerie.Otero@colorado.edu),
University of Colorado

Abstract: Many words are used in physics differently than they are used in everyday speech. Thus, physics learners must develop conceptual understandings of physical phenomena while learning to use words in new ways. This simultaneous construction of physics concepts and discourse requires that students talk about partially understood concepts using partially acquired vocabulary. In this paper, we present an analysis of physics students as they use terms such as momentum and energy to explain unexpected observations involving acceleration. Our analysis shows that students use science terms that they do not fully understand to temporarily resolve conceptual conflict. Even when terms are used in ways inconsistent with accepted scientific definitions, this practice contributes both to the development of students' conceptual understanding of physics and to their acquisition of science discourse.

This project is supported by the National Science Foundation Grant 0096856.

CP-22
Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations

Charles Henderson (Charles.Henderson@WMICH.edu), Western Michigan University, *Melissa Dancy* (mhdancy@email.uncc.edu), University of North Carolina, Charlotte

Abstract: Physics Education Research (PER) practitioners have engaged in substantial curriculum development and dissemination work in recent years. Yet, it appears that this work has not had a significant influence on the basic teaching practices of typical physics faculty. We conducted interviews with five likely users of educational research to identify barriers to dissemination. One significant barrier appears to be that faculty and educational researchers have different expectations about how they should work together to improve student learning. This discrepancy was expressed directly (and often emotionally) by all of the instructors we interviewed. Although different instructors described different aspects of this discrepancy, we believe that they are all related to a single underlying issue: PER expects to disseminate curricular innovations and have faculty adopt them with minimal changes while faculty expect PER to work with them to adapt PER knowledge and materials for their unique instructional situations. We will explore this claim and the evidence found in the interview transcripts. We will also discuss implications for the PER community.

CP-23
Developing an inquiry-based physical science course for preservice elementary teachers

Zdeslav Hrepic (zhrepic@fhsu.edu), *Paul Adams* (padams@fhsu.edu), *Jason Zeller* (zeller@hometelco.net), *Nancy Talbott* (ntalbott@media-net.net), *Germaine Taggart* (gtaggart@fhsu.edu), *Lanee Young* (lyoung@fhsu.edu), Fort Hays State University

Abstract: Pre-service elementary teachers should experience science through inquiry in order to be effective in teaching science. In addition, inquiry as a mode of teaching is mandated by Kansas and National Science Education Standards. As a result of the No Child Left Behind Act, teachers also need to be prepared to include basic skills in reading and mathematics in all instruction. To address these issues Fort Hays State University (FHSU) is adapting and extending the NSF-developed teacher enhancement materials Operation Primary Physical Science (OPPS) for use in a physical science course for pre-service elementary teachers. We will present main features of OPPS, demonstrate its effectiveness as shown through workshops with in-service teachers and discuss results that we have collected with students enrolled in the adapted course since the beginning of the Fall 2004 semester.

Supported in part by NSF grants DUE-0311042 and DUE-0088818.

CP-24
Investigating students ideas about X-rays and development of teaching materials for a medical physics course

Spartak Kalita (kalita@phys.ksu.edu), *Dean Zollman* (dzollman@phys.ksu.edu), Kansas State University

Abstract: Contemporary medicine both diagnostic and treatment involve sophisticated applications of fundamental principles of physics. By the time pre-med students reach a general physics course they have often already heard of or undergone procedures such as X-ray screening. Yet, the pre-med physics course curricula mention them in passing. This is lamentable because while pre-med students often complain that physics lacks relevance - we are missing a great opportunity to show them how useful it will be in their future profession. The Modern Miracle Medical Machine project is proposed to fill this deficiency. The X-ray teaching-learning module is going to be one of the central parts of it. We have conducted some preliminary research on the topic, including more then a dozen semi-structured clinical interviews with KSU Physics students with various backgrounds. Further investigation of students mental models, teaching interviews and the development of instructional materials utilizing appropriate assessment and evaluation tools is being planned and will follow soon

This research is supported by the National Science Foundation under grant DUE 0427645.

CP-25
Tricky calorimetry: making sense of the real world

Anna Karelina (anna.karelina@gmail.com), *Eugenia Etkina* (etkina@rci.rutgers.edu), *Sahana Murthy* (sahana@physics.rutgers.edu), *Maria Rosario, Ruibal Villasenor* Rutgers University

Abstract: The Rutgers PAER group developed and implemented introductory physics laboratory tasks where students design and perform experiments to solve practical problems and the rubrics that allow students to self-assess their work. Researchers use the rubrics to score lab reports. Our research indicates that the most common students' difficulties are evaluating the effects of the assumptions that they make building a model of a situation and evaluating measurement uncertainties. Consequently students have trouble assessing whether their solution of a particular problem makes sense. In this study we investigate the work of 70 students solving two experimental problems in calorimetry and correlate the trends in student work with the goals of instructors, found through interviews. Our findings indicate that although students have the same lab write-ups and used the same rubrics for assessment, their work depends on the unspoken goals of the instructor. This is an important finding for teacher preparation.

Supported by grant DUE-0241078

CP-26
Assessing the effectiveness of a computer simulation in conjunction with Tutorials in Introductory Physics in undergraduate physics recitations

Christopher Keller (christopher.keller@colorado.edu), *Noah Finkelstein* (finkelsn@colorado.edu), *Katherine Perkins* (katherine.perkins@colorado.edu), *Steven Pollock* (steven.pollock@colorado.edu), University of Colorado

Abstract: We present two studies documenting the effectiveness of the use of a computer simulation with Tutorials in Introductory Physics [1] in a transformed college physics course [2]. An interactive computer simulation, entitled the Circuit Construction Kit (CCK) [3], was introduced to investigate its possible impact on students conceptual understanding. The first study compared students using either CCK or real laboratory equipment to complete two Tutorials on DC circuits. The second study investigated the impact of the simulation s explicit conceptual model for current flow by removing this feature for a subset of students. In the first study, the use of CCK with Tutorials yielded slightly better improvements in conceptual understanding compared to real equipment, as measured by exam performance soon after the intervention. In the second study, students using CCK with and without the explicit current model performed similarly to their real-equipment counterparts. We discuss the implications of adding (or removing) such explicit models within computer simulations.

[1] McDermott, Schaffer. Tutorials in Introductory Physics. Prentice Hall, New Jersey. 2002.
[2] Colorado PhysTEC
[3] Physics Education Technology Project (PhET), phet.colorado.edu

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CP-27

Students' cognitive conflict and conceptual change in a PBI class

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Abstract: With proper context settings, instructors need to guide students to explicitly recognize cognitive conflicts among students existing understandings and the new knowledge being taught. To study this issue, we have developed an easy-to-use instrument, the in-class Conflict and Anxiety Recognition Evaluation (iCARE), for monitoring the status of students cognitive conflicts and anxiety in the context of Physics by Inquiry (PBI) classes. Using iCARE, we investigate what types of cognitive conflict is constructive or destructive in conceptual change when college students are confronted with anomalous situations in a PBI class. In this research, we will present our results about the relationship between students types of cognitive conflicts and their conceptual changes and show among students with different levels of motivational beliefs the relationship between the characteristics of students prior knowledge and cognitive conflicts. We will also discuss the implications for the more effective cognitive conflict strategy in real school setting.

This work was supported by NSF grants REC-0087788 and REC-0126070.

CP-28

The effect of educational environment on representational competence in introductory physics

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Abstract: In a previous study of a traditional, large-lecture algebra-based physics course, we demonstrated that giving students a choice of representational format when they solve quiz problems could have either significantly positive or negative performance effects, depending on the topic and representation used. Further, we see that students are not necessarily aware of the representation at which they are most competent .[1] Here, we extend these results by considering two courses taught by a reform-style instructor. These performance data are substantially different in character, with the students from the reform courses showing much smaller performance variations when given a choice of representation. From these data, we infer that students in the reform courses may be learning a broader set of representational skills than students in the traditional course. We therefore examine major components of the courses (exams, homework, lectures) to characterize the use of different representations. We find that the reform courses make use of richer selections of representations, and make more frequent use of multiple representations, suggesting a mechanism by which these students learned improved skills.

[1] P. B. Kohl and N. D. Finkelstein. Representational Format, Student Choice, and Problem Solving in Physics. Proceedings of the 2004 Physics Education Research Conference (in press)

CP-29

How students form conclusions in the student laboratory

Rebecca Kung (rebecca.kung@fysik.uu.se), Uppsala University

Abstract: A large component of most laboratory courses is using results from measurements to make conclusions. Many of these decisions involve comparing data to theory or data to data to see whether they agree or disagree. Frequently students are given a prescriptive cutoff (such as 10% difference or 2 standard deviations) to determine agreement. To understand the different ways students form conclusions without such a rule, their arguments have been analyzed in terms of the information used, the comparisons made, and the argument's complexity. I have found this analysis useful as a researcher and an instructor, to make sense of how students are thinking and to determine what intervention might be needed. As part of the discussion, students' arguments from several introductory university physics laboratory courses will be presented.

CP-30

Student assessment of laboratory in introductory physics courses

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Abstract: In inquiry labs we try to help students learn to make scientific decisions. How successful are we? Are the instructor and the lab material getting the message across to the students? A modified version of the Laboratory Program Variables Inventory (LPVI), a Q-type instrument has been used to study students perceptions of the lab. We identified statements related to student dependence on instructors, separating the statements into categories of student directed , intermediate , and instructor directed . We analyzed different labs from different universities and found that students perceptions of how much control they had over the lab varied with lab type. We also found a dependence of student perceptions on lab instructor within each type of lab. The variation between different types of lab was greater than the variation between instructors within the lab type. This is a promising tool for assessing the lab material and instruction.

CP-31

Student Learning and Dynamic Transfer while Interacting with 'Constructing Physics Understanding' (CPU) Curriculum: A Case Study

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Abstract: This research investigated the extent of the effectives of the Constructing Physics Understanding (CPU) curriculum on mechanical wave properties in effecting student learning. The research was conducted at University of San Carols, Philippines. Six (6) students were the participants of the study. We used the phenomenographic approach coupled with the constructivism philosophy as the underlying; further on, we used the Dynamic Transfer Model developed at Kansas State University - Physics Education Group in plotting out the students' intellectual development so as to gauge the extent of the effectiveness of the CPU.

Supported in part by NSF grant REC-0133621.

CP-32

Strengthening the Connection between Coursework and Real-World Phenomena

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Abstract: Positively influencing students' attitudes and beliefs about the nature of science and scientific inquiry should be a critical goal of a well-intentioned curriculum. Unfortunately, several researchers have revealed that it can be difficult to improve such attitudes and beliefs. In an attempt to overcome some of these difficulties we looked to improve a narrow range of students' attitudes, instead of the broad spectrum of attitudes addressed in previous works. Specifically, we designed curricular materials for first-year general science students intended to help them make connections between the material they cover in class and real-world phenomena. To help us characterize changes in student's attitudes we administered the EBAPS at the beginning and end of the semester. Although the overall improvement in scores from pre-test to post-test was not significant, upon finer inspection of responses we did see some trends toward more sophisticated attitudes and beliefs.

CP-33
A Quantum Mechanics Conceptual Survey

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Abstract: We have developed a survey of conceptual understanding of quantum mechanics. The survey is based on interviews of faculty members about what they think are the most important concepts in quantum mechanics and on known student misconceptions about this topic. We have tested the survey through student interviews and have given it to two modern physics courses. We are in the process of surveying physics faculty and graduate students as well. Student interviews, which were designed to test the validity of survey questions, have revealed many interesting results about student ideas about quantum mechanics. We have seen many of the same student conceptions discussed in other studies, as well as some that have not previously been reported.

CP-34
Investigations of Student Reasoning in Thermochemistry

David E. Meltzer (dem@iastate.edu), *Thomas J. Greenbowe* (tgreenbo@iastate.edu), Iowa State University

Abstract: Students in both chemistry and general science classes often have their first encounter with concepts of heat and temperature in the context of calorimetry. In particular, it is a topic often addressed in courses directed at pre-service elementary- and middle-school teachers. However, understanding the origins of energy flows resulting from chemical reactions presents a substantial conceptual challenge for introductory students. We have carried out an investigation of the ways in which students in an introductory university chemistry course attempt to solve basic problems in solution calorimetry. We will report on several specific conceptual difficulties that were encountered by these students. Among these difficulties are a misunderstanding of the meaning of the mass 'm' in the equation $Q=mc\Delta T$, and a failure to understand that heats of reaction originate from the breaking and forming of chemical bonds between atoms.

Supported in part by NSF DUE-9981140 and PHY-0406724.

CP-35
A more complete way to follow development of student ideas in mechanics

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Abstract: Although different kinds of misconceptions can give rise to the same scores, in general total scores are used to define teaching strategies. A more complete strategy would be analyze students' pattern of answers for identifying present misconceptions and generate specific strategies to address them. In this work, we use cluster analysis to classify students in base of their misconceptions in mechanics, to identify those students with the same nature of misconceptions. Moreover, this analysis allows us to keep track of their misconceptions along a standard lecture and to show how they can stay unchanged without a specific strategy.

CP-36
Examining the Evolution of Student Ideas About Quantum Tunneling

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Abstract: We have been investigating student understanding of quantum tunneling for the past three years. Our data include interviews with, and surveys and exam questions from sophomores who have completed a modern physics course and seniors who have completed a quantum physics course. Consequently, we have acquired multiple data points for a small set of students who have taken both courses that allow for longitudinal study. Our analysis yields a few promising results, including abandonment of the energy loss misconception [1] however, many difficulties remain. We focus on one student to illustrate the persistent lack of coherence between pieces of knowledge surrounding the example of quantum tunneling through a one-dimensional potential energy barrier even after completion of two courses in quantum physics.

[1] J.T. Morgan, M.C. Wittmann, and J.R. Thompson in 2003 Physics Education Research Conference, J.

Marx, K. Cummings, S. Franklin, Eds., AIP Conference Proceedings 720, 97-100 (2004).

CP-37
A replication study of the use of concentration analysis to characterize student response patterns on a multiple-choice concept test in mechanics

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Abstract: The current study investigated conceptions of the concepts of force and motion at pre- and post-instruction of 261 students enrolled in the calculus-based introductory physics course at Arizona State University in the spring 2005 semester. The experimental design and analysis procedure were based on an empirical study by Bao & Redish [1], in which they proposed the concentration analysis methodology. Concentration analysis is a quantitative method intended to measure the evolution of common reasoning patterns given by students between a pre- and post-test on a multiple-choice assessment. Overall, the study found similar characteristic reasoning patterns reported earlier.

[1] Bao, L., & Redish, E.F. (2001). Concentration analysis: A quantitative assessment of student states, Phys. Educ. Res., Amer. J. Phys. Supplement, 69, S45-S53.

CP-38
Investigating the reliability of the MPEX survey

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Abstract: The Maryland Physics Expectations Test (MPEX) is a Likert-scale survey used to measure students' attitudes both before and after taking a physics course. Student responses are categorized as either favorable or unfavorable as determined by the prevalent responses given by an expert control group [1]. We investigated the possibility of false negative or positive responses on the student surveys by asking students to elaborate on their responses to some of the statements. While the majority (usually 90-100%) of explanations were consistent with the corresponding Likert choice, a few questions generated multiple student responses that deserved further review. These interesting student responses were compiled and sent to physics faculty to gauge the favorability of the students entire response. Here we present our analysis of the questions that generated the highest number of inconsistent responses.

[1] E. Redish, J. Saul, R. Steinberg. Student Expectations in Introductory Physics. American Journal of Physics (March 1998) 212-224.

CP-39
Research-based laboratories for introductory physics courses*

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Abstract: In the introductory courses at many universities, the lab is the only venue for research-based curricula. We are in the process of developing a modified laboratory sequence for introductory mechanics that builds upon proven curricular materials including Tutorials in Introductory Physics [1]. Some labs are closely related to existing Tutorials. For other topics we are conducting basic research into student understanding and applying what we learn to the development of new labs. Our poster will provide an overview of the curriculum development project and give specific examples of laboratory exercises and the underlying research.

[1] McDermott, Shaffer, and the U. Wash. P.E.G., 2002.

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CP-40
Towards characterizing the relationship between students self-reported interest in and their surveyed beliefs about physics

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Abstract: Repeated measurements of students beliefs about physics and learning physics have shown that students beliefs typically degrade -- that is become more novice-like -- over the course of most introductory physics classes. In this paper, we begin to examine the relationship between students beliefs and their self-reported interest in physics as well as the relationship between their respective changes over the term. We report results from survey data collected in a large calculus-based introductory mechanics courses (N=391). We used the Colorado Learning Attitudes about Science Survey (CLASS v3) to characterize students beliefs and asked students to rate their interest in physics, how it has changed, and why. We find positive correlations (R=0.65) between students Overall belief and their self-rated interest at the end of the term. An analysis of students reasons for why their interest changed showed that a sizable fraction of students cited reasons tied to beliefs about physics or learning physics probed by the CLASS survey with the leading reason for increased interest being the connection between physics and the real world.

CP-41
Analogical Scaffolding: A Research Based Model of Learning Abstract Ideas in Physics

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Abstract: Analogies are ubiquitous in physics. An analogy is often considered to be a mapping from a familiar domain to an unfamiliar domain (e.g. water system to electric circuits). Drawing on the work of Lakoff, Roth, and Fauconnier, we seek to develop a model for student learning of abstracted electromagnetic (E-M) waves. Applying this model we posit that students can productively learn about E-M waves via a series of linked analogies of increasing abstraction, what we refer to as analogical scaffolding . We employ this model to interpret the results of a two part experiment. College students in introductory physics were divided into two groups: in one group, sound waves were used as an analogy for E-M waves; the other group used waves on a string as an analogy for E-M waves. In part one of the experiment, students were asked to choose a representation that best characterized their understanding of sound or string waves and answered a question on these. Students were then asked to choose a representation and answer a question for E-M waves. Here, we apply our model to interpret how students draw on linked representational formats in understanding these different phenomena. In part two, students completed a tutorial on E-M waves after being prepared with either sound, string, or no analogy. The effect of the different analogical scaffolds for E/M waves was probed with a final exam question on E-M waves. We find associations between which preparation students received (sound, string, no prep) and how they answered questions on the characteristics of E-M waves.

CP-42
Transferring Transformations: Learning Gains, Student Attitudes, and the Impacts of Multiple Instructors in Large Lecture Courses.

Steven Pollock (Steven.pollock@colorado.edu), University of Colorado

Abstract: We have implemented several research-based transformations in our introductory calculus-based physics course at CU Boulder. These include Peer Instruction with student response system in lecture[1], Tutorials[2] with trained undergraduate learning assistants in recitations, and personalized computer assignments[3]. In an effort to distinguish the effects of instructor, TA training, and particular research-based activities, we present extensive new measurements from six courses representing a spectrum of reforms. This study includes data from mechanics courses with and without Tutorials, and E&M courses with Tutorials. We present multiple quantitative and qualitative measures of success, including validated pre/post content- and attitude-surveys and common exam questions. We investigate the hand-off of reforms between faculty implementing different suites of activities, and begin to assess elements and requirements for success with these transformations. We present evidence that combining research-based interactive engagement methods in lecture, Tutorials, and homework plays a significant positive role in conceptual and attitudinal development.

[1] Mazur (1997) Peer Instruction
[2] McDermott et al (1998). Tutorials in Introductory Physics
[3] lon-capa.org, masteringphysics.com Work supported by NSF and APS PhysTec

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CP-43
Movie Physics: Transfer to the Real World

Carina M. Poltera (cmp3377@ksu.edu), *Peter R. Fletcher* (fletcher@phys.ksu.edu), *N. Sanjay Rebello* (srebello@phys.ksu.edu), Kansas State University

Abstract: Physics is an integrated part of our lives. Yet students in introductory physics can seldom transfer their learning from the classroom to their life experiences. We used action clips from popular movies to examine the extent to which students in introductory physics courses can transfer their learning from the classroom and their personal experiences to the situations shown in clips. A total of eight movie clips were shown to students in a semi-structured interview format. We describe here the results for each movie as well as general trends in students' reasoning patterns.

This research is supported in part by NSF grant REC-0133621.

CP-44
Automated Instrument for Observing and Recording Behaviors Over Time of Large Numbers of Students

Wendell Potter (whpotter@ucdavis.edu), University of California, Davis

Abstract: All of us who have been involved in implementing active-learning formats in settings that involve multiple numbers of instructors face the difficulty of helping many of these instructors become familiar and comfortable teaching in a new and strange learning environment. We have found that one of the most valuable experiences for both graduate student teaching assistants and faculty who are teaching in an active-learning environment is to spend time critically observing what students actually do in such an environment. However, these observational experiences are most effective if they are systematic and well structured. We have implemented an automated recording tool for lap tops that facilitates detailed observation over time (typically one hour or more) of two or three students simultaneously. The great advantage of this tool is that the detailed data is immediately available for analysis. We will present examples and comparisons of active-learning and traditional instruction in introductory physics.

CP-45
Teacher Researcher Professional Development: PER Case study Kansas State University

N. Sanjay Rebello (srebello@phys.ksu.edu), *Peter Fletcher* (fletcher@phys.ksu.edu), Kansas State University

Abstract: In this presentation we report on a case study which provides administrative and methodological professional development to undergraduate and graduate research team members of the Kansas State University Physics Education Research (KSU-PER) group. An integral component of a student s professional development is the opportunity to participate in a range of research activities and work in collaboration - both as a mentor and a junior researcher. In order to coordinate and facilitate these opportunities KSU-PER established an ongoing research project investigating students conceptions of the physics underlying devices. The project utilized an integrated methodological and administrative framework - combining elements from grounded theory, phenomenology and action research. This framework provides a forum and research setting allowing junior and experienced researchers to act in various project management roles and perform a range of research activities. We will conclude the presentation by reflecting upon our experiences.

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CP-46
Case Study: Students' Use of Multiple Representations

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Abstract: Being able to represent physics concepts and problem situations in multiple ways for qualitative reasoning and problem solving is a scientific ability we want our students to develop. Physics education literature indicates that using multiple representations is beneficial for student understanding of physics ideas and for problem solving [1]. To find out why and how students use multiple representations for problem solving, we conducted a case study of six students during the second semester of a two semester introductory physics course. These students varied both in their use of representations and in their physics

background. This case study gives us an in-depth look at how students use of representations relates to their ability to solve problems. This research helps us in teacher preparation because it allows us to understand how students use multiple representations.

[1] J.I. Heller and F. Reif, 'Prescribing effective human problem solving processes: Problem description in physics,' Cog. Inst. 1, 177-216 (1984)

Supported by NSF grants DUE 0241078, DUE 0336713.

CP-47
Enhancing High School Physics Instruction through the Physics Van Inservice Institute

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Chicago State University

Abstract: There are many research-based programs for the professional development of high school physics teachers that have proven to be effective in preparing teachers to conduct inquiry-based activities in the classroom. These programs serve as a model for The Physics Van Inservice Institute, a professional development program operated by Chicago State University, Chicago Public Schools, and the University of Illinois (Chicago) as part of the Chicago Collaborative for High School Science Education and Outreach. The Physics Van Program addresses the specific needs of inner-city teachers and students by utilizing inquiry-based physics modules and making all necessary equipment available so that teachers can borrow the equipment and conduct the activities in their schools. Results from Physics Education Research are used as a guide in the development of the modules and inform what occurs in the teachers classrooms.

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CP-48
Students' Conceptual and Mathematical Difficulties with Quantum Wave Functions

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Abstract: In contrast to a classical particle, localized at a point, a wave function spreads out in space. This and the statistical interpretation of the wave function are disturbing for students. As part of an ongoing investigation of students' difficulties learning quantum mechanics, we bring examples of students' common difficulties with the wave function. These difficulties include: recognizing the wave function as a probability distribution, the interpretation of the sketch of wave functions in regions with different potentials, distinguishing the wave functions from energy eigenstates, and mathematical difficulties involving the graphs of wave functions. This poster has two main parts. The first part discusses students' conceptual difficulties with the understanding of quantum wave functions. The second part explores students' mathematical difficulties with the representations of wave functions.

CP-49
Implementation of the Physics for Elementary Teachers Curriculum, a New Faculty s Perspective

Steven Sahyun (sahyuns@uww.edu), University of Wisconsin, Whitewater

Abstract: The Physics for Elementary Teachers (PET) course developed by San Diego State University s CPU project[1] was adopted at the University of Wisconsin Whitewater and taught during the 2004-2005 academic year. The course is a one-semester introductory physics curriculum that uses student-oriented pedagogy and activities designed to help students focus on the nature of science and on learning. This poster outlines the course adoption process from the perspective of a junior faculty member as well as some initial results for conceptual questions given to students pre-course adoption and during the course implementation.

[1] PET curriculum information located at http://petproject.sdsu.edu/

CP-50
Local consistency without global consistency in intermediate mechanics students

Eleanor C Sayre (eleanor.sayre@umit.maine.edu), *Michael C Wittmann* (wittmann@umit.maine.edu), University of Maine

Abstract: As part of ongoing research into cognitive processes and student thought, we have investigated mathematics intuitions in intermediate mechanics students enrolled in a reformed class which features both lecture and tutorial1 components. In the context of damped harmonic motion, students work though separation of variables using operator notation. Data suggest that students exhibit local consistency but not global consistency in their reasoning about differentials. The pattern of these inconsistencies between new ideas, a characteristic of many students at many levels, leads to differing proposed solution paths. We present data from a help session where students work on a homework problem.

[1] B.S. Ambrose. 'Investigating student understanding in intermediate mechanics: Identifying the need for a tutorial approach to instruction.' Am J Phy 72, 453 (2004).

CP-51
Teaching General Physics in an accelerated course format

Nataliya Serdyukova (nserdyuk@nu.edu), National University

Abstract: There is a growing need in teachers of science and Physics in particular. A changing paradigm of adult learning and a demand for faster and shorter educational programs bring to life new methodological approaches for teacher preparation. Accelerated college level programs provide quality learning outcomes by compressing traditional semester-long courses into one-month long courses. This presentation discusses factors affecting the efficiency and delivery of General Physics instruction in an accelerated undergraduate program. An Iterative Instructional Model is presented as an effective methodological tool.

CP-52
Preliminary Testing of Physics Problem-Solving Self-Efficacy Instrument

Kimberly Shaw (kshaw@siue.edu), Southern Illinois University Edwardsville

Abstract: Self-Efficacy is a person's belief in their own abilities to accomplish a given task. As self-efficacy is often strongly correlated with performance on that same task, it offers an interesting avenue for exploring student successes and failures in our classroom (where those successes do not always correlate with ability). In the physics literature [1], work has focused on Bandura's [2] four dimensions of performance accomplishment, social persuasion, vicarious learning and emotional arousal. The Mathematics Self-Efficacy Scale-Revised [3] has three domains, focusing on solution of problems, completion of everyday math tasks, and completion of coursework. This study consists of a pilot instrument for self-efficacy in physics problem solving, with data taken in three phases: student self-efficacy rating on mechanics problems; open ended questions of those same problems; and interviews. Preliminary data will be presented.

[1] H.Fencl and K.Scheel, 2003 Phys.Ed.Res.Conf Proc. 720, ed. J.Marx, et.al.
[2] A.Bandura, Self-Efficacy, Freeman and Company, 1997.
[3] N.Betz and G.Hackett, J. Vocational Behavior, p329-345.

CP-53
Interactive Video Lectures in a Distance Learning Course for In-Service High School Teachers

Bruce Sherwood (Bruce_Sherwood@ncsu.edu), *Ruth Chabay* (Ruth_Chabay@ncsu.edu), North Carolina State University

Abstract: A distance learning version of the Matter & Interactions course [1] was successfully offered to in-service high school physics teachers. The goal was not to train teachers to teach this contemporary college curriculum in high schools but rather to enhance teachers' general culture in physics. A key component of the course was a complete set of interactive video lectures. Each lecture was segmented to end with a 'clicker' question, at which point there appeared on the teacher's screen a simulated clicker for the teacher to respond. After the response, the next video segment was shown, including the histogram of student responses shown and discussed in the original classroom. The effect was that the videos had much of the interactive character of the original lectures.

[1] See http://www4.ncsu.edu/~rwchabay/mi

CP-54
Improving Student Understanding of Quantum Mechanics

Chandralekha Singh (clsingh@pitt.edu), University of Pittsburgh

Abstract: We investigate the difficulties that advanced students have with the material covered in the upper-level undergraduate quantum mechanics. Our analysis is based upon tests administered to students from several universities and individual interviews with some students. We find a number of common difficulties and analyze the student responses in order to extract their origin. It is striking that most students shared the same difficulties, given both the variance in their background and the variety of teaching styles and textbooks. Analysis suggests that the widespread misconceptions originate from the tendency to over-generalize concepts learned in one context to another inappropriate context. We are designing and evaluating interacting tutorials to help improve student understanding.

Supported in part by the NSF award PHY-0244708.

CP-55

Student Understanding of Partial Differentiation in Thermal Physics

John Thompson (thompsonj@maine.edu), *Brandon Bucy Donald Mountcastle* University of Maine

Abstract: We are engaged in a research project to study teaching and learning in upper-level thermal physics courses. These courses are taken by third- and fourth-year undergraduate physics majors, and may include first-year graduate students. We have begun to explore student functional understanding of mathematical concepts when applied to thermal physics contexts. We report here on findings associated with total differentials and the Maxwell relations, which equate mixed second partial derivatives of various state functions. Our preliminary results suggest that students are often unable to apply the appropriate mathematical concepts and operations to the physical situations encountered in the course, despite having taken the appropriate prerequisite mathematics courses. Furthermore, many students have difficulties understanding either the mathematical or physical significance of the Maxwell relations even after instruction.

Supported in part by NSF Grant PHY-0406764

CP-56

Evidence of knowledge transfer in web-based physics tutor

Rasil Warnakulasooriya (rasil@mit.edu), *David Pritchard* (dpritch@mit.edu), Massachusetts Institute of Technology

Abstract: We demonstrate evidence of knowledge transfer using the data collected from the Socratic web-based tutor, Mastering Physics. We divide a class of ~400 students into two equally skilled groups, one of which is given a preparatory problem before a related problem. We show that the group that is being prepared by solving an immediate prior related problem gives 11.0 +/- 2.5% fewer incorrect answers, request 17.2 +/- 4.9% fewer hints, and were able to solve in 14.6 +/- 2.2% less time on a subsequent problem than the group that did not receive immediate prior training on that problem. The evidence is based on fourteen instances across seven different concept domains in a calculus-based Newtonian mechanics course at MIT.

CP-57

Student Self-Evaluation & Problem-Solving Performance

Aaron Warren (Aawarren@physics.rutgers.edu), *Alan Van Heuvelen* (Alanvan@physics.rutgers.edu), Rutgers University

Abstract: One of our goals when teaching introductory science courses is to help students become self-regulating learners. Towards this end, I have developed a set of activities to help students learn specific self-evaluation strategies, such as special-case analysis. These strategies allow the students to check, judge, and modify their own work. During the 2004/5 academic year, we conducted a comparison group study involving two large-enrollment algebra-based introductory physics courses. The goal of the study is to investigate whether the use of my activities can help students: (a) understand how and why to use self-evaluation strategies; (b) better understand the physics subject matter; (c) incorporate the use of self-evaluation strategies into their personal learning behavior. Results from the study will be presented and discussed.

CP-58

Different Views on Inquiry, A Survey of

Science and Mathematics Methods Course Instructors.

Thomas Withee (twithee@siue.edu), *Rebecca Lindell* (rlindel@siue.edu), Southern Illinois University Edwardsville

Abstract: The national science standards encourage the use of inquiry-based instruction to teach difficult scientific concepts. As part of a larger study to investigate teachers' views on the nature of inquiry-based instruction, a survey was administered to Science and Mathematics methods course instructors to determine their views on inquiry, as well as to explore the successes and difficulties associated with teaching this difficult concept. In addition, we wished to obtain their views on the 5 E's [1] method, an inquiry method specifically designed to promote conceptual change that is often taught as the method to utilize. Initial survey data suggests there are many different views among Science and Mathematics methods course instructors about the nature of inquiry. This poster discusses the difficulties encountered with the 5 E's and teaching inquiry-based methods to teachers.

[1] 5-E Instructional Model: Engage, Explore, Explain, Elaborate, Evaluate discussed in Biological Sciences Curriculum Study, Biological Perspectives, 1998, Dubuque, IA: Kendall Hunt

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CP-59
How general education students understand wave functions in quantum physics

Michael C. Wittmann (wittmann@umit.maine.edu), *Jeffrey T. Morgan* (jeffrey.morgan@umit.maine.edu),*Katrina Black* (katrina.black@umit.maine.edu), *R. Padraic Springuel*, University of Maine

Abstract: Students in a general education course at the University of Maine are asked to build on their studies of wave physics as they learn basic concepts of quantum physics. In addition, they use discussions of macroscopic particles and chance events to develop the concepts of probability. Course materials are adapted from several sources [1,2] or written in-house, and most ideas are introduced in a tutorial/laboratory setting. We gather data from ungraded pretests and examinations. In two years of instruction, we find that students with little or no mathematical background are able to reason about quantum physics situations and the Schrödinger equation qualitatively using graphical representations and simple rules of analysis. We present examples of students' reasoning about wave functions, probability, and potential energy diagrams for several bound state systems.

[1] L.C. McDermott et al., Tutorials in Introductory Physics (Prentice Hall, New York, 2004)
[2] M.C. Wittmann et al., Activity-Based Tutorials Vol. 2 Modern Physics (John Wiley & Sons, New York, 2005).

Sponsored in part by NSF grant DUE 0410895

CP-60
A Journey through Physics by Inquiry: From Student to Student Teacher

Maria Zahran (zahran.4@osu.edu), *Gordon Aubrecht, II* (aubrecht@mps.ohio-state.edu), The Ohio State University

Abstract: Zahran was an undergraduate student of Aubrecht in Properties of Matter from Physics by Inquiry [1]. She later became a student teacher for the same course. This poster presents aspects of her personal journey of discovery in the first class and some of her discoveries about student attitudes during her second Physics by Inquiry experience that will affect her when she becomes a teacher in middle school.

[1] L. M. McDermott, Physics by Inquiry, V. I (New York: Wiley, 1995).

CP-61
What Is Entropy? Assessing Advanced Undergraduate Performance Comparing Ideal Gas Processes

Brandon R. Bucy (brandon.bucy@umit.maine.edu), *John R. Thompson* (John_Thompson@umit.maine.edu), *Donald B. Mountcastle* (donald.mountcastle@umit.maine.edu) University of Maine

Abstract: We are currently conducting a broad investigation of student understanding of thermodynamics concepts in advanced-level thermal physics courses. Here we discuss student understanding of the roles of entropy and the Second Law of Thermodynamics when comparing isothermal and free expansions of an ideal gas. Our preliminary investigation has revealed ways in which

students think about these topics both before and after instruction in advanced thermodynamics. In addition to a basic unfamiliarity with the concept of entropy, student difficulties include confusion about how to apply the 2nd Law to various processes, and an inability to apply the state function property of entropy when necessary.

Supported in part by NSF Grant PHY-0406764.

CP-62
Building a community for physics education research

Vincent H. Kuo (hvkuo@ncsu.edu), *Robert J. Beichner* (Beichner@ncsu.edu), North Carolina State University

Abstract: This poster serves as a progress report on the development of the Physics Education Research - Community Enhancing Network for Teaching, Research And Learning project (PER-CENTRAL) and the Physical Review Special Topics – Physics Education Research journal (PRST-PER).

The PER-CENTRAL website <http://www.compadre.org/PER/> is 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, grant opportunities, and many other things of interest to our community. PER-CENTRAL is provided by the American Association of Physics Teachers, and is supported, in part, by the National Science Foundation and their National Science Digital Library Initiative.

The PRST-PER journal <http://prst-per.aps.org/> is a peer reviewed electronic-only journal. The scope of the journal is the full range of experimental and theoretical research on the teaching and/or learning of physics. Review articles, replication studies, descriptions of the development and use of new assessment tools, presentation of research techniques, and methodology comparisons/critiques are also welcome. PRST-PER is sponsored by the American Association of Physics Teachers and the American Physical Society's Forum on Education

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CP-63
(Not) Motivating Changes in Student Behavior with Extra Credit

Scott Bonham (Scott.Bonham@wku.edu), Western Kentucky University

Abstract: Completing assigned homework is an important factor for student success in introductory physics. Starting work on assignments well in advance of the deadline results in higher homework scores, providing opportunity for more time-on-task and obtaining needed assistance. In this experiment, one group of students in an introductory algebra-based course were offered additional credit for completing homework in advance of the deadline as an incentive to work on homework early. Data from WebAssign logs and survey responses were analyzed as to the effectiveness of this strategy. No discernable effect was observed. An explanation suggested by the data is that the extra credit merely re-enforced existing motivation of some students to do well on the homework rather than significantly changing student motivation.

Instructions for Presenters

Contributed Poster Presenter Instructions

Preparation

- Your poster must occupy an area **no larger than 4 feet x 4 feet**.
- We **will provide** you with **poster boards and thumb tacks or push pins**.
- There will be **no table** available for you to place any computer or demonstration equipment at the poster.
- There will be **no electrical power** source near your poster. So, if you need to use your laptop, please make sure it is fully charged before the session.

Display

- Please put up your poster between 6:00-8:00pm on Wednesday, August 10 in Union Ballroom.
- Each poster has been assigned a code and a specific spot in the room. (See last page of Program). Please determine from the Presenter List in this program (or by doing a search on the website) the code (e.g. CP-11) that your poster has been assigned and put up the poster in the spot indicated for that code on the room layout (See last page of Program).
- Please **put up your poster in your assigned spot alone**. *If you need to change that spot please do so after informing one of the PERC Organizing Committee members*
- ***Post-deadline Poster Presenters***: We strongly discourage post-deadline submissions. However, if you are a post-deadline submitter we have spots marked with an **X** in the room layout (See last page of Program). Please choose one of the spots marked with an **X** on the layout.
- Typically you are sharing your 8 feet wide x 4 feet high poster board with another presenter. If you arrive to put up your poster first, please be sure to leave room for the poster that shares the board with you.

Exhibiting

- Please ensure that either you or one of your co-authors is at your poster as follows:
  - If your poster is **odd numbered** (e.g. CP-**21**), then please be at your poster for the **first hour** i.e. from **8:00-9:00PM**.
  - If your poster is **even numbered** (e.g. CP-**08**), then please be at your poster for the **second hour** i.e. from **9:00-10:00PM.**
- In addition the Contributed Poster Session, we hope that the posters will be available for viewing all of Thursday, August 11 especially during the breaks. We strongly urge you to keep your poster up until you leave the conference.

Targeted Poster Presenter Instructions

Preparation

- Each poster must occupy an area **no larger than 8 feet wide x 4 feet high**.
- You will be provided with as many poster boards as there are posters in your session, so that each poster can have one full poster board.
- You will be provided with thumb tacks or push pins and an overhead projector, but **no** computer projector.

Display

- Each Targeted Poster Session has a dedicated room. Although your session will meet twice during the day, you do not need to take down your poster until your second session meeting.
- We strongly urge you to put up your poster on Wednesday night, or early Thursday morning.
- You will be provided with as many poster boards as there are posters in your session. You may move these around as you wish into an arrangement that you most prefer. A suggested arrangement is to have the poster boards arranged around the room, with one side (that is not used) of each board against the wall, and the other side facing the audience.

Presentation

In presenting your session, please keep the following guidelines in mind

1. The first 20-25 minutes for the discussant (organizer) to present the overarching theme and for the individual poster presenters to briefly describe their research that speaks to this theme.
2. For the next 40-45 minutes, participants walk around the room and interact with individual poster presenters. Please urge the participants to take the opportunity to circulate around the room and view all of the posters.
3. The last 20 minutes will be a panel discussion led by the discussant.

Workshop Presenter Instructions

- Please prepare materials for about 50-60 participants for each of your two sessions.
- You will be provided with a computer projector and any other special equipment or services that you requested (e.g. flip chart, tables, wireless internet etc.)
- Please inspect the room by Wednesday, August 10 and make sure that it meets all of your requirements.

PERC2005 Presenter List

Last Name, First Name	Participating Events
Acar, Omer	[CP-27]
Adams, Wendy	[CP-01][CP-40]
Adams, Paul	[CP-23]
Adrian, Brian	[TP-B3]
Allain, Rhett	[CP-02]
Ashcraft, Paul	[CP-03]
Aubrecht, Gordon	[CP-04][CP-15][CP-30][CP-35][CP-60]
Bao, Lei	[CP-15][CP-27][CP-35][CP-48][W-B]
Bennett, Andrew G.	[CP-11]
Berrah, Norah	[TP-A3]
Beuckman, Joseph	[CP-05]
Black, Katrina	[CP-59]
Blue, Jennifer	[CP-06]
Bober, Kendra M.	[TP-C4]
Bonham, Scott	[CP-63]
Braun, Greg	[CP-17]
Brookes, David	[CP-07]
Bucy, Brandon	[CP-55]
Calder, Austin	[CP-08]
Cervenac, John	[TP-C2]
Chabay, Ruth	[CP-16][CP-53]
Churukian, Alice D.	[CP-09]
Corpuz, Edgar	[CP-10]
Cui, Lili	[CP-11]
Dancy, Melissa	[CP-12][CP-22]
Danielsson, Anna	[CP-13]
De Leone, Charles	[CP-14]
Demaree, Dedra	[CP-04][CP-15][CP-30]
Ding, Lin	[CP-16]
Dubson, M.	[TP-A2]
Dykstra, Dewey	[W-C]
Endorf, Robert	[CP-17]
Engelhardt, Paula V.	[CP-09]
Escalada, Lawrence	[TP-B2]
Etkina, Eugenia	[CP-07][CP-18][CP-25][CP-46]
Finkelstein, Noah	[CP-26][CP-28][CP-40][CP-41][TP-A][TP-A2]
Fletcher, Peter R.	[CP-19][CP-45][CP-31][CP-43]
Foster, Thomas	[TP-C3]

Last Name, First Name	Participating Events
Frank, Brian	[CP-39]
Franke, Douglas	[TP-C3]
Gire, Elizabeth	[CP-14]
Gratny, Mindy	[CP-40]
Greenbowe, Tom J.	[CP-34]
Hagedorn, Eric. A	[CP-20]
Harlow, Danielle	[CP-21]
Harper, Kathleen	[TP-C2][W-A]
Heckler, Andrew	[CP-05][TP-C2]
Hein, Warren	[TP-A4]
Henderson, Charles	[CP-12][CP-22][TP-A3]
Hernandez, Cecilia	[TP-B4]
Heron, Paula R. L.	[WDS]
Himmelfarb, Harold	[Luncheon Banquet Speaker]
Hodapp, Ted	[Invited Talk 2][TP-A]
Hrepic, Zdeslav	[CP-23]
Kalita, Spartak	[CP-24]
Kanim, Stephen	[CP-39]
Karelina, Anna	[CP-25]
Keller, Christopher	[CP-26][TP-A2]
Kim, Yeounsoo	[CP-27]
Knouse, Bill	[CP-32]
Koenig, Kathleen	[CP-17]
Kohl, Patrick	[CP-28]
Kung, Rebecca	[CP-29]
Layman, John	[TP-A4]
Lin, Yuhfen	[CP-04][CP-15][CP-30]
Lindell, Rebecca	[CP-05][CP-58][TP-C][TP-C1][TP-C3]
Lising, Laura	[TP-A][TP-A1]
Loverude, Michael	[CP-39]
Malina, Eric	[TP-C1]
Mamolo, Charles	[CP-31]
Marx, Jeff	[CP-32]
McDermott, Lillian C.	[Keynote Speaker][WDS]
McKagan, Sarah	[CP-33]
Meltzer, David E.	[CP-34]
Messina, Donna	[WDS]
Moeller, Julia	[TP-B2]
Moin, Laura	[TP-B1]
Montenegro, Maximiliano	[CP-35]
Morgan, Jeffrey T.	[CP-36][CP-59]
Mountcastle, Donald	[CP-55]
Murthy, Sahana	[CP-18][CP-25]

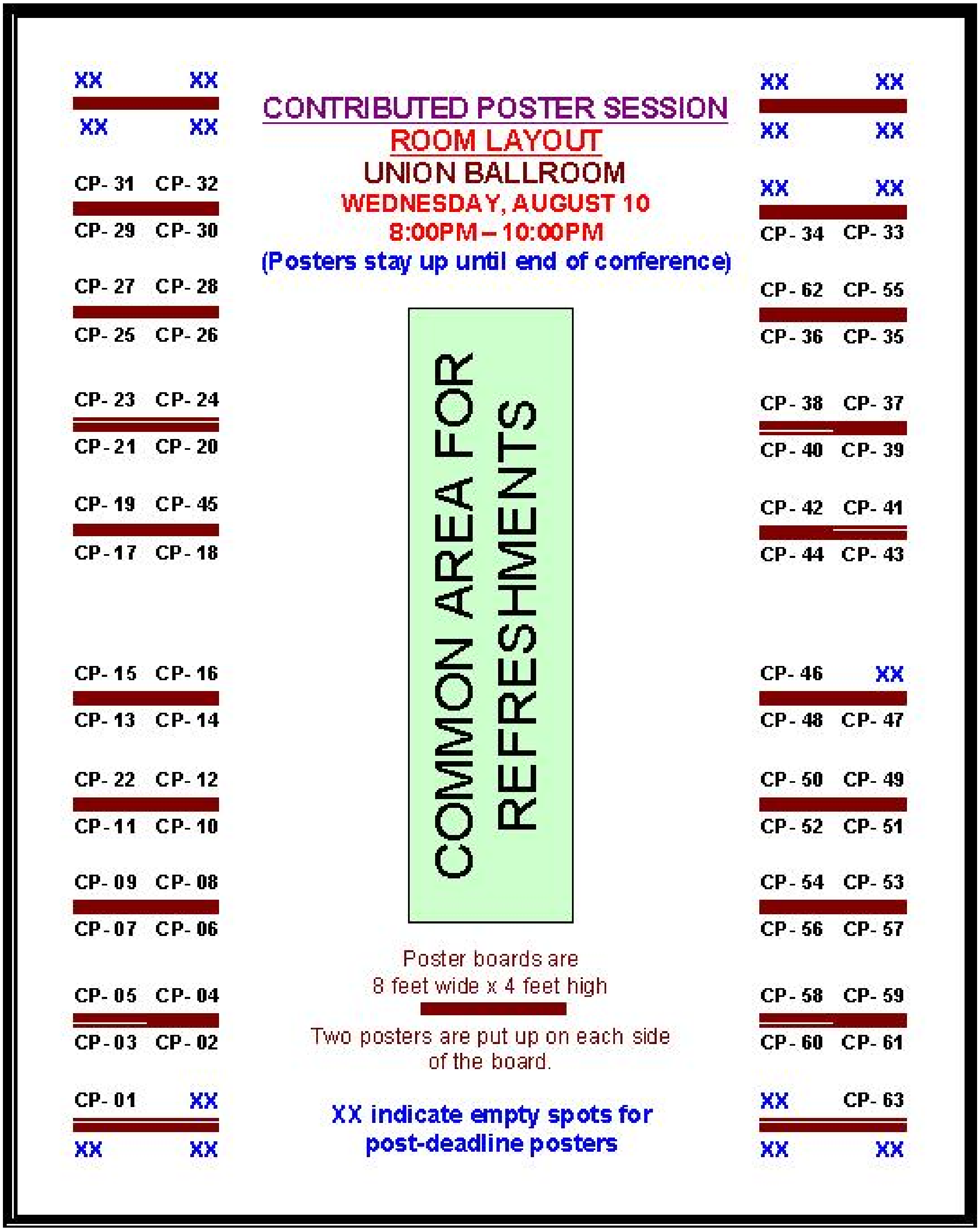
Last Name, First Name	Participating Events
Neakrase, Jennifer	[CP-37]
Omasits, Christopher	[CP-38]
Ortiz, Luanna G.	[CP-39][CP-37]
Otero, Valerie	[CP-21]
Otero, Valerie	[Invited Talk 1][TP-A2]
Paulius, Lisa	[TP-A3]
Peak, Elizabeth	[TP-C3]
Perkins, Katherine	[CP-26][CP-40]
Plunk, Denise	[TP-C1]
Podolefsky, Noah	[CP-41]
Poel, Bob	[TP-A]
Pollock, Steven	[CP-26][CP-42][TP-A2]
Poltera, Carina	[CP-43]
Potter, Wendell	[CP-44]
Pritchard, David	[CP-56]
Pritikin, Gloria	[CP-47]
Reay, Neville	[W-B]
Rebello, N. Sanjay	[CP-10][CP-11] [CP-19][CP-31] [CP-43][CP-45]
Rosario, Maria	[CP-25]
Rosengrant, David	[CP-46]
Rosenthal, Alvin	[TP-A3]
Sabella, Mel	[CP-47]
Sadaghiani, Homeyra	[CP-48]
Sahyun, Steven	[CP-49]
Sandifer, Cody	[TP-A1]
Sayre, Eleanor C	[CP-50]
Schunn, Chri	[TP-B1]
Serdyukova, Nataliya	[CP-51]
Shaffer, Peter S.	[WDS]
Shaw, Kimberly	[CP-52]
Sherwood, Bruce	[CP-16][CP-53]
Singh, Chandralekha	[CP-54][TP-B][TP-B1]
Spears, Jaqueline	[TP-B4]
Springuel, R. Padraic	[CP-59]
Stevens, Scott	[TP-B3]
Talbott, Nancy	[CP-23]
Thompson, John	[CP-55]
Thornton, Ron	[Invited Talk 3]
Tirocchi, Lisa	[TP-A1]
Turpin, C.	[TP-A2]
Urquhart, Mary L.	[TP-C4]
Van Heuvelen, Alan	[CP-46][CP-57]
Villasenor, Ruibal	[CP-25]
Wagner, DJ	[CP-38]

Last Name, First Name	Participating Events
Warnakulasooriya, Rasil	[CP-56]
Warren, Aaron	[CP-57]
Wieman, Carl	[CP-01][CP-33][CP-40]
Withee, Thomas	[CP-58][TP-C3]
Wittmann, Michael C.	[CP-36][CP-50][CP-59]
Zahran, Maria	[CP-60]
Zeller, Jason	[CP-23]
Zollman, Dean	[CP-24][TP-B3]
Zou, Xueli	[CP-04][CP-30]

Contributed Poster Room Layout

Union Ballroom

Contributed Poster Presenters: Please put up your poster on the board assigned to you.



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