# Table of Contents



***Additional Information, email addresses, etc. can be found at: http://www.compadre.org/PER/perc/browse.cfm***

# Invited Talks

***Wednesday, July 23rd***

3:30 PM
JA.01

ETLC
E1-001

**Inequities in Physics Access and Enrollment in Urban High Schools**
*Angela Kelly, Lehman College, ANGELA.KELLY@lehman.cuny.edu*

Despite reports to the contrary, the availability of physics as a course for secondary students is not equitably distributed throughout the U.S. While some schools provide physics access for all, a more common scenario is limited availability to select students. This is particularly true in urban districts, where this study examined access to and availability of high school physics. New York City's secondary schools were surveyed to determine where physics was offered and how many students were enrolled. Statistics were performed to compare differences between physics and non-physics schools. Additionally, organizational factors were examined that relate to physics availability, such as the magnet school configuration, the AP Physics and conceptual physics options, and science curricular sequence. Overall, it was determined that physics availability is limited in NYC schools, a serious inequity that disproportionately affects students of color and poor children. Strategies for improving access and enrollment will be discussed.

4:00 PM
JA.02

ETLC
E1-001

**A Race-identity Perspective on Mathematics Learning and Participation**
*Danny Martin, University of Illinois – Chicago, dbmartin@uic.edu*

I discuss how race and identity have emerged as primary considerations in my research and teaching. This program spans twenty years and has focused on mathematics learning and participation among African American adults and adolescents in school and non-school contexts. While mainstream mathematics education research has conceptualized learning and participation as cognitive and cultural activities, my work pushes these perspectives to consider mathematics learning and participation as racialized forms of experience; that is, as activities structured by the larger relations and discourses of race that exist in the broader society. For many African American learners, African American identity has served as a marker for degradation in mainstream research and policy contexts. Meanwhile, the concept of race has remained under theorized. One consequence is a widely accepted, yet uncontested, racial hierarchy of mathematical ability that constructs African American learners as mathematically illiterate relative to other learners. My work challenges these constructions.

4:30 PM
JA.03

ETLC
E1-001

**Impact of Chemistry Teachers' Knowledge and Practices on Student Achievement**
*Kathryn Scantlebury, University of Delaware, kscantle@UDel.Edu*

Professional development programs promoting inquiry-based teaching are challenged with providing teachers content knowledge and using pedagogical approaches that model standards based instruction. Inquiry practices are also important for undergraduate students. This talk focuses on the evaluation of an extensive professional development program for chemistry teachers that included chemistry content tests for students and the teachers and the impact of undergraduate research experiences on college students' attitudes towards chemistry. Baseline results for the students showed that there were no gender differences on the achievement test but white students scored significantly higher than non-white students. However, parent/adult involvement with chemistry homework and projects, was a significant negative predictors of 11th grade students' test chemistry achievement score. This talk will focus on students' achievement and attitude results for teachers who are mid-way through the program provide evidence that on-going, sustained professional development in content and pedagogy is critical for improving students' science achievement.

---

7:00 PM
DT.01

Dinwoodie
Lounge

**Fostering Science Learning in Diverse Urban Settings**
*Kenneth Tobin, Graduate Center of the City University of New York, ktobin@gc.cuny.edu*

A common approach to the teaching of science is to create learning communities around sameness. In such circumstances students who differ from the mainstream are disadvantaged and often are regarded as learning disabled. This paper presents research on the uses of cogenerative dialogue to afford the creation of learning communities in which difference is respected and regarded as a resource for advancing learning of the collective as well as individuals within the collective. I describe what we learned from a five-year longitudinal authentic ethnography in which cogenerative dialogues were used in high schools in the Bronx Borough of New York City to create productive learning environments in which student achievement increased equitably for categories defined by ethnicity, class and native language. The route toward higher achievement was paved by expanded roles for science teachers and students. The ways in which these roles were enacted are described in the paper.

## Thursday, July 24th

10:30 AM
IT.01
Telus 150

**What is Nepantla and How Might it Help Educational Researchers Conceptualize Knowledge for Teaching?**
*Rochelle Gutierrez, University of Illinois, Urbana-Champaign, rgutirrz@uiuc.edu*

This presentation draws on Latina/Latino studies to offer education a potential framework for reconceptualizing "knowledge" and for engaging teacher candidates in a process that acknowledges the complex identities of students and the power relations they negotiate while in school. Specifically, I use Gloria Anzaldúa's notion of Nepantla--a liminal space that facilitates transformation. In this presentation, I will describe aspects of a model of teacher education I have developed and offer examples of how teacher candidates move through states of what Anzaldúa would call ignorance/distancing versus knowledge/connection with others. Finally, I suggest that our work of preparing teachers must help them not only recognize a state of Nepantla (to see and participate in multiple realities) but also come to expect the uneasiness with being in that space, while celebrating its potential to birth new identities and create new (forbidden) knowledges.

11:00 AM
IT.02
Telus 150

**A Variety of Diversity: Facing Higher Education's Educational Challenges**
*Eric Dey, University of Michigan, dey@umich.edu*

First among the many important challenges facing American higher education is the need to improve the effectiveness of our educational programs. Public concern has heightened the sense of urgency for colleges and universities to make progress on improving and measuring educational outcomes, which is made more challenging by the varieties of diversity facing us. Students are more diverse than ever, both in terms of their personal characteristics but also in terms of their abilities, preparation, and expectations.

In order to make sense of the increasing varieties of diversity affecting our postsecondary educational efforts this session will draw upon research from a range of local and national efforts in these areas. One example is ongoing research at the University of Michigan that explores the educational implications of implementing a web-based lecture capture system in large lecture courses. Student use of and reactions to such systems is important, as is the potential to influence course performance for students in general, but also for underrepresented and at-risk student subpopulations. In addition to helping bring our current landscape into focus, the session will identify effective practices as well as continuing challenges to improving educational practice for undergraduate students.

---

## Invited Speaker Biographies

**Eric L. Dey** is Associate Professor in the Center for the Study of Higher and Postsecondary Education and Special Advisor to the Dean for Research on Undergraduate Teaching and Learning at the University of Michigan School of Education. Dey's research is concerned with the ways that colleges and universities shape the experiences and lives of students and faculty. The central concern of this work is in identifying the influence that different institutional characteristics (e.g., admissions policies, student quality, curricular requirements, and faculty teaching approaches) have on individuals, and the degree to which these influences are dependent on the evolving context within which the enterprise of higher education operates. His current work falls at the intersection of student interests and faculty practices, and is focused on diversity and technology issues.

**Rochelle Gutiérrez'** research focuses on equity in mathematics education, race/class/language issues in teaching and learning, effective teacher communities, and social justice. Her current research projects include: teacher community and secondary mathematics teaching in México, developing pre-service teachers' knowledge and disposition to teach powerful mathematics to marginalized students, and the notion of "Nepantla" as it relates to teaching. Dr. Gutiérrez has served as a member of the RAND National Mathematics Study Panel, the National Academy of Sciences' Committee on Increasing Urban High School Students' Engagement and Motivation to Learn, and the board of directors of Society for Advancement of Chicanos and Native Americans in Science (SACNAS). She was awarded a Fulbright fellowship to study secondary mathematics teachers in Zacatecas, México, and is currently part of a PME working group on Transnational/Borderland Research in Mathematics Education. Her work has been published in such journals as *Mathematical Thinking and Learning, Journal of Curriculum Studies, Journal for Research in Mathematics Education, American Educational Research Journal*, and the *Urban Review*. Before and throughout graduate school, she taught middle and high school mathematics to adolescents in East San José, California.

**Angela Kelly** is an Assistant Professor and Coordinator of the Graduate Program in Science Education at Lehman College, City University of New York. She received a B.A. in Chemistry from La Salle University; and M.A., M.Phil., and Ph.D. degrees in Science Education, as well as an Ed.M. degree in Curriculum and Teaching, from Teachers College, Columbia University. She previously taught high school physics and chemistry, and also worked as an industrial chemist. While developing her teaching practice, she implemented pedagogical strategies that promoted physics accessibility to a broader range of students. This experience greatly influenced her current research, which examines inequities in physics opportunities for urban youth. This year, she has published findings in *The Physics Teacher*, and she recently presented her work on Capitol Hill, and at NARST, AERA, the Acoustical Society of America, the AIP Liaison Committee on Underrepresented Minorities, and the National Association of Black Physicists. She resides in South Orange, NJ, with her husband and five children.

**Danny Martin** is an Associate Professor at the University of Illinois at Chicago where he holds a joint appointment in the College of Education and the Department of Mathematics, Statistics, and Computer Science. Martin is currently Chair of the Department of Curriculum and Instruction in the College of Education. His primary research area is mathematics education with a particular focus on African American learners. He publishes on topics ranging from race, identity, socialization, and policy in mathematics education. He teaches mathematics content and methods courses in the undergraduate elementary education program and mathematics education courses in the Ph.D. program in Curriculum and Instruction. Prior to coming to UIC, Martin was Instructor and Professor in the Department of Mathematics at Contra Costa College for 14 years and Chair from 2001-2004. He was a National Academy of Education/Spencer Foundation Postdoctoral Fellow from 1998-2000. He is author of the book *Mathematics Success and Failure Among African Youth*, published in 2000 (Erlbaum), and editor of the forthcoming book *Mathematics Teaching, Learning, and Liberation in African American Contexts* (Routledge).

**Kathryn Scantlebury** is a professor in the Department of Chemistry and Biochemistry and Coordinator for Secondary Science Education in the College of Arts and Sciences at the University of Delaware. She taught high school chemistry, science, and mathematics before completing her doctorate at Purdue University. Her research interests focus on equity issues, especially related to gender, in various aspects of science teacher education, including urban education, preservice teacher education, and teachers' professional development. Dr. Scantlebury serves on the editorial boards of Cultural Studies of Science Education and Research in Science Education and is co-editing a book on women in science education.

**Kenneth Tobin** is Presidential Professor of Urban Education at the Graduate Center of the City University of New York. Among many awards he has received are *The Distinguished Contributions to Science Education through Research Award* from NARST (2007) and the *Distinguished Teaching Scholar Award* from NSF (2004 ). He does research on teaching and learning science in urban schools. He edited *Teaching and Learning Science; Doing Educational Research* (with Joe Kincheloe); and *Improving Urban Science Education* (with Rowhea Elmesky and Gale Seiler). With Wolff-Michael Roth he co-authored *Teaching to Learn* and *The culture of science education: Its history in person*. Ken has supervised more than 40 doctoral students in science education and maintains active collaborative links with them. Also, he collaborates actively with numerous post docs and junior colleagues with the goal that they too will become mentors for new science educators—taking seriously a responsibility to expand the infrastructure to support high quality science education.

# Invited: Targeted Poster Sessions

***Thursday, July 24th***

8:30 AM
Telus 217
&
1:15 PM
Telus 217

TP.A**: Implementing PER in Other Cultures**

*Organizers:*

*Dewey Dykstra, Boise State University, ddykstra@boisestate.edu*
*Andy Johnson, Black Hills State University, andyjohnson@bhsu.edu*

It is not obvious to what extent PER findings with English-speaking students apply to students from other cultures in other parts of the world and vice versa. Some PER community members have experience that shed light on this issue, which includes anticipations concerning initial conceptions, typical student responses to PER-based instructional strategies, preparation and understanding of teachers, and lack of resources available to teachers to a degree not generally seen in the US. Experiences, evidence, lessons learned and recommendations will be offered by the presenters in this targeted poster session.

TP.A01: **Using PER Materials and Technology with Teachers of the Very Poor in Bangalore**

*Ronald K. Thornton, Tufts University*

Physics education research has shown that learning environments that engage students and allow them to take an active part in their learning can lead to large conceptual gains compared to traditional instruction. Although curricular materials and real-time data collection tools developed by the Activity-based Physics group have been used all over the world there was some question whether such materials would be useful to teachers in Bangalore who teach the very poorest children. The Parikrma Foundation runs four schools near four of Bangalore's worse slums and serves more than 800 children. The science teachers from the schools attended a two-week activity-based workshop where they used real-time data collection and explored multiple curricula. Interactive Lecture Demonstrations (ILDs) using real-time data logging were emphasized since they would be teaching in a one-computer classroom. This poster describes the workshop experience. Equipment was donated by Vernier International.

TP.A02: **Similarities and Differences in Ideas Generated by Students of Physics: US College Students vs. Tibetan Buddhist Monks.**

*Andy Johnson, Black Hills State University*
*Dewey Dykstra, Boise State University*
*Hunter Close, Seattle Pacific University*
*Mel Sabella, Chicago State University*

We have used PER-based course materials to teach various physics topics to Tibetan Buddhist monks over the last four years. While listening to the monks' ideas through interpreters, we found some striking similarities with ideas that we hear in our own classrooms in the US. However, the degree of similarity of monks' ideas with those of US students varied with the topic. For example, ideas that emerged in the topic of magnetism were often consistent with western ideas while ideas about color addition were sometimes strikingly different from ideas that American students use. The monks' ways of talking lead us to believe that cultural background partially determines how they think initially about particular physics topics. This poster will give examples of similarities and of differences, and attempt to identify reasons for both.

TP.A03: **Making Sense of Measurements, Making Sense of the Textbook**

*Saalih Allie, University of Cape Town, South Africa*
*Dedra Demaree, Oregon State University*
*Julian Taylor, University of Cape Town, South Africa*
*Fred Lubben, University of York, UK*
*Andy Buffler, University of Cape Town, South Africa*

Students entering the special access course in physics at the University of Cape Town generally do not speak English as first language and have experienced poor science teaching. As a consequence they experience a range of difficulties in a number of areas related to learning physics. We discuss research carried out in two such areas (a) understanding of measurement and (b) engagement with the textbook. With regard to (a), an overview of the methodology, analysis framework and findings of previous work will be presented together with more recent preliminary findings regarding audience dependence when conveying measurement results. With regard to (b), the idea of writing chapter summaries was used to guide students through the book with the aim that the textbook would come to be valued as an accessible resource. Findings from the analysis of the student summaries and their attitudes toward summary writing will be presented.

TP.A04: **Experiences Sharing PER in Mexico**

*Dewey Dykstra, Boise State University*

Sharing work in PER in other countries can take several forms. Conferences, workshops, and publications are possibly the most accessible places to start. Several challenges are often encountered: language, working conditions, availability of technology, different systems of preparation of teachers, access to the literature of our field. In spite of the differences in language, many clues as to their thinking about the phenomena present themselves, in particular body language and non-verbal communication. This poster will illustrate how these challenges have played out in the experience of one PER community member sharing PER in Mexico.

TP.A05: **New Research from Cross Culture Studies**

*Lei Bao, The Ohio State University*
*Tianfang Cai, Beijing Jiaotong University*
*Kathy Koenig, Wright State University*

Student content knowledge and general reasoning abilities are two important areas in education practice and research. In this paper, we report one study of a systematic research to investigate the possible interactions between students' learning of physics content knowledge and the development of general scientific reasoning abilities. Specifically, this study seeks to answer the research question of whether and to what extent content learning may affect the development of general reasoning abilities. College entrance testing data of freshman college students in both USA and China were collected using three standardized tests, FCI, BEMA, and Lawson's Classroom Test of Scientific Reasoning (Lawson Test). The results suggest that years of rigorous training of physics knowledge in middle and high schools have made significant impact on Chinese students' ability in solving physics problems, while such training doesn't seem to have direct effects on their general ability in scientific reasoning, which was measured to be at the same level as that of the students in USA.

8:30 AM Telus 219 & 1:15 PM Telus 219

TP-B: **Does PER-based Instruction Help Underrepresented Groups Succeed, and How Can It Do So Better?**

*Organizer:*

*Catherine H. Crouch, Swarthmore College, ccrouch1@swarthmore.edu*

An issue of widespread concern among physicists is the low representation of women and certain ethnic minorities in physics. As PER seeks to improve physics learning for all, we must ask whether PER-based instructional methods can also help ameliorate (or at least not aggravate) the under-representation of these groups. This poster session will facilitate a forward-looking discussion of how PER-based instruction can best foster the success of these groups by bringing together insights from work in three areas: (1) evaluating the success of underrepresented students with PER-based methods, (2) identifying barriers to these students' success in ordinary instructional environments, and (3) existing programs (not necessarily PER-based) aimed at improving the retention and learning of these underrepresented groups. After work in these three areas is presented and discussed, all attendees will participate in brainstorming future work that will identify strengths and weaknesses in the current PER-based methods, with the ultimate goal of developing improved instructional methods.

TP.B01: **The Persistence of the Gender Gap in Introductory Physics**

*Steven Pollock, University of Colorado at Boulder*
*Lauren Kost, University of Colorado at Boulder*

We previously showed [1] that despite teaching with interactive engagement techniques, the gap in performance between males and females on conceptual learning surveys persisted from pre- to posttest, at our institution. Such findings were counter to previously published work [2]. Subsequent work [3] suggested the gender gap may be attributable to differences in physics background. Our current work analyzes factors that may influence the observed gender gap in our courses. We find that there are significant differences ($p<0.05$) between males and females on several measures of math and physics preparation, as well as attitudes about physics. Posttest conceptual assessment data are modeled using both multiple regression and logistic regression to estimate the gender gap in posttest scores after controlling for these prior factors. We find that at our institution the gender gap persists in interactive physics classes, but is largely due to differences in physics and math preparation and attitudes.

[1] Pollock, et al, Phys Rev: ST: PER 3, 010107. [2] Lorenzo, et al, Am J Phys 74, 118. [3] Kost, et al, PERC Proceedings 2007, 137.

TP.B02: **Gender Differences in Both Force Concept Inventory and Introductory Physics Performance**

*Kenneth Heller, University of Minnesota*
*Jennifer Docktor, University of Minnesota*

We will present data from a decade of introductory calculus-based physics courses for science and engineering students at the University of Minnesota taught using cooperative group problem solving. The data include 40 classes with more than 5500 students taught by 23 different professors. The average normalized gain for males is 0.4 for these large classes that emphasized problem solving. Female students made up approximately 20% of these classes. We present relationships between pre and post FCI scores, course grades, and student background factors for females and males. Examples of background factors include major, high school physics, and math preparation. We will compare our results with previous studies from Harvard [1] and the University of Colorado [2]. Our data show there is a significant gender gap in pre-test FCI scores that persists post-instruction although there is essentially no gender difference in course performance as determined by course grade.

[1] M. Lorenzo, C.H. Crouch, and E. Mazur, "Reducing the gender gap in the physics classroom," Am. J. Phys. 74(2), 118-122 (2006).
[2] S.J. Pollock, N.D. Finkelstein, and L. E. Kost, "Reducing the gender gap in the physics classroom: How sufficient is interactive engagement?" Phys. Rev. ST Phys. Educ. Res. 3, 010107 (2007).

TP.B03: **Gender and Student Achievement with Peer Instruction**

*Catherine Crouch, Swarthmore College*
*Mercedes Lorenzo, IES Universidad Laboral, Albacete, Spain*
*Jessica Watkins and Eric Mazur, Harvard University*

We investigated the effect of physics education research-based teaching methods on the gender gap in conceptual understanding in introductory physics. We analyzed data from the introductory calculus-based mechanics course for non-majors at Harvard University taught traditionally and taught with different degrees of interactive engagement. On average, female students have lower Force Concept Inventory (FCI) pretest scores than males. Teaching with Peer Instruction not only yields significantly greater FCI posttest scores for both males and females but also reduces the FCI posttest gender gap. Teaching with several interactive components (Peer Instruction, Tutorials in Introductory Physics, and Just-in-Time Teaching) eliminates the FCI posttest gender gap, and no gender disparity exists in grades, in spite of females' lower FCI pretest scores. We also analyzed data from the algebra-based mechanics course; although the gender gap reduction is not as pronounced as in the calculus-based course, interactive teaching also reduces the gender gap.

TP.B04: **Gender Differences in Student Responses to Peer Instruction**

*Jessica Watkins, Harvard University*
*Eric Mazur, Harvard University*

Laws, et al. [1] found that upper-year female students responded the most negatively to Workshop Physics. Our recent study on student responses to Peer Instruction also found that females rated these methods more negatively, even when controlling for precourse beliefs and expectations. In this poster I will present student interview data exploring the differences between male and female responses to both traditionally-taught and PI-taught introductory physics courses.

[1] Laws, et al. (1999) Am. J. Phys. 67, S1.

TP.B05: **Improving Learning for Underrepresented Groups in Introductory Physics for Engineering Majors**

*Suzanne White Brahmia, Rutgers University*

The Extended Physics program at Rutgers University has been successfully improving the learning and degree completion of students from groups underrepresented in STEM majors (science, technology, engineering and mathematics) for nearly 20 years. This poster will target what we are doing to address the issues known to contribute to the low representation of women and some ethnic minority groups, with an emphasis on the importance of discipline-specific reforms in attaining equitable representation in STEM professions. We have diversified assessment in the program and will present information on assessment instruments we've developed that help us measure whether or not we are reaching our goals.

TP.B06: **Learning and Success in Introductory Physics for Black Science Students in the Post-Apartheid Era**

*Saalih Allie, University of Cape Town, Cape Town, South Africa*

Participation and success rates of black students at universities in South Africa are still very low compared to their white counterparts, particularly in mathematics and science, due to general economic disadvantage and a lack of qualified teachers and resources at high schools. The General Entry to Programmes in Science (GEPS) at the University of Cape Town is designed to increase the number of black students enrolling for a science degree and maximize their chances of graduating. Students in this program spend an extra year during which they participate in a number of "intensive" science courses including physics. The physics course is designed around three areas: "in context" mathematical techniques, problem-solving laboratories, and scientific writing skills. The physics course covers half of the material that is covered in the regular physics course after which students complete the remaining material in their second year at a similar pace to the regular students.

TP.B07: **Enhancing the Number of African Americans in STEM PhD Programs: Meyerhoff Scholarship Program Outcomes, Processes, and Individual Predictors**

*Kenneth I. Maton, University of Maryland Baltimore County*
*Mariano R. Sto Domingo, University of Maryland Baltimore County*
*Kathleen E. Stolle-McAllister, University of Maryland Baltimore County*
*J. Lynn Zimmerman, University of Maryland Baltimore County*
*Freeman A. Hrabowski, III, University of Maryland Baltimore County*

This study examines the outcomes, processes, and individual predictors of pursuit of a STEM PhD among African-American students in the Meyerhoff Scholarship Program. Meyerhoff students were nearly five times more likely than comparison students to pursue a STEM PhD. Program components consistently rated as important were financial scholarship, being part of the Meyerhoff Program community, the Summer Bridge program, study groups, staff personal advising, and summer research opportunities. Furthermore, focus group findings revealed student internalization of key Meyerhoff Program values, including a commitment to excellence, accountability, group success, and giving back. In terms of individual predictors, multinomial logit regression analyses revealed that Meyerhoff students with higher levels of research excitement at college entry were more likely to pursue a STEM PhD than those pursuing a medical degree, a master's or allied health degree, or no post-college education in STEM.

8:30 AM
Telus 236
&
3:00 PM
Telus 217

TP-C: **Developing Learning Skills in the Physics Classroom to Attend to Diverse Populations**

*Organizers:*
*Edit Yerushalmi, Weizmann Institute of Science, yerushalmi@vms.huji.ac.il*
*Chandralekha Singh, University of Pittsburgh, clsingh@pitt.edu*

Physics Instructors believe many students enter their classes lacking the learning skills required to perform well in the introductory physics course. Yet traditional university teaching typically does not attempt to develop students' learning skills required to benefit from the physics course.

An essential skill mentioned frequently is reflection in problem solving while carrying out a paper pencil task or while performing an experiment. Reflection upon the problem solving process in both types of tasks could include evaluating one's own solution, self-diagnosing former steps while elaborating the understanding of the physics involved in the problem, as well as the perception that such behavior is constructive. How do students entering the introductory physics classroom differ in their reflection in problem solving? To what extent does this distribution of skill predict students' ability to learn the material taught in the course? Does this skill improve as the students progress through traditional university courses which typically do not attempt to develop students' learning skills? How can we modify instruction to help develop these learning skills in students who need it while also benefiting the students who already possess these learning skills?

The posters in the session will shed light on diverse aspects of the subject as follows: (1) the connection between learning skills and the achievements of the students in class, (2) instructors' approaches regarding the development of these skills, (3) students' epistemic stance regarding learning from problem solving both while performing paper pencil tasks and performing experiments, and (4) possible interventions aimed to help students reflect upon the problem solving process in different situations.

TP.C01: **From Diagnostic Skills to Success in the Physics Classroom**

*Edit Yerushalmi, Wiezmann Institute of Science*
*Elisheva Cohen, Wiezmann Institute of Science*
*Andrew Mason , University of Pittsburgh*
*Chandralekha Singh, University of Pittsburgh*

"Self-diagnosis tasks" aim at fostering diagnostic behavior by explicitly requiring students to present diagnosis as part of the activity of reviewing their problem solutions. The recitation classes in an introductory physics class (~200 students) were split into three experimental groups in which different levels of guidance was provided for performing the self-diagnosis activities and a control group. We have been investigating how a) students in each group performed on subsequent near and far transfer questions given as part of the exams; and b) comparing the relation between student's initial scores on their quizzes vs. their performance on the exams, and the relation between student's self-diagnosis scores and their performance on the exams.

We conclude with some hypotheses about the students' ability to self-diagnose that emphasizes the importance of teaching students how to diagnosis their own mistakes.

Supported by ISF 1283/05 and NSF DUE-0442087

---

TP.C02: **Strategy Writing and Conceptual Gains Among At-Risk Physics Students**

*Adam D. Smith, University of Illinois, Urbana Champaign*
*Gary Gladding, University of Illinois, Urbana Champaign*
*Jose Mestre, University of Illinois, Urbana Champaign*
*Robert Putman, University of Illinois, Urbana Champaign*

Many novice physics students studying mechanics, particularly those at risk for poor performance, do not attend to the physical principles behind the particular equations they use to solve problems. This leads to the well-known novice behavior of preoccupation with the surface features of a problem rather than the cueing on deep conceptual structure exhibited by experts. A small subset (N=50) of students pre-identified to be at risk for failing an introductory calculus-based physics class (N~1100) participated in a concurrent supplemental course designed to promote conceptual awareness and use in solving problems. The supplement requires students to explicitly identify the operative physical principle needed to solve the problem, provide a short justification explaining what features of the problem imply the principle is applicable, create a written procedure for solving the problem using said principle, and finally generate a fully worked solution with written explanations of each step. We will discuss performance in: a) a problem categorization task involving sorting problems by operative physical principle and b) examinations in the introductory course.

---

TP.C03: **Helping Students Develop Scientific Habits of Mind**

*E. Etkina, Rutgers University*
*A. Karelina, Rutgers University*
*M. Ruibal-Villaseno, Rutgers University*

This poster will describe the iterative process of the development of curriculum that focuses on helping students develop scientific abilities while constructing physics knowledge. The central idea of the curriculum is formative assessment and self-assessment, which were found to be the most powerful interventions to improve student learning. Formative assessment, done through specially designed rubrics, not only provides feedback to the students but most importantly provides feedback to instructors. Rubrics used for research purposes allow us to document student progress, their difficulties, and to subsequently revise curriculum materials. We will provide the details of the curriculum development and examples of student work that show how their learning changes from year to year as we improve the materials.

---

TP.C04: **Reflective Problem Solving Skills are Essential for Learning, But it is Not My Job to Teach Them**

*Charles Henderson, Western Michigan University*
*Edit Yerushalmi, Weizmann Institute of Science*
*Elisheva Cohen, Weizmann Institute of Science*
*Vince Kuo, University of Minnesota*
*Ken Heller, University of Minnesota*
*Pat Heller, University of Minnesota*

Students in introductory physics courses are expected to learn physics content through the process of solving problems. In an interview study with six university physics faculty, we have identified an important conflict in the way that they view problem solving in the context of an introductory course. Three important findings will be described in this poster: 1) physics instructors believe that student learning in a physics course primarily occurs when students generalize and refine their physics knowledge by reflectively solving physics problems; 2) physics instructors realize that most students do not possess the skills necessary to engage in reflective problem solving when they enter an introductory physics course; and 3) physics instructors do not expect and do not intervene to make students improve their reflective problem solving skills during the introductory physics course. Suggestions will be made for how to help instructors resolve the conflict represented on one hand by their (correct) assessment that students do not have the skills necessary to engage in the primary learning activity of the course and on the other hand by their pessimistic estimation of students' ability to improve in these very skills.

---

TP.C05: **Collaborative Diagnosis of Scientific and Pedagogical Conceptions: A Strategy for Training Preservice Teachers**

*Osnat Eldar, Weizmann Institute of Science*
*Bat-Sheva Eylon, Weizmann Institute of Science*
*Miky Ronen, Weizmann Institute of Science*

One of the important skills of teaching is the ability to follow closely the students' conceptual understanding and to respond accordingly with appropriate instruction. This poster is concerned with the design and study of Collaborative Diagnosis of Conceptions (CDC), an instructional strategy aimed at developing pre-service teachers' deep understanding of content and at the same time develop their pedagogic content knowledge about ways to interact in the future with their students' conceptual understanding using a similar instructional strategy. The CDC strategy was tried out and studied in a geometrical optics course with a total of 123 pre-service elementary science teachers from multicultural backgrounds (rural Bedouin communities and multicultural urban communities).
The results of the study show that the pre-service teachers, in particularly the low achieving students, advanced significantly in their understanding of the optical concepts. However, only after we added a meta-cognitive component requiring the pre-service teachers to discuss and explicate, continuously, the pedagogical characteristics of the strategy, they also advanced significantly in their understanding of the pedagogical merit of this strategy.

8:30 AM Telus 238 & 3:00 PM Telus 219

TP-D: **It Works There. Will it Work Here?**

*Organizers:*
*Karen Cummings, Southern Connecticut State University, cummingsk2@southernct.edu*

This targeted poster session will focus on projects involving the use and/or adaptation of exemplary curricular materials at a wide variety of institutions. We will report on our successes, difficulties and insights gained in transplanting locally successful research-based materials and approaches.

TP.D01: **Lessons from the Adaptation and Implementation of a Non-Traditional Introductory Physics Course**

*Charles De Leone, California State University, San Marcos*
*Catherine Ishakawa, University of California, Davis*
*Edward Price, California State University, San Marcos*

This poster reports on lessons learned from an adaptation of a non-traditional introductory calculus-based physics course for students in the biological sciences. The poster will propose criteria for a successful adaptation/implementations, and then provide an analysis of how this particular adaptation and implementation met those criteria. Lastly, the poster will explore how these results suggests practices that may improve the chances of further successful implementations of this particular curriculum.

TP.D02: **Curriculum Design for the Algebra-based Course: Just Change the d's to Deltas?**

*Michael Loverude, California State University-Fullerton*
*Steve Kanim, New Mexico State University*
*Luanna Gomez, Buffalo State College*

The PIs have been involved in an NSF-funded project to develop materials for the introductory mechanics laboratory. The materials are based on the instructional approach taken in Tutorials in Introductory Physics (curriculum developed in the context of the calculus-based course at the University of Washington). While the materials being developed are intended for the algebra-based course, at many universities the labs are common to the two courses. As a result, we have been looking at differences in performance between these two student populations. In this poster, we describe the differences we have observed, especially as related to graphs, proportional reasoning, and algebra. It turns out that you cannot just change the d's to Deltas--who knew? We will discuss implications for instructors and for curriculum developers.

Supported in part by the National Science Foundation through grants DUE-0341333, -0341289, and -0341350.

TP.D03: **Adaptations of the Physics By Inquiry Curriculum: Part I-Tips for Successful Implementation and Conceptual Learning Outcomes**

*Karen Cummings, Southern Connecticut State University*
*Leon Hsu, University of Minnesota*
*Jack W. Taylor, Baltimore City Community College*

This poster is a companion to the one by Hsu. In this presentation, we report on a collaborative investigation into ways in which the Physics by Inquiry (PbI) curriculum (by McDermott and the PEG at the University of Washington) can be implemented by utilizing undergraduate peer instructors in large enrollment courses serving student populations other than the one in which it was originally intended. Typically, PbI is implemented in small classes of pre-service teachers with multiple instructors. However, many institutions, including community colleges and primarily undergraduate institutions, have various implementation constraints. We present three models for implementation of the PbI curriculum as responses to our local constraints at the University of Minnesota, Southern Connecticut State University and Baltimore City Community College. We will also report on conceptual learning outcomes in these courses.

This work was supported by NSF DUE-0410804, DUE-0433736 and DUE-0410839

TP.D04: **Adaptations of the Physics By Inquiry Curriculum: Part II-Assessing Shifts in Student Attitudes**

*Leon Hsu, University of Minnesota, Twin Cities*
*Karen Cummings, Southern Connecticut State University*
*Jack W. Taylor, Baltimore City Community College*

This poster is a companion to the one by Cummings. It focuses on an assessment of student attitudes toward physics and the learning of physics using the Colorado Learning Attitudes about Science Survey (CLASS). In virtually all standard introductory physics courses, students' responses to CLASS questions regress toward less expert-like attitudes or at best, remain largely stable over the time frame of the course. However, in our adapted PbI courses, we observe large, significant shifts toward more expert-like attitudes based on students' responses.

This work was supported by NSF DUE-0410804, DUE-0433736 and DUE-0410839

1:15 PM Telus 236 & 3:00 PM Telus 236

## TP-E: Applications of PER in Diverse Settings: Perspectives on Audience, Method and Implementation

*Organizer:*
*Eric Brewe, Florida International University, eric.brewe@gmail.com*

Physics education research has traditionally not addressed variation in student population. Are the tools, practices, and findings of PER relevant, applicable and valid across populations? This session includes four PER groups working with underrepresented student populations differing by audience, method and implementation. Brewe, Kramer and O'Brien at Florida International University, a Hispanic-Serving Institution, use reform to develop community; Sabella, Coble and Bowen of Chicago State University, a Black-Serving Institution, apply PER methods to identify underrepresented university students' resources; Finkelstein and Mayhew of the University of Colorado investigate impacts and institutional implications of informal education programs; Steinberg of City College of New York implements PER-based approaches as a science teacher at a mixed public high school in Harlem. These researchers are united by the goal of identifying problems within the structures of physics/science education relevant to encouraging student successes. These posters identify a diversity of approaches to improving educational opportunities for underrepresented student groups and limitations, challenges and opportunities for broadening inclusion.

### TP.E01: **Using Educational Reform as a Kernel for Growing Community at a Hispanic Serving Institution**

*Eric Brewe, Florida International University*
*Laird Kramer, Florida International University*
*George O'Brien, Florida International University*

In 2004 Florida International University (FIU) began a physics education reform effort by implementing Modeling Instruction in university physics classes and holding Modeling Workshops for high school teachers as a way to increase participation in physics by underrepresented students. By working at multiple levels, across high school and university, Modeling has become a common theme and has helped to establish a vibrant research and learning community. The primary and secondary effects of Modeling Instruction within FIU (improved intro physics experience and participation in a learning community) have spurred greater participation in physics and increased persistence. In this poster, we present the implementation of Modeling Instruction and discuss the impacts on the diverse population of students at FIU.

### TP.E02: **Utilizing the Individual and Collective Resources of Urban University Student to Develop an Effective Instructional Environment**

*Mel S. Sabella, Chicago State University*
*Kim Coble, Chicago State University*
*Samuel Bowen, Chicago State University*

Physics Education Researchers have provided instructors with (1) tools to assess student learning, (2) details on the state of student knowledge, and (3) instructional materials and learning environments that have proven to be effective in promoting understanding. Unfortunately, the vast majority of this work has centered on students and instruction at the traditional research university. As instructors begin to implement innovative instructional materials, and as researchers begin to investigate student learning with diverse populations, complex differences emerge. The use of traditional PER tools in non-traditional environments, such as the urban, comprehensive university, often leads to a very narrow picture of student development. Often, this limited view highlights deficiencies in learning and fails to reveal the strengths and resources of this population. In this poster we highlight some of the resources we have found with the population of students at urban institutions in Chicago. In addition, we describe how these resources have guided the implementation of a specific type of instructional approach.

### TP.E03: **Acting in Our Own Self-interest: Blending University and Community**

*Noah Finkelstein, University of Colorado at Boulder*
*Laurel Mayhew, University of Colorado at Boulder*

Research in physics education has demonstrated new tools and models for improving the understanding and engagement of traditional college students. [1] The research community has bridged the gap to pre-college education, even elementary school. [2] However little work has been done to engage students in out-of-school settings, particularly for those students from populations under-represented in the sciences. We present a theoretically-grounded model of university-community partnership [3] that engages students and children in a collective enterprise that has the potential to improve the participation and education of all. We document the impact of these programs on: university participants (undergraduates, graduates, and postdocs in physics) who learn about education, the community and even some science; children in the community who learn about science, the nature of science and develop the identities and attitudes towards science; and, shifts in institutional practice which may allow these programs to be sustained. We conclude by identifying some of the structural barriers to implementing and sustaining these programs.

[1] E.F. Redish, Teaching Physics with the Physics Suite ( Wiley, New York, 2003).
[2] F. Goldberg, S. Robinson, and V. Otero, Physical Science and Everyday Thinking, (Its About Time, Herff Jones Education Division, Armonk, NY, 2008).
[3] Cole, M. Cultural Psychology, Harvard University Press 2006.

### TP.E04: **Challenges Faced by a (White) Idealist Teaching Science in a Public High School in Harlem**

*Richard Steinberg, City College of New York*

After many years of conducting research into student learning of physics and implementing PER-based curricula in all kinds of settings and levels, I decided to spend my sabbatical as a full time science teacher at a public high school in Harlem, New York City. I went with enthusiasm and optimism, confident that my knowledge of student learning of science and my personality would translate to great student achievement. While I feel that I met with some success, in this poster I instead focus on the overwhelming challenges of succeeding in this environment. I will share my perspective of how these challenges are related to race, culture, and expectations (both mine and theirs). In addition, I will share how the focus on high stakes, low level testing drives so much of the instruction and frustration (more mine than theirs).

1:15 PM
Telus 238

&

3:00 PM
Telus 238

TP-F: **Showing Ourselves Friendly: Addressing Race in Physics Culture**

*Organizer:*
*Melissa H. Dancy, melissa.dancy@gmail.com*

It is said that if you want to be a friend, you must show yourself friendly. This means that in order to forge a connection, we must deal with our own actions rather than the actions of those we want to befriend. This year's PERC has been organized around issues of diversity, and this targeted poster session focuses specifically on issues of race. In order to show ourselves friendly in this context, we must examine our own behaviors and the effects they have on racial minorities. Each poster in this session offers us an opportunity to examine our own contributions to the racial aspects of physics culture. We hope that you will accept the invitation this opportunity extends, and share your ideas and experiences with us.

TP.F01: **Understanding Privilege: An Interactive Poster**

*Melissa H. Dancy*

We are accustomed to talking and thinking about diversity issues in terms of the –ism's such as racism, sexism, and classism. The -ism lens, which focuses our attention on those who are oppressed, obscures a broader understanding. Oppression can not exist without privilege. When one group is denied opportunity, there is necessarily another which is advantaged. Through the lens of privilege our focus is turned to those who benefit. This new lens allows for new understandings. In this interactive poster we will explore the concept of privilege.

TP.F02: **An Idea for generating Diversity Conversations: Physics Jeopardy and the "Future Faces of Physics" Kit**

*Gary White, Society of Physics Students - American Inst. of Physics*
*Kendra Rand, Society of Physics Students - American Inst. of Physics*

Is there a way to engage typical physics undergraduates in a conversation about under-represented groups in physics that doesn't result in rolled-eyes or fingers-in-the-ears? The Society of Physics Students has begun an experiment using a jeopardy-like game at physics meetings in an attempt to generate conversations about diversity. The physics jeopardy game is part of a "Future Faces of Physics" kit that includes a variety of materials that are of interest to those wanting to address under-represented audiences in physics, such as video clips exhibiting common physics words in sign language, tactile representations of the lunar surface for blind students, guidelines regarding lab procedures for the wheel-chair bound, and the book, "Einstein on Race and Racism" with a challenge letter directed at SPS chapters from the authors. While attempts to assess the impact of the game are modest, we will report anecdotally some of the qualitative features seen in the discussions when the game is played. We will also strive to indulge in a few physics jeopardy game moments during the poster session so that attendees get a sense of how the game works. If you are hosting a meeting, large or small, and would like to receive this kit for use at your meeting, notify Kendra Rand, SPS Program Coordinator at krand@aip.org.

TP.F03: **Inside the Golden Kingdom: Views of Physics from "Inside the Double Bind"**

*Apriel K. Hodari, National Society of Black Physicists*
*Maria (Mia) Ong, TERC*

The project, "Inside the Double Bind: A Synthesis of Literature on Women of Color in Science, Technology, Engineering, and Mathematics" (NSF/DRL # 0635577), synthesizes literature on women of color in STEM fields, specifically U.S.-born African Americans, Asian Americans/ Pacific Islanders, Chicanas/Latinas, Alaska Natives, and Native Americans. Rachel Ivie and Kim Nies Ray stated in 2005 [1], "[m]inority women especially represent a great, untapped resource that can be drawn on to increase the size of the scientific workforce," and this study seeks to address this serious problem by identifying challenges, strategies that work, and research gaps. In this poster, we will summarize findings from 8 empirical research papers and 10 personal narratives describing the experiences of women of color in physics. We will give priority to issues relating to the teaching and learning of physics, and our recommendations will center on practical advice for physics educators and education researchers.

[1] Rachel Ivie and Kim Nies Ray. Women in Physics and Astronomy, 2005. College Park, MD: American Institute of Physics, 2005.

TP.F04: **Proving Process: Minority High Achievers in the Classroom**

*Toyia K. Younger, University of Maryland at College Park*
*Sharon Fries-Britt, University of Maryland at College Park*

This study of 110 minority physicists is based on four years of data collection (2004-2008) with the National Society of Black Physicists and the National Society of Hispanic Physicists. Through individual interviews and focus groups the research team sought to understand the academic, social and racial experiences of the participants. The primary purpose was to understand the nature of their interactions with faculty and peers inside and outside of the classroom, their experiences in physics programs, their racial experiences and the extent to which they were motivated by race to succeed as a scientist. In this poster session I report findings on the "proving process" and students' experiences with faculty in the classroom.

# Contributed: Roundtable Discussions & PER Dating Service

***Thursday, July 24th***

8:30 AM
TELUS 145

RT-A: **Analyzing PSET for Content, Confidence and Comfort…So Why Don't You Want to Teach Physical Science?**

*Laura Van Wormer, Hiram College,* vanwormerla@hiram.edu
*Roxanne Sorrick, Hiram College*

Physical Science for Everyday Thinking is a guided inquiry approach to teaching physical science. Pre and post survey data was collected over two years from two courses using PSET. The course was taught in an intensive format at a small, private liberal arts college; at least half the students were education majors. The surveys assessed content knowledge and confidence in the answers, attitudes toward science and understanding of the process of learning science. Analysis indicated significant increases in content knowledge, confidence in content knowledge and comfort levels with physical science; also significant changes in identification as a science person, what is a fact, objectivity of scientists and science as a solitary pursuit. I'm interested in discussing why these changes occurred, why other ideas didn't change and what affects a willingness to teach K-8 physical science.

1:15 PM
TELUS 145

RT-B: **Learn "How to Teach Physics" from The Feynman Lectures on Physics: An Example from Gravitation**

*Gyoungho Lee, Seoul National University, ghlee@snu.ac.kr*
*Jiwon Kim, Seoul National University*

In order to better understand and teach physics, it would be beneficial teachers to understand the teaching structure of an outstanding physicist like Feynman. Feynman is well known for not only being one of the greatest physicists of the 20th century but also for being an excellent physics lecturer. Thus, we tried to analyze and identify the individual and holistic characteristics of The Feynman Lectures on Physics by using the framework of knowledge & belief. The results revealed that diverse knowledge & belief were integrated, and the storyline was well-organized in Feynman's lectures on gravitation. Furthermore, emphasis was placed on open investigation. Further research issues stemming from this result are discussed.

---

5:30 PM
TELUS
Atrium

DS.01: **Evaluating How Students View Questioning in the Physics Class**

*Geraldine Cochran, Chicago State University, moniegeraldine@gmail.com*
*Mel S. Sabella, Chicago State University*

CSU is looking to partner with other institutions to assess how students at diverse institutions view the use of questioning in the classroom. Specifically, we would like other institutions to administer a survey we have developed in which students comment on instructional episodes. We would like partners at:
(1) institutions similar to our own (minority serving, comprehensive) and (2) research universities with more traditional populations.

Research Question: Do students at different institutions view effective teaching differently? How do different populations view the use of guided inquiry in instruction?
Research Methods: Written survey.
Desired Audience: minority serving institutions, research universities

5:30 PM
TELUS
Atrium

DS.02: **Evaluating Safe Science Teaching Practice in the U.S.**

*Cathy Mariotti Ezrailson, University of South Dakota,* *Cathy.Ezrailson@usd.edu*

Science safety in is a vital issue in 2008 because: 1) it is tested on many state science content tests, 2) pre-service teachers take the Praxis test which also requires knowledge of safe science practice, 3) teachers are being trained in alternative ways that may omit safe science methods, 4) science content standards in many states emphasize doing science without specific safety guidelines, especially for middle and elementary classrooms and 5) science methods curricula have not always included planning for and conducting experiments safely. National Science Education Standards (NSES) encourage active science learning with "best practices" promoting inquiry-based and hands-on instruction at all instructional levels. Teachers who teach science are using equipment that may or may not be developmentally appropriate for their students (using open flames in K-2nd grade, for example). Accidents occur and go unreported. Based on a survey of practice in South Dakota schools, a national survey of science teaching practice K-12 is proposed.

Research Question: To this end I propose a study that will answer the following research questions:

1. Do U.S. teachers use correct (and safe) practices (as outlined in the National Science Teachers Association Guidelines and elsewhere) when teaching science?
2. What is the state of safety training for K-12 science teachers in South Dakota as well as nationally?
3. What are the key safety issues that face the classroom teacher and for which they MUST be trained? And, how do these vary by grade level?

4. How will K-12 teachers, when trained explicitly in safe science teaching practices, demonstrate learning of knowledge and skills of appropriate safety practices?
5. Will U.S. K-12 teachers, when trained explicitly in safe science teaching practices, apply those practices when teaching science in their classrooms?

Research Methods: Based on the preliminary results from the South Dakota Science Safety Survey field test, a national study is proposed that includes a mixed methods study that includes:

1. construction of a survey of practice;
2. a series of focus groups held around the country with common questions posed about safe science teaching practice and other safety issues;
3. semi-structured interviews to produce a snapshot of science practice in public schools.
   It would be useful to design this as a 5-year longitudinal study, adding locations to be surveyed each year.

Desired Audience: Possible collaborators, PER's, National, Regional and Local Government officials, university researchers, school administrators.

5:30 PM TELUS Atrium

**It's not too late – if you haven't submitted an abstract for the PERC Dating Service but you are interested in trying a study at a different institution, just show up.**

# Contributed: Posters

### *Wednesday, July 23rd*

### *8:00 PM – 10:00 PM*

***8:00 PM – 9:00 PM (even numbered posters present) and 9:00 PM – 10:00 PM (odd numbered posters present)***

TELUS Atrium *(posters may remain up until Thursday, 5:30 PM)*

| *Primary Author Last Name* | *Poster-ID* | *Title* |
|---|---|---|
| **Adams** | **719** | Identification of Specific Cognitive Processes Used for In-Depth Problem Solving |
| **Adams** | **726** | What Levels of Guidance Elicit Engaged Exploration with Interactive Simulations? |
| **Alarcon** | **769** | Implementing Tutorials in a Statistical Physics Course |
| **Atkins** | **777** | The Roles of Evidence in Scientific Argument |
| **Baily** | **720** | Student Understanding of Quantum Measurement and Uncertainty |
| **Bing** | **754** | Using Warrants as a Window to Epistemic Framing |
| **Blue** | **790** | Southwest Ohio Science Institutes: A Partnership Model for Professional Development |
| **Bonham** | **804** | Latent Response Times and Cognitive Processing on the FMCE |
| **Brookes** | **748** | The Specificity Effect: Implications for Transfer in Physics Learning |
| **Bucy** | **787** | Identifying and Addressing Partial Differentiation Difficulties in Calculus and Thermodynamics |
| **Byun** | **762** | Identifying Student Difficulty in Problem Solving Process via the Framework of the House Model(HM) |
| **Cerny** | **771** | Examples of Student Geometric Reasoning in Upper-Division E&M Problems |
| **Chasteen** | **718** | Assessing Student Understanding in Upper-Division Undergraduate Electricity & Magnetism I |
| **Christensen** | **747** | Assessing the Concepts of Integration and Differentiation in Multivariable Calculus |
| **Cochran** | **752** | Understanding and Encouraging Effective Collaboration in Introductory Physics Courses [1] |
| **Cummings** | **813** | A Study of Peer Instruction Methods with High School Physics Students |
| **Demaree** | **727** | Developing a Framework for Analyzing Student Summaries of Textbooks |
| **Dietz** | **802** | The Gender Gap on the FCI - Question by Question |
| **Ding** | **767** | Assessing the Effect of Single-Concept Clicker Sequences on Students' Learning |
| **Dominguez** | **779** | How Differentials are Taught in Mathematics and Used in Physics |
| **Duda** | **757** | Probing Student Online Discussion Behavior with a Course Blog in Introductory Physics |
| **Gallardo** | **751** | Applying Successful Techniques to Transform Physics and Astronomy in Urban Classrooms* |
| **Gire** | **795** | Resources Students Use to Understand Quantum Mechanical Operators |
| **Goertzen** | **729** | How TAs Infer Understanding from Student Responses |
| **Gray** | **717** | Analysis of Learning Assistants Views of Teaching and Learning |
| **Gupta** | **768** | Ontologies of Physics Concepts: A Toy Model |
| **Ha** | **785** | The Dynamics of Small Group Verbal Interaction: A Case Study in Mechanics Problem Solving |
| **Haynicz** | **812** | Students' Understanding of Inclined Planes Using the CoMPASS Curriculum |
| **Henderson** | **745** | Facilitating Change in Undergraduate STEM: Preliminary Results from an Interdisciplinary Literature |
| **Hinrichs** | **743** | Student Difficulty with Vector Field Notation in Upper Level E&M |
| **Ivanov** | **766** | Disentangling the Force Concept Inventory Using Latent Class Analysis |
| **Jones** | **798** | Pre-Service Teachers' Conceptual Understanding of and Attitudes toward Physics |
| **Koenig** | **749** | Targeting Student Success and Retention through Development of Scientific Reasoning Skills |
| **Kohl** | **808** | Studio Physics at the Colorado School of Mines: Studying the Implementation |
| **Kost** | **715** | The Persistence of the Gender Gap in Introductory Physics |
| **Lindell** | **806** | College Students' Lunar Phases Concept Domain |
| **Maier** | **753** | How Students Delineate "Force" from Other Terminology: Is There Change Following Instruction? |
| **Mariotti-Ezrailson** | **799** | A Design and Evaluation Study for Teaching Science Safely in South Dakota |
| **Marx** | **820** | Effect of Initial Conditions and Discussion on Predictions for Interactive Lecture Demonstrations |
| **Mason** | **724** | Identifying Differences in Diagnostic Skills between Physics Students: Developing a Rubric |
| **Mateycik** | **811** | Students' Use of Structure Maps to Facilitate Problem Solving in Algebra-Based Physics |
| **Mayhew** | **760** | New Media and Models for Engaging Under-Represented Students in Science |
| **McBride** | **772** | Examining Student Responses for Meaningful Understanding in the Context of Wavefront Aberrometry |
| **Monteyne** | **805** | An Investigation of Student Ability to Connect Particulate and Macroscopic Representations of a Gas |
| **Murthy** | **821** | Learning Problem-Solving Using Formative Assessment Rubrics |
| **Otero** | **791** | From Physics Major to Physics Teacher and From Elementary Teacher to Elementary Physics Teacher |
| **Paulson** | **721** | Research on Student Use of Simulations |
| **Podolefsky** | **758** | How Abstract is Abstract? Signs, Salience, and Meaning in Physics |
| **Pollock** | **711** | Comparing Student Learning with Multiple Research-Based Conceptual Surveys: CSEM and BEMA |
| **Pollock** | **763** | Student Understanding of P-V Diagrams and Conceptions about Integration |
| **Price** | **803** | Archiving Student Solutions with Tablet PCs in a Discussion-Based Introductory Physics Class |
| **Ramlo** | **731** | Student Perspectives on Learning Physics and Their Learning of Force and Motion Concepts |
| **Richards** | **788** | All Roads Lead to Palinscar and Brown |
| **Richards** | **789** | Which One is Right? How Students Choose between Problem Solutions |
| **Rodriguez** | **765** | Assessing Pre-Service Teachers Using an Interview Protocol Based on C-LASS |
| **Rosenblatt** | **759** | Toward a Comprehensive Picture of Student Understanding of Force, Velocity, and Acceleration |
| **Rosengrant** | **773** | Preliminary Study of Impulse-Momentum Diagrams |

| | | |
|---|---|---|
| **Ruibal-Villasenor** | **716** | What Happens when Students Design Their Own Experiments: Frames, Goals and Strategies |
| **Sabella** | **712** | Involving Undergraduate Researchers in PER |
| **Sadaghiani** | **796** | Physics Education Research with Diverse Student Populations |
| **Sawtelle** | **761** | Mind the Gap Please |
| **Sayre** | **764** | Student Response to Instruction: When and How Much? |
| **Singh** | **723** | Coupling Conceptual and Quantitative Problems to Develop Student Expertise in Introductory Physics |
| **Springuel** | **739** | The Difficulties in Turning Students into Numbers |
| **Tarabek** | **793** | Curricular Process and Communicative Conception in Physics Education |
| **Tarabek** | **794** | Triangular Model of Concept Structure |
| **Teodorescu** | **714** | A Taxonomy of Introductory Physics Problems (TIPP) |
| **Thompson** | **746** | Assessing Knowledge in a Graduate Course on PER |
| **Turpen** | **722** | Institutionalizing Change: Case Studies & Institutional Analysis of Pedagogical Reform in Intro Phys |
| **Undreiu** | **770** | Interactive Problem Solving Tutorials through Visual Programming |
| **Undreiu** | **792** | Reasoning Modes, Knowledge Elements, and Their Interplay in Optics Problem-Solving |
| **Van Domelen** | **732** | Gender Differences in Conceptual Physics Lab Technology |
| **Warren** | **750** | Network Analysis of Social Interactions in Laboratories |
| **Watkins** | **730** | Gender Differences in Student Responses to Peer Instruction |
| **Watkins** | **744** | Examining the Effectiveness of Clickers on Student Learning by Tracking Student Responses |
| **Wells** | **775** | Impact of the FIU PhysTEC Reform of Introductory Physics Labs |
| **Wook** | **756** | The Role of Inference in the Problem Solving about Friction |
| **Yerushalmi** | **725** | Identifying Differences in Self-Diagnosis with Alternative Scaffolding |
| **Zavala** | **780** | Evaluation of Instruction Using the Conceptual Survey of Electricity and Magnetism in Mexico |
| **Zavala** | **781** | Implementing Tutorials in Introductory Physics in an International Context: The Effect of Language |
| **Zavala** | **782** | Tutorials in Introductory Physics: A Mexican Experience |
| **Zavala** | **783** | An Investigation of the Concept of Vectors with College Students in Mexico |

CP.711: **Comparing Student Learning with Multiple Research-Based Conceptual Surveys: CSEM and BEMA**

*Steven Pollock, University of Colorado at Boulder, steven.pollock@colorado.edu*

We present results demonstrating similar distributions of student scores, and statistically indistinguishable gains on two popular research-based assessment tools: the Brief Electricity and Magnetism Assessment (BEMA) and the Conceptual Survey of Electricity and Magnetism(CSEM). To deepen our understanding of student learning in our course environment and of these assessment tools as measures of student learning, we identify systematic trends and differences in results from these two instruments. We investigate correlations of both pre- and post- conceptual scores with other measures including traditional exam scores and course grades, student background (earlier grades), gender, a pretest of scientific reasoning, and tests of attitudes and beliefs about science and learning science. Overall, for practical purposes, we find the BEMA and CSEM are roughly equivalently useful instruments for measuring student learning in our course.

CP.712: **Involving Undergraduate Researchers in PER**

*Mel S. Sabella, Chicago State University, msabella@csu.edu*

The physics program at Chicago State University (CSU) is currently involved in making major revisions to the introductory physics courses as a result of funding from the National Science Foundation - Course, Curriculum, and Laboratory Improvement (CCLI) Program. Underlying these revisions is a strong research component that seeks to assess the effectiveness of these instructional innovations. This project has involved over half the faculty in the Physics Program and over ten student researchers who received degrees or are currently pursuing degrees in science. These students have been involved in curriculum development, research on student learning, and work as laboratory and classroom facilitators. Because of the large scope of departmental involvement the project has evolved into a community endeavor in which both faculty and students play an active role in program innovations.

In this poster we discuss how undergraduates have been involved in the project and describe the benefits of involving science majors in education research.

Supported by NSF DUE-0410068, DUE 0632563, 0618128

CP.714: **A Taxonomy of Introductory Physics Problems (TIPP)**

*Raluca E. Teodorescu, George Washington University, rteodore@gwu.edu*
*Cornelius Bennhold, George Washington University*
*Gerald Feldman, George Washington University*

The existing collection of physics problems (both traditional and research-based) is becoming larger and more diverse. In order to be efficiently used in classroom settings a classification of these problems is needed. In the past few years we created a categorization of physics problems that establishes a connection between the physics problems, the type of declarative and procedural knowledge they involve and the cognitive processes they develop in students. This taxonomy is intended to be a valuable instructional resource for physics instructors which will enable them to select the problems used in their curricular materials based on the specifics of their students populations and the learning objectives they want to achieve for their class. This taxonomy will also provide a framework for creating physics-related assessments with a cognitive component. We will report on the design and validity and reliability studies that have been carried out during the development of this classification tool.

CP.715: **The Persistence of the Gender Gap in Introductory Physics**

*Lauren Kost, University of Colorado at Boulder, Lauren.Kost@colorado.edu*
*Steven Pollock, University of Colorado at Boulder*
*Noah Finkelstein, University of Colorado at Boulder*

Our previous research[1] showed that despite the use of interactive engagement techniques, the gap in performance between males and females on a conceptual learning survey persisted from pre- to posttest, at our institution. Such findings were counter to previously published work[2]. A follow-up study[3] suggested the gender gap may be more a result of differences in previous physics knowledge than gender. Current research continues to analyze factors that may influence the observed gender gap in our courses. We find that there are significant differences ($p<0.05$) between males and females on several measures of background understanding of math and physics, as well as attitudes about physics. The posttest data from conceptual assessments are modeled using two regression models (multiple regression and logistic regression) to estimate the gender gap in posttest scores after controlling for these prior factors. The results indicate that the gender gap exists in interactive physics classes at our institution, but is due in large part to differences in previous physics and math knowledge, and attitudes and beliefs.

[1]Pollock, et al, Phys Rev: ST: PER 3, 010107.
[2]Lorenzo, et al, Am J Phys 74, 118. [3]Kost, et al, PERC Proceedings 2007, 137.

---

CP.716: **What Happens when Students Design Their Own Experiments: Frames, Goals and Strategies**

*Maria Ruibal-Villasenor, Rutgers University, mruibal@eden.rutgers.edu*
*Anna Karelina, Rutgers University*
*Eugenia Etkina, Rutgers University*

Several reform curricula (such as the Investigative Science Learning Environment (ISLE)) incorporate design tasks under the assumption that by overcoming the challenges of the assignment, students would not only construct scientific concepts, but they will develop, as well, the abilities necessary to build new knowledge and solve new problems.
What happens when students have to generate their own procedures and conclusions? How do they frame these problems? How do they interact with each other and the material? To explore these issues, we video-recorded several student groups designing and conducting an experiment in an unknown topic and we analyzed these recordings using qualitative techniques.

---

CP.717: **Analysis of Learning Assistants Views of Teaching and Learning**

*Kara E. Gray, University of Colorado Boulder, kara.gray@colorado.edu*
*Valerie K. Otero, University of Colorado Boulder*

For several years the University of Colorado has been using undergraduate Learning Assistants (LAs) in their introductory science and math courses. While the LAs have teaching duties very similar to graduate Teaching Assistants (TAs), first year LAs are also required to take an education course focused on teaching methods. The purpose of this course is to first help LAs improve their teaching in the university classrooms and to encourage some of the LAs to consider careers as K-12 science teachers. Throughout the semester LAs are asked to reflect on their learning about teaching and on the applications of these concepts to their current teaching experience. This poster will present an analysis of this learning experience from the perspective of the LAs. The poster will also present how LAs evolve as teachers and as learners throughout this experience.

---

CP.718: **Assessing Student Understanding in Upper-Division Undergraduate Electricity & Magnetism I**

*Stephanie V. Chasteen, University of Colorado at Boulder, stephanie.chasteen@yahoo.com*
*Steven J. Pollock, University of Colorado at Boulder*

We apply the approaches of PER to a relatively under-studied population -- potential future physicists, or physics and astrophysics majors. We have investigated student understanding of upper-division Electricity & Magnetism I using a variety of approaches, including: student interviews, analysis of homework and exams, and performance on the Brief Electricity and Magnetism Assessment (BEMA) and a new content-specific post-course assessment test. We find persistent difficulties with conceptual understanding, which can hamper student success in choosing and implementing correct problem solving strategies. We compare student understanding after participation in two courses   a traditional course, and one reformed using principles of active engagement and learning theory. All course materials and evaluation tools are available for use by other instructors and researchers.

---

CP.719: **Identification of Specific Cognitive Processes Used for In-Depth Problem Solving**

*Wendy Adams, University of Colorado at Boulder, wendy.adams@colorado.edu*
*Carl Wieman, University of British Columbia*

The education and cognitive science literature contains a wide range of ideas about problem solving in math and science and the teaching of scientific problem solving. Neuroscience studies provide a rich source of information about how the brain works at the cellular level and the location of brain activity while using specific processes. We use the results of research in these fields to frame the 44 specific component processes that were identified while interviewing a wide range of people solving a wide range of in-depth problems during the development of the CAPS (Colorado Assessment of Problem Solving). Understanding the component processes used in problem solving provides insight for improved teaching. We will present ways that solvers can compensate for certain weaknesses, show stoppers (processes that are required to solve a problem) and provide a sampling of cognitive processes that are needed in the real world but are not taught in the classroom.

Supported in part by funding from National Science Foundation

---

CP.720: **Student Understanding of Quantum Measurement and Uncertainty**

*Charles Baily, University of Colorado at Boulder, baily@colorado.edu*
*Noah Finkelstein, University of Colorado at Boulder*

Introductory courses in classical physics appear to be promoting in students a perspective we are calling local realism, where, for example, it is assumed that a particle s position and momentum have simultaneous reality both physical quantities can be described with well-defined values at all times. Such a perspective can be problematic for introductory quantum physics students, who must develop new epistemic and ontological resources in order to properly interpret what it means to have knowledge of quantum observables. We document this evolution in student thinking in part through pre/post-instruction evaluations using the CLASS survey.[1] We further characterize variations in student epistemic and ontological commitments by examining responses to coupled essay questions and quantum attitudes statements. We find that, despite performance level in the course, many students are still exhibiting a realist perspective in some quantum contexts. We also find that this effect can be significantly influenced by instruction, where we observe variations for courses with differing learning goals.

[1] Adams, et al. "The design and validation of the Colorado Learning Attitudes about Science Survey," PERC Proceedings 2004.

CP.721: **Research on Student Use of Simulations**

*Archie Paulson, University of Colorado at Boulder, archie.paulson@colorado.edu*
*Kathrine Perkins, University of Colorado at Boulder*
*Wendy Adams, University of Colorado at Boulder*

The Physics Education Technology (PhET) project develops interactive, research-based simulations of physical phenomena that emphasize interactivity, animation, and real world connections. We are seeking a better understanding of how students learn from simulations (sims) in order to inform both simulation design and use. We find that the type of guidance provided to the student controls the amount of independent exploration and inquiry in which the students engage. It is common for teachers to create activities that include specific instruction on how to manipulate the sim, but too much instruction seems to limit the benefits of a complex simulated environment. We will report on our recent research in this regard, involving careful study of students' interaction with a few select sims. Results of this study improve our understanding of how students learn complex physical concepts using sims, and have implications for designing effective sim-based in-class activities, homework and labs.

CP.722: **Institutionalizing Change: Case Studies & Institutional Analysis of Pedagogical Reform in Intro Phys**

*Chandra Turpen, University of Colorado at Boulder, Chandra.Turpen@colorado.edu*
*Noah D. Finkelstein, University of Colorado at Boulder*

We examine how the University of Colorado has created a sustained use of a research-based curriculum in two courses simultaneously, despite the significant increases in cost and time commitment. The adoption of the research-based University of Washington Tutorials in Introductory Physics [1] curriculum required significant pedagogical shifts in the role of students, faculty and their interactions. We describe both successful and unsuccessful hand-offs of the curriculum to professors from traditional physics research disciplines.[2] Through faculty interviews, we capture a shift in how professors talk about this curriculum, as well as their views about teaching and learning physics before and after they implement the tutorial curriculum. We find that teaching with the Tutorial curriculum can result in shifts in professors' views about teaching and learning physics, although this does not always happen. We describe characteristics of the professor's participation in implementing this curriculum and in the professor's background in order to make sense of when we do and do not see shifts.

[1] L. C. McDermott and P. S. Shaffer, Tutorials in Introductory Physics (Prentice-Hall, Upper Saddle River, NJ, 2002).
[2] N. D. Finkelstein and S. J. Pollock, Replicating and understanding successful innovations: Implementing tutorials in introductory physics, Phys. Rev. ST Physics Ed. Research 1, 010101 (2005).

CP.723: **Coupling Conceptual and Quantitative Problems to Develop Student Expertise in Introductory Physics**

*Chandralekha Singh, University of Pittsburgh, clsingh@pitt.edu*

We discuss the effect of administering conceptual and quantitative isomorphic problem pairs (CQIPP) back to back vs. asking students to solve only one of the problems in the CQIPP in introductory physics courses. Students who answered both questions in an CQIPP often performed better on the conceptual questions than those who answered the corresponding conceptual questions only. Although students often took advantage of the quantitative counterpart to answer a conceptual question of an IPP correctly, when only given the conceptual question, students seldom tried to convert it into a quantitative question, solve it and then reason about the solution conceptually. Even in individual interviews when students who were only given conceptual questions had difficulty and the interviewer explicitly encouraged them to convert the conceptual question into the corresponding quantitative problem by choosing appropriate variables, a majority of students were reluctant and preferred to guess the answer to the conceptual question based upon their gut feeling.

CP.724: **Identifying Differences in Diagnostic Skills between Physics Students: Developing a Rubric**

*Andrew Mason, University of Pittsburgh, ajm54+@pitt.edu*
*Elisheva Cohen, Weizmann Institute of Science, Israel*
*Edit Yerushalmi, Weizmann Institute of Science, Israel*
*Chandralekha Singh, University of Pittsburgh*

Expert problem solvers are characterized by continuous evaluation of their progress towards a solution. One characteristic of expertise is self-diagnosis directed towards elaboration of the solvers conceptual understanding, knowledge organization or strategic approach. Self-diagnosis tasks aim at fostering diagnostic behavior by explicitly requiring students to present diagnosis as part of the activity of reviewing their problem solutions. We have been investigating how introductory physics students perform in such tasks.
Developing a robust rubric is essential for objective evaluation of students' self-diagnosis skills. We discuss the development of a grading rubric that takes into account introductory physics students' content knowledge as well as analysis, planning and presentation skills. Using this rubric, we have found the inter-rater reliability to be better than 80%. The rubric can easily be adapted to other problems.

Supported by ISF 1283/05 and NSF DUE-0442087

CP.725: **Identifying Differences in Self-Diagnosis with Alternative Scaffolding**

*Edit Yerushalmi, Weizmann Institute of Science, Israel, Edit.Yerushalmi@weizmann.ac.il*
*Elisheva Cohen, Weizmann Institute of Science, Israel;*
*Andrew Mason, University of Pittsburgh*
*Chandralekha Singh, University of Pittsburgh*

Self-diagnosis tasks aim at fostering diagnostic behavior by explicitly requiring students to present diagnosis as part of the activity of reviewing their problem solutions. We have been investigating the extent to which introductory physics students can diagnose their own mistakes when explicitly asked to do so with different levels of scaffolding support provided to them. In our study in an introductory physics class with more than 200 students, the recitation classes were split into three different experimental groups in which different levels of guidance was provided for performing the self-diagnosis activities. We will present our findings regarding how well students were able to self-diagnose their mistakes in the three experimental groups.

Supported by ISF 1283/05 and NSF DUE-0442087

CP.726: **What Levels of Guidance Elicit Engaged Exploration with Interactive Simulations?**

*Wendy Adams, University of Colorado at Boulder, wendy.adams@colorado.edu*
*Carl Wieman, University of British Columbia*

We became teachers because we want everyone to be able to see through science the elegance in nature as we do. Our instincts and years of training lead us to tell students about science and math as we understand it. Unfortunately research has shown that telling is not always the most effective way to share our understanding. Approximately 250 interviews have been conducted with simulations developed by the Physics Education Technology (PhET) Project [1]. These interviews have provided a wealth of data about student engagement and learning. We ve conducted interviews using several different levels of guidance and found that the level of guidance influences the amount of student engagement. Minimal but nonzero guidance with many of these simulations creates the optimum engaged exploration and impressive amounts of learning.

This work is supported in part by the National Science Foundation and the William and Flora Hewlett Foundation.

[1] phet.colorado.edu

CP.727: **Developing a Framework for Analyzing Student Summaries of Textbooks**

*Dedra Demaree, Oregon State University, demareed@science.oregonstate.edu*
*Michael Low, Oregon State University*
*Saalih Allie, University of Cape Town*

As part of an ongoing study to develop methods to do quantitative assessment of student writing and therefore measure the effectiveness of writing to learn, a framework was developed to analyze student textbook summary writing in physics. The framework was based on Waywood, which defines three cognitive levels seen in mathematics journaling: recounting (telling what happened), summarizing (putting it into your own words), and dialoging (sense-making). This framework was refined, expanded, and tested in the context of analyzing student textbook summary writing in introductory physics. The students participating in this study were enrolled in the 2007 spring semester of the Foundation Physics Course at the University of Cape Town, a component of the special access program which contains mostly second language English speakers.

[1] Waywood, A. (1992) Journal writing and learning mathematics, For the Learning of Mathematics, 12, 2, 34 - 43

CP.729: **How TAs Infer Understanding from Student Responses**

*Renee Michelle Goertzen, University of Maryland at College Park, goertzen@umd.edu*
*Rachel E. Sherr, University of Maryland at College Park*
*Andy Elby, University of Maryland at College Park*

Before we can develop effective, research-based professional development programs for graduate student physics TAs, we must first identify their current classroom practices and why they engage in these practices. Framing, a theoretical framework developed in sociology and linguistics, provides an analytical toolbox for examining the expectations that guide the actions and attention of individuals while teaching. We use framing to develop fine-grained analyses of two episodes of TAs teaching tutorials. Despite the differences in their behaviors, the two TAs are in a sense both doing the same thing; they organize their interactions with students around searching for indicators that the students understand the targeted ideas.

CP.730: **Gender Differences in Student Responses to Peer Instruction**

*Jessica Watkins, Harvard University, watkinsj@seas.harvard.edu*

Laws, et al. found that upper-year female students responded the most negatively to Workshop Physics. Our recent study on student responses to Peer Instruction also found that females rated these methods more negatively, even when controlling for precourse beliefs and expectations. In this poster I will present student interview data exploring the differences between male and female responses to both traditionally-taught and PI-taught introductory physics courses.

[1] Laws, et al. (1999) Am. J. Phys. 67, S1.

CP.731: **Student Perspectives on Learning Physics and Their Learning of Force and Motion Concepts**

*Susan Ramlo, The University of Akron, sramlo@uakron.edu*

Considerable research and curriculum development has focused on students' learning of force and motion concepts, yet research shows that many students fail to gain Newtonian-based understanding of force and motion concepts. Researchers have demonstrated the connection between learning in physics and students' personal epistemologies. Yet this research has typically used time intensive qualitative methods or Likert scale surveys which can result in loss of meaning. Thus this study used Q methodology, a sophisticated technique for determining the various perspectives on a topic by correlating people with similar views. Four distinct perspectives about learning physics concepts in a first semester physics classroom were revealed with Q. One of these four perspectives was positively correlated with the posttest scores on the Force and Motion

Conceptual Evaluation (FMCE) while the remaining perspectives were negatively correlated with the FMCE posttest scores. Implications of these results will be presented.

CP.732: **Gender Differences in Conceptual Physics Lab Technology**

*Dave Van Domelen, Kansas State University, dvandom@phys.ksu.edu*

Students in a conceptual physics laboratory course making extensive use of new technology were surveyed on a number of factual and affective topics as part of the ongoing revision of the course. The results were examined for gender differences, and very few were found.

CP.739: **The Difficulties in Turning Students into Numbers**

*R. Padraic Springuel, University of Maine, R.Springuel@umit.maine.edu*
*John R. Thompson, University of Maine*
*Michael C. Wittmann, University of Maine*

While the qualitative classification of student responses is often practiced within PER, quantitative methods open up a large set of analysis tools that are unavailable to qualitative methods. However, since PER data is based on student responses, there are often several difficulties that arise in taking those responses and turning them into quantitative measures. Using methods and tools from the field of classification (data mining), we look at how the type of question being asked (e.g., multiple choice, free response, ranking task) determines what kind of measurement can appropriately be made and how that in turn effects the mathematics of comparison. We also examine the extent to which, when using a hierarchical clustering method, the resolution of quantitative ties responses that are determined to be equidistant to more than one classification category leads to changes in the final classification.

CP.743: **Student Difficulty with Vector Field Notation in Upper Level E&M**

*Brant Hinrichs, Drury University, bhinrichs@drury.edu*

An upper level E&M course (i.e. based on Griffiths) involves the extensive integration of vector calculus concepts and notation with abstract physics concepts like field and potential. We hope that students take what they have learned in their math classes and apply it to help represent and make sense of the physics. This poster looks at how students in an upper level E&M course interpret (i) mathematical notation used to represent vectors and vector fields and (ii) diagrams used to represent vector fields. I present preliminary data from student interviews and paper and pencil worksheets that suggest some difficulties with interpretation are related to ambiguities in notation that are context dependent.

CP.744: **Examining the Effectiveness of Clickers on Student Learning by Tracking Student Responses**

*Erica P. Watkins, Chicago State University, ericapwatkins87@yahoo.com*
*Mel S. Sabella, Chicago State University*

Clickers have been used for a number of years to help create active learning environments in the lecture classroom [1,2]. Researchers have shown that clickers stimulate student-student and student-lecturer interaction. In addition, students value the use of clickers and feel that these devices contribute to their understanding [3]. Unfortunately, there are few research studies focusing on how knowledge is enhanced through their use.
To contribute to this body of research, we compared student responses on exam questions to similar or identical clicker questions presented during lecture. Analysis of the responses to clicker and exam questions show how individual student knowledge evolves during instruction. Although there is evidence of improvement during lecture, our results indicate that many students struggled when the questions were posed on exams. In this poster, we present the findings from this study and discuss how open-ended questions and interviews allow us to better understand how clickers are affecting our instructional environment.

Supported by NSF Grant #DUE-0618128

[1] N. W. Reay, L. Bao, P. Li, R. Warnakulasooriya, and G. Baugh, Toward the effective use of voting machines in physics lectures, Am. J. Phys., Vol. 73, No. 6, 554-558 (2005).
[2] N. W. Reay, P. Li, L. Bao, Testing a New Voting MachineQuestion Methodology, Am. J. Phys., Vol. 76, No. 2, 171-178 (2008).
[3] I. D. Beatty, W. J. Gerace, W. J. Leonard, and R. J. Dufresne, Designing effective questions for classroom response system teaching, Am. J. Phys. Vol. 74, No. 1, 31-39 (2006).

CP.745: **Facilitating Change in Undergraduate STEM: Preliminary Results from an Interdisciplinary Literature**

*Charles Henderson, Western Michigan University, charles.henderson@wmich.edu*
*Andrea Beach, Western Michigan University*
*Noah Finkelstein, University of Colorado at Boulder*
*R. Sam Larson, Kaiser Permanente and Regis University*

Although decades of research have identified effective instructional practices for improving Science, Technology, Engineering and Mathematics (STEM) education, these practices are not widely implemented. Scholars in three fields are interested in promoting these practices and have engaged in research on pedagogical change. Disciplinary-based STEM Education Researchers (SER) focus on changing curricula and pedagogical materials. Faculty Development Researchers (FDR) focus on changing faculty. Higher Education Researchers (HER) focus on policies and structures. There is little interaction between the fields and efforts in all areas have met with only modest success. We have systematically analyzed journal articles since 1995 related to instructional change to describe and critique the change efforts of these three fields. Results suggest that approaches to change differ by fields in important ways that have implications for their success. We hope this literature review and related efforts will result in improved interdisciplinary work towards the facilitation of lasting change.

CP.746: **Assessing Knowledge in a Graduate Course on PER**

*John R. Thompson, University of Maine, john.thompson@umit.maine.edu*
*Warren M. Christensen, University of Maine*
*Michael C. Wittmann, University of Maine*

The University of Maine Master of Science in Teaching program includes a pair of graduate courses entitled Integrated Approaches in Physics Education. The courses integrate understanding of different elements of physics education research (PER), including research into student learning, content knowledge (CK) from the perspective of how it is learned, and reform-based curricula together with published evidence of their effectiveness. Course elements include equal parts studying physics through proven curricula and discussion of research results from PER literature. As part of our course development, we are researching course participants understanding of content, pedagogy, and education research. We are also exploring assessment methods to analyze graduate student pedagogical content knowledge (PCK). Early findings indicate that the courses improve both CK and PCK. However, the improvement in these two arenas seems to be dependent on the background physics content knowledge of the student.

Supported in part by the Maine Economic Improvement Fund and the Maine Academic Prominence Initiative.

CP.747: **Assessing the Concepts of Integration and Differentiation in Multivariable Calculus**

*Warren M. Christensen, University of Maine, warren.christensen@umit.maine.edu*
*John R. Thompson, University of Maine*

Previous work on student understanding of graphical interpretation of slope, derivative, and area under curves in various physics contexts has shown substantial difficulties, most notably in kinematics. Concurrently, several reports point toward students lack of algebraic acumen as a likely cause for their low achievement in a physics classroom. In order to see if some of the documented issues arise from being asked mathematical questions about single- and multivariable calculus concepts in a physics course, we administered a brief survey on these basic concepts to students near the end of multivariable calculus. Some of the questions are based on our earlier work in thermal physics that are essentially stripped of their physics content. Initial findings show that even after three semesters of university-level calculus, students struggle with basic concepts of integration and differentiation. Individual survey items and summative scores will be presented.

Supported in part by NSF Grants PHY-0406764, REC-0633951, and the Maine Academic Prominence Initiative.

CP.748: **The Specificity Effect: Implications for Transfer in Physics Learning**

*David T. Brookes, University of Illinois at Urbana-Champaign, dbrookes@uiuc.edu*
*Brian H. Ross, University of Illinois at Urbana-Champaign*
*José Mestre, University of Illinois at Urbana-Champaign*

In physics instruction we often present students with an abstract principle, and then illustrate the principle with one or more examples. We hope that students will use the examples to refine their understanding of the principle and be able to transfer the principle to new situations. However, research in cognitive science has shown that students understanding of a new principle may become bound up with the example(s) used to illustrate it. We report on a study with physics students to see if this specificity effect was present in their reasoning. The data show that even students who understand and can implement a particular physics principle have a strong tendency to discard that principle when the transfer task appears superficially similar to their training example. The implications of this effect for transfer and expertise will be discussed.

CP.749: **Targeting Student Success and Retention through Development of Scientific Reasoning Skills**

*Kathleen Koenig, Wright State University, kathy.koenig@wright.edu*
*Melissa Schen, Wright State University*
*Doug Bradley-Hutchison, Sinclair Community College*
*Michele Wheatly, Wright State University*

SM 101, Scientific Thought and Method , was designed to target students interested in majoring in science but who entered college unprepared for the academic rigors of such degrees. The course integrates explicit scientific reasoning training techniques into the context of multi-disciplinary scientific investigations in an effort to develop those skills deemed necessary for success in future majors courses. Targeted skills include proportional, probabilistic, correlational, and hypothetico-deductive reasoning as well as identification and control of variables and cohesive scientific arguments. The course was piloted in Fall 2007 and Spring 2008 to roughly 50 students. The poster will include specifics about the course, course curriculum, and the results of the study that was implemented to determine the effectiveness of SM 101 at meeting its objectives. Successes, as well as challenges, will be addressed in terms of how the course will be modified for Fall quarter 2008.

Supported by NSF grant number DUE-0622466.

CP.750: **Network Analysis of Social Interactions in Laboratories**

*Aaron Warren, Purdue University North Central, awarren@pnc.edu*

An introduction to techniques of network analysis, based upon graph theory and statistics, is presented. These techniques allow rigorous quantification and hypothesis-testing of the interactions inherent in social groups. For example, the impact of stable intrinsic characteristics of individuals on their social interactions may be determined. Some aspects of network analysis which are useful for physics education are reviewed, along with several examples using data from videotaped laboratory groups.

CP.751: **Applying Successful Techniques to Transform Physics and Astronomy in Urban Classrooms**

*Sean Gallardo, Chicago State University, sean1g1@yahoo.com*
*Kim Coble, Chicago State University*
*Mel S. Sabella, Chicago State University*

The physics program at Chicago State University (CSU) has adopted an instructional environment that embraces inquiry-based instruction, research on student learning, and instructional revision. Based upon successes in our introductory physics courses, we have expanded our program to include the introductory astronomy and modern physics courses at CSU and the introductory physics sequence at Olive Harvey College, a nearby urban community college. In this poster we describe our implementation, preliminary research on the effectiveness of our materials, and the successes and challenges we face as our project expands to different instructional environments.

Supported in part by NSF grant #DUE 0632563

CP.752: **Understanding and Encouraging Effective Collaboration in Introductory Physics Courses**

*Geraldine L. Cochran, Chicago State University, moniegeraldine@gmail.com*
*Virginia L. Hayes, Chicago State University*
*Mel S. Sabella, Chicago State University*

Anecdotal evidence from the introductory physics classrooms at Chicago State University suggests that our students view collaboration as an important tool in their learning. Despite this, students often need additional instruction and support for effective collaboration in order to make discussions productive. In order to aid students in establishing effective collaborations we want to capitalize on the fact that students at CSU readily accept the inquiry approach to instruction.
In this poster, we present the initial stage of this work. Specifically, we have begun to video-tape student interactions in the classroom and interview students about the nature of learning. In addition, we have developed and administered an instrument that gauges the value students place on the use of guided inquiry. By utilizing a specific criteria and analyzing the occurrence of specific behaviors in the classroom we can determine the effectiveness of collaboration during group work.[1] Responses regarding how students value the use of questions in instruction suggest how peer questioning can be used to promote effective collaboration.

Supported by the NYC Louis Stokes Alliance Bridge to Teaching and NSF grant #DUE 0632563.

[1] Vellom, R. P., & Anderson, C. W. (1999). Reasoning about data in middle school science. Journal of Research in Science Teaching, 36(2), 179.

CP.753: **How Students Delineate "Force" from Other Terminology: Is There Change Following Instruction?**

*Steven J. Maier, Northwestern Oklahoma State University, sjmaier@nwosu.edu*

A short paper and pencil survey was developed to gage the degree students delineate the term force from energy, power, strength and momentum. The items on this survey were modeled after specific items on the FCI. Upon reading the survey items, students select any combination of responses. These responses are categorized: 1) strictly force, 2) mixed and 3) force independent. Pre and post test data were collected using this survey in addition to FCI pre and post data and Lawson s Classroom Test of Scientific Reasoning. In this poster, the status of this current research will be presented along with a discussion of implications and limitations.

CP.754: **Using Warrants as a Window to Epistemic Framing**

*Thomas Bing, University of Maryland at College Park, tbing@physics.umd.edu*
*Edward F. Redish, University of Maryland at College Park*

Mathematics can serve many functions in physics. It can provide a computational system, reflect a physical idea, conveniently encode a rule, and so forth. A physics student thus has many different options for using mathematics in his physics problem solving. We present a short example from the problem solving work of upper level physics students and use it to illustrate the epistemic framing process: framing because these students are focusing on a subset of their total math knowledge, epistemic because their choice of subset relates to what they see (at that particular time) as the nature of the math knowledge in play. We illustrate how looking for students warrants, the often unspoken reasons they think their evidence supports their mathematical claims, can serve as a window to their epistemic framing.

This work is supported by NSF grants DUE-05-24987, REC-04-40113, and a Graduate Research Fellowship.

CP.756: **The Role of Inference in the Problem Solving about Friction**

*Cheong Yong Wook, Seoul National University, zimusa@snu.ac.kr*
*Byun Tae Jin, Seoul National University*
*Ha Sangwoo, Seoul National University*
*Lee Gyoungho, Seoul National University*

Frictional force is a very difficult concept for students to understand; even university students have difficulties in learning friction. We theoretically discussed the importance of inference in understanding dynamics related to friction. Furthermore, we conducted a survey to investigate university students concepts concerning frictional force. By analyzing the result, we found evidence that lack of inference in the reasoning process could create difficulties in problem solving about friction. Our result suggests that the role of inference must be emphasized in the instruction of friction.

CP.757: **Probing Student Online Discussion Behavior with a Course Blog in Introductory Physics**

*Gintaras K. Duda, Creighton University, gkduda@creighton.edu*
*Katherine Garrett, Creighton University*

Since the fall of 2005 a course blog has been used in introductory physics courses at Creighton University to discuss real-world applications of physics and engage students in discussion and thinking outside of class. Specifically, the blog was created to address elements of the "hidden curriculum" that are difficult to cover in class. Previous work showed that students who posted to and read the blog did not suffer a deterioration in attitude/expectations as seen elsewhere using the MPEX or CLASS instrument. Here we analyze the content of student posts to the blog along several dimensions: student interactivity, self-disclosure of previous knowledge, integration of outside information, and links made between posts and specific physical concepts. Students' online discussion behavior is analyzed and compared to the results on standard assessment instruments like the FCI, CSEM, and DIRECT tests to determine if discussion behavior is linked to student learning. We also present gender differences in student's online discussion behaviors.

CP.758: **How Abstract is Abstract? Signs, Salience, and Meaning in Physics**

*Noah S. Podolefsky, University of Colorado at Boulder, noah.podolefsky@colorado.edu*
*Noah D. Finkelstein, University of Colorado at Boulder*

External representations, including pictures, graphs, text, gestures, and utterances, are key components of all curricular materials in physics. Such representations play a key role in cognitive function, particularly insofar as individuals interpret the meanings of and apply meanings to these representations. We have proposed a model of how individuals can make meaning of and with external representations through layered analogies and applied this model to learning abstract ideas in physics, i.e. EM waves. [1] [2] We extend this model in two ways. (1) We distinguish individuals interpretations of representations, which can be highly variable and fleeting, from the physics communities agreed upon interpretations, which are more stable and coherent. (2) Two characteristics of representation use emerge: abstraction based on the community consensus of concepts and salience based on readily accessible pieces of knowledge for an individual.

[1] N.S. Podolefsky & N.D. Finkelstein, Phys. Rev. ST - Phys. Educ. Res. 3, 010109 (2007)
[2] N.S. Podolefsky & N.D. Finkelstein, Phys. Rev. ST - Phys. Educ. Res. 3, 020104 (2007)

CP.759: **Toward a Comprehensive Picture of Student Understanding of Force, Velocity, and Acceleration**

*Rebecca Rosenblatt, The Ohio State University, rosenblatt.rebecca@gmail.com*
*Eleanor C Sayre, The Ohio State University*
*Andrew F Heckler, The Ohio State University*

Students difficulties with conceptual questions about force, velocity, and acceleration have been well documented. However, there has been no single systematic study of student understanding of all paired relations among the concepts of force, velocity and acceleration. For example, a student who believes an object with a net force on it must be moving might not believe an accelerating object must be moving. In this paper, we describe the development of a test to build a more comprehensive picture of student understanding. We also report preliminary data suggesting that there are interesting differences in how students believe force, velocity, and acceleration are related. Specifically there are a higher number of students reporting that force and velocity are directionally related then that acceleration and velocity are directionally related.

CP.760: **New Media and Models for Engaging Under-Represented Students in Science**

*Laurel M. Mayhew, University of Colorado at Boulder, Laurel.Mayhew@colorado.edu*
*Noah Finkelstein, University of Colorado at Boulder*

We describe the University of Colorado Partnerships for Informal Science Education in the Community (PISEC) program in which university volunteers participate in classroom and after school science activities with K-12 students in the local community. We use technology in innovative ways to engage the students and teach about science, and the nature of science. Across several different K-12 environments, we use stop action motion (SAM) movies [1] and simulations from the physics education technology project (PhET) [2] in which the students can creatively show and tell their understanding of the science. This provides an alternative way for reluctant or ESL students who may have trouble writing their ideas. We present the model of university community partnership, and demonstrate its utility in a case study one 3rd grade student learning about velocity and acceleration.

[1] Center for Engineering Education and Outreach, Tufts University, Stop Action Motion Animation, http://www.samanimation.com
[2] Physics Education Technology Project, University of Colorado, http://phet.colorado.edu

CP.761: **Mind the Gap Please**

*Vashti Sawtelle, Florida International University, davisvas@gmail.com*
*Eric Brewe, Florida International University*
*Jeffery M. Saul, Florida International University*

In a 2005 American Institute of Physics report, Ivie and Ray showed that 46% of the students taking physics at the high school level are women. Yet, only 22% of the bachelor's degrees in physics are awarded to women. Often referred to as the leaky pipeline, it is evident that a large hole exists between high school and college. This investigation will examine how the gender learning gap, the difference in learning gains experienced by men and women, affects participation of women in high school physics. We will present an overview of the investigation study design including the interview protocol, focusing on the persistence of high school women in physics, epistemological surveys, and pre/post diagnostics to be used in evaluating the actual and perceived learning gap. The presentation will include a discussion of the issues that were considered in creating the study design.

CP.762: **Identifying Student Difficulty in Problem Solving Process via the Framework of the House Model(HM)**

*Taejin Byun, Seoul National University, vesaboy@dreamwiz.com*
*Yongwook Cheong, Seoul National University*
*Sangwoo Ha, Seoul National University*
*Gyoungho Lee, Seoul National University*

Recently, many students have been losing their interest in physics. One of the essential reasons why students look away from physics is the fact that they face difficulty in solving physics problems. Since mechanics is a fundamental subject in physics, many researchers have studied how students learn mechanics and solve problems related to mechanics. However, there is little research on the students' specific difficulties in the process of problem solving. This study investigated students specific difficulties (with degrees of difficulties) and the core sources of these difficulties. Twenty-five university students who majored in physics education participated in this study. We have developed a framework, the House Model, for helping and analyzing students' problem solving. We found that students felt greater difficulty in planning and executing steps than in visualizing, knowing and finding steps. As the problems grew in difficulty, this pattern became more distinct. We will also describe the sources of the students difficulties and discuss the educational implications of these results.

CP.763: **Student Understanding of P-V Diagrams and Conceptions about Integration**

*Evan B. Pollock, University of Maine, evan.pollock@umit.maine.edu*
*Brandon R. Bucy, University of Maine*
*John R. Thompson, University of Maine*
*Donald B. Mountcastle, University of Maine*

As part of ongoing research into upper-level undergraduate student understanding of thermodynamics at the University of Maine, we report on students' understanding of thermodynamic work, internal energy and the associated mathematics.
New interview data of physics majors, as well as written data obtained in a calculus III class, support our previous findings and

provide for a more in-depth look into factors impacting student difficulties with thermodynamic quantities.
Analysis of written and interview data has revealed student conceptions about integration that might otherwise be interpreted as conceptual difficulties with the physics. The data suggest that students' application of the state function concept to thermodynamic work may be due in part to incorrect conceptions regarding integration. The data also suggest that students lack the correct mathematical foundation of the state function concept, which may be a factor in its indiscriminate application.

CP.764: **Student Response to Instruction: When and How Much?**

*Eleanor C Sayre, The Ohio State University, le@zaposa.com*
*Andrew F Heckler, The Ohio State University*

In the physics education research community, a common format for evaluation is pre- and post-tests. At The Ohio State University, we take advantage of our large class sizes by collecting more frequent data points. The data cover the first two quarters (mechanics, E&M) of a calculus-based introductory sequence populated primarily by first- and second-year engineering majors. Different subpopulations of students are evaluated every week of the quarter using a variety of conceptual and procedural tasks related to different topics in the curriculum. Unsurprisingly for a traditional introductory course, there is little change on many conceptual questions. However, some student ideas peak and decay during a quarter, a pattern expected from memory research yet unpredicted by pre-/post-testing. In addition, some correct ideas decrease dramatically when newer topics interfere with prior knowledge.

This research is partially supported by a grant from the Institute of Education Sciences, U.S. Department of Education (#R305H050125).

CP.765: **Assessing Pre-Service Teachers Using an Interview Protocol Based on C-LASS**

*Idaykis Rodriguez, Florida International University, irodr020@fiu.edu*
*Eric Brewe, Florida International University*
*Larid Kramer, Florida International University*

We report results from an interview study of prospective pre-service teachers serving as undergraduate Learning Assistants (LAs) in Florida International Universitys Physics Teacher Education Coalition (PhysTEC) Project. The goal of the study is to investigate both characteristics of students drawn to the PhysTEC program and how they changed as a result of their first early field experience. Their early field experience included assisting in reformed physics classrooms and laboratories. Seven students were interviewed prior to and after their field experiences, using a protocol based on the Colorado Learning Attitudes about Science Survey (C-LASS) instrument. Students completed the C-LASS and then were asked to explain their responses in interview sessions. Students were also asked about their background and experiences in physics courses. Results of the interview study and measured impact on course reform will be presented.

CP.766: **Disentangling the Force Concept Inventory Using Latent Class Analysis**

*Ivan Ivanov, Vanier College, ivanovi@vaniercollege.qc.ca*
*Helena Dedic, Vanier College and CSLP Concordia University*
*Steve Rosenfield, Vanier College and CSLP Concordia University*
*Nathaniel Lasry, John Abbott College*

This study probes the states of knowledge concerning three physics concepts, Newton s Third Law, Newton s Second Law, and the Motion/Force Relationship, as measured by several groups (factors) of FCI items. These knowledge states are not postulated, but rather extracted FCI pre/post instruction records from three universities. For each factor, via patterns of response, students were statistically grouped into latent classes , subsequently seen to correspond to (groups of) specific student misconceptions. Using Latent Transition Analysis we estimated the (transition) probabilities of students moving, pre/post, between such classes. Transitions in these factors seem uni-directional, towards classes corresponding to fewer misconceptions, indicating gains in understanding at all three universities. However, students in some latent classes are unlikely to learn, and students starting in the bottom classes appear to have virtually no chance of transitioning to the top. These results/methods can aid physics educators by providing detailed assessment of instructional effectiveness.

CP.767: **Assessing the Effect of Single-Concept Clicker Sequences on Students' Learning**

*Lin Ding, Department of Physics, The Ohio State University, lding@mps.ohio-state.edu*
*Albert Lee, The Ohio State University*
*Neville W. Reay, The Ohio State University*
*Lei Bao, The Ohio State University*

Clickers have been increasingly used in modern physics classes to facilitate students conceptual learning. At the Ohio State University, we developed, validated and implemented a series of single-concept clicker sequences for the entire calculus-based introductory physics course. Uniquely, each clicker sequence targets the same fundamental concept but contains questions with diverse surface features. To assess the effect of clicker sequences on students conceptual understanding, we conducted a comparative study between two parallel classes (a clicker class and a non-clicker class) in the spring 2008 quarter. These two classes address the same topics on waves and optics and share identical materials, including labs, recitations, homework, quizzes and tests. Results for students increased conceptual learning gains in the clicker class as compared to the non-clicker class are promising.

CP.768: **Ontologies of Physics Concepts: A Toy Model**

*Ayush Gupta, University of Maryland at College Park, ayush@umd.edu*
*David Hammer, University of Maryland at College Park*
*E. F. Redish, University of Maryland at College Park*

A prominent approach towards understanding the source of naive misconceptions in science argues that misconceptions arise due to novices' commitment to categorizing physics processes (such as heat, current) as substances and that there is a significant cognitive barrier to re-categorizing these concepts correctly [1]. Methodologically, this approach assumes a one-to-one

correspondence between verbal expression and ontology in the mind. Previously, we have used this methodology to show that expert as well as novice reasoning of a concept is not constrained within a single ontological category [2]. Here we present an alternative way to model students' ontologies, without the assumption binding verbal expression directly to ontologies. We model a graduate student's reasoning about heat in terms of the conceptual resources [3] that she uses. We claim that clusters of closely-associated resources activated in the moment reflect her ontology of heat and explore how her epistemological stance influences her ontology of heat over the course of her explanation.

This research is supported by NSF grants REC 04-40113 & DUE 05-24987

[1] Chi, M. T. H., Slotta, J., & de Leeuw., N. (1994). Learning & Instruction, 4, 27-43; Slotta, J., & Chi, M. T. H., (2006). Cog. & Instr. 24, 261-289.
[2] Gupta, A., Hammer, D., & Redish, E. F. (In Press). Proceedings of International Conference of the Learning Sciences 2008, In Press.
[3] Hammer, D., Elby, A., Scherr, R. E., & Redish, E. F. (2004). Resources, framing, and transfer, in Transfer of Learning: Research and Perspectives, J. Mestre, ed. (Information Age Publishing).

CP.769: **Implementing Tutorials in a Statistical Physics Course**

*Hugo Alarcon, Tecnologico de Monterrey, halarcon@itesm.mx*
*Alejandro Mijangos, Tecnologico de Monterrey*
*Juan J. Velarde-Magaña, Tecnologico de Monterrey*

Statistical Physics is an intermediate course for engineering physics students at Tecnologico de Monterrey in Monterrey, Mexico. Prior to this course, students have taken a traditional lecture-based introductory course in thermal physics and a thermodynamics course focused on thermal processes. In order to review some important required concepts at the beginning of the course, such as the behavior of an ideal gas and the First Law of Thermodynamics, two Tutorials designed by the Physics Education Group at the University of Washington have been used. In this implementation, students have taken the pre- and post-tests recommended by the authors, have worked on the Tutorials assisted by qualified teaching assistants and have solved tutorial problems in cooperative groups. We present the results of the implementation and contrast them to previous results reported by the authors of these particular Tutorials when used by US students.

CP.770: **Interactive Problem Solving Tutorials through Visual Programming**

*Lucian Undreiu, UVA Wise, lmu8y@uvawise.edu*
*David Schuster, Western Michigan University*
*Adriana Undreiu, Western Michigan University*

We have used LabVIEW visual programming to build an interactive tutorial to promote conceptual understanding in physics problem solving. This programming environment is able to offer a web-accessible problem solving experience that enables students to work at their own pace and receive feedback. Intuitive graphical symbols, modular structures and the ability to create templates are just a few of the advantages this software has to offer. The architecture of an application can be designed in a way that allows instructors with little knowledge of LabVIEW to easily personalize it. Both the physics solution and the interactive pedagogy can be visually programmed in LabVIEW. Our physics pedagogy approach is that of cognitive apprenticeship, in that the tutorial guides students to develop conceptual understanding and physical insight into phenomena, rather than purely formula-based solutions. We demonstrate how this model is reflected in the design and programming of the interactive tutorials.

CP.771: **Examples of Student Geometric Reasoning in Upper-Division E&M Problems**

*Leonard Cerny, Oregon State University, cernyl@onid.orst.edu*
*Elizabeth Gire, Oregon State University*
*Corinne Manogue, Oregon State University*

Students use a variety of problem-solving strategies involving geometric reasoning as they solve upper-division E&M problems in Oregon State University s Paradigms in physics courses. Seven classroom cameras were used to capture six groups of three students each as they solved a variety of electrostatic and magnetostatic problems. We look at two examples of student problem solving to illustrate the types of things students find challenging and the types of strategies they employ. In one example, students struggled with how to use integration as chopping and adding to find the electric potential in all space due to a static ring of charge. A second example shows interesting issues students address while finding the current for a spinning ring of charge Q, radius R, and period T. An analysis of classroom video shows some of the wrestling, sense making, geometric reasoning, and problem-solving strategies these groups used to eventually make fruitful progress.

CP.772: **Examining Student Responses for Meaningful Understanding in the Context of Wavefront Aberrometry**

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

We present a qualitative study from group learning and teaching interviews that were conducted as part of an ongoing study to examine how students use their physics knowledge in novel situations. The data were analyzed for meaningful understanding using techniques previously presented by Lawson et al. and Nieswandt and Bellomo. Preliminary results indicate that students primarily utilize lower-level concepts and concept links when attempting to construct an understanding of wavefront aberrometry.

CP.773: **Preliminary Study of Impulse-Momentum Diagrams**

*David Rosengrant, Kennesaw State University, drosengr@kennesaw.edu*
*Taha Mzoughi, Kennesaw State University*

In this paper, we present a new representation to help students learn about momentum, impulse and conservation of momentum. We call this representation an Impulse-Momentum Diagram. We include a description of these diagrams as well as examples on how instructors can use them in the classroom. Next, we present preliminary quantitative and qualitative data on a study where students used these representations to learn the previous physics concepts. Our final analysis shows how students benefit from these representations.

CP.775: **Impact of the FIU PhysTEC Reform of Introductory Physics Labs**

*Leanne Wells, Florida International University, Leanne.Wells@fiu.edu*
*Ramona Valenzuela, Florida International University*
*Eric Brewe, Florida International University*
*Laird Kramer, Florida International University*
*George O'Brien, Florida International University*

We report results from a study of pre and post assessments of students enrolled in reformed and non-reformed introductory physics laboratory sections. The goal of the study was to assess the results of the impact of Florida International University s (FIU) PhysTEC reform of introductory physics labs. Prospective pre-service teachers were trained and placed in six lab sections serving as undergraduate Learning Assistants (LAs) and implementing tutorial-based curriculum. LAs facilitated epistemological and metacognitive discussions designed to challenge and then refine student understanding of physics concepts. Conceptual understanding and beliefs about physics of students in the six reform sections were compared with students enrolled in non-reformed laboratory settings. Students completed the Force Concept Inventory (FCI) , the Maryland Physics Expectation Survey (MPEX 2), and common exam questions embedded in the exams for their regular physics classes. Results of the study and measured impact of lab reform will be presented.

CP.777: **The Roles of Evidence in Scientific Argument**

*Leslie Atkins, California State University - Chico, ljatkins@csuchico.edu*

The view of science in the education community is shifting from a rhetoric of conclusions to a social process of knowledge construction, and engagement in scientific argumentation is a hallmark of such knowledge construction. This emphasis on argument recasts the role of evidence and data in scientific classrooms: rather than being used to demonstrate scientific principles, it is the grounds on which claims are warranted. In this poster, I explore a transcript of scientific discourse, exploring the rules by which participants in the discourse endorse or reject scientific claims. I appeal for a more nuanced understanding of evidence as one of many criteria by which scientific claims are evaluated, and that evidence, at times, is incommensurable with other (possibly more scientific ) criteria for evaluating claims. This view of argumentation, and the peculiar language games associated with argumentation, is particularly relevant for understanding difficulties that diverse student populations may face.

CP.779: **How Differentials are Taught in Mathematics and Used in Physics**

*Angeles Dominguez, Tecnologico de Monterrey, Mexico, angeles.dominguez@itesm.mx*
*Ricardo Pulido, Tecnologico de Monterrey, Mexico*

Differentials are widely used in mathematics and applied in physics and engineering courses. However, there is little understanding of the concept of differentials among undergraduate students. This paper is part of an ongoing project to understand how differentials are taught in mathematics classrooms and used in physics undergraduate courses taken by a diverse group of engineering majors. To that end, we analyzed the mathematics instruction based on what is taught; specifically, we looked at the most commonly used calculus textbooks for a first-year calculus course. It is our claim that the way differentials are introduced in mathematics textbooks does not support undergraduate student understanding of the use of differentials in physics and engineering.

CP.780: **Evaluation of Instruction Using the Conceptual Survey of Electricity and Magnetism in Mexico**

*Genaro Zavala, Tecnologico de Monterrey, Mexico, genaro.zavala@itesm.mx*
*Hugo Alarcon, Tecnologico de Monterrey, Mexico*

The Conceptual Survey of Electricity and Magnetism (CSEM) is regularly administered to students at the beginning of the semester as a pretest and at the end of the semester as a post-test in a large private university in Mexico. About 500 students each semester, from different engineering majors, take electricity and magnetism, divided into sections of 30-40 students so there are several different instructors, both full-time and part-time. We report on the analysis of the CSEM data using concentration analysis for the purpose of evaluation of instruction. The results showed that students learning is dependent on instructor and on CSEM concept area. Students have large learning gains in some concept areas but small learning gains in others. Deeper analysis of a concept area showed that some instructors may tend to strengthen some misconceptions that students have. The analysis can be used to give feedback to instructors for the purpose of improving instruction.

CP.781: **Implementing Tutorials in Introductory Physics in an International Context: The Effect of Language**

*Genaro Zavala, Tecnologico de Monterrey, Mexico, genaro.zavala@itesm.mx*
*Christian H. Kautz, Hamburg University of Technology*

Tutorials in Introductory Physics from the University of Washington have become widely recognized as one of the more successful educational strategies for teaching physics. They were originally developed in English and have been translated to different languages. Instructors in non-English speaking countries wanting to implement Tutorials therefore have a choice between using the materials in the original English versions, and consequently teaching in a language other than the native language of most of their students, or using translations into the local language. We present two experiences: a large private university in Mexico and a small public university in Germany, both of which use the Tutorials as the main strategy for physics courses. Through analysis of empirical data on student performance, we have been investigating to what extent the effectiveness of such materials is affected by their translation when the instruction is in the local language or by the non-native language capabilities of the participating students when the instruction is in English.

CP.782: **Tutorials in Introductory Physics: A Mexican Experience**

*Genaro Zavala, Tecnologico de Monterrey, Mexico, genaro.zavala@itesm.mx*
*Hugo Alarcon, Tecnologico de Monterrey, Mexico*
*Carlos Hinojosa, Tecnologico de Monterrey, Mexico*
*Gustavo Quintanilla, Tecnologico de Monterrey, Mexico*

This paper will describe how physics courses are taught for Mexican engineering students in a large private university in Mexico with a

particular student population and with a different academic structure than American universities. The courses are designed to use Tutorials in Introductory Physics from the University of Washington as the main educational strategy, although some other active-learning methods, for instance Peer Instruction and Context Rich Problems, are used. The assessment of learning is based on the use of standard tests such as the Force Concept Inventory (FCI) and the Conceptual Survey of Electricity and Magnetism (CSEM). In some courses the attitudes and expectations of students have been assessed with the Maryland Physics Expectations Survey (MPEX). This report will present results of the implementation and learning of students, and will describe how professors have adopted these strategies.

CP.783: **An Investigation of the Concept of Vectors with College Students in Mexico**

*Genaro Zavala, Tecnologico de Monterrey, Mexico, genaro.zavala@itesm.mx*
*Christian A. Moran, Tecnologico de Monterrey, Mexico*

It has been reported that students lack conceptual understanding of vectors and consequently have difficulties performing basic operations needed in the physics curriculum. We report results of a study of conceptual understanding of vectors among college students in their first physics course in a large private university in Mexico. Students in this institution have conceptual difficulties similar to those of American students, such as identifying magnitude and direction of a vector and performing vector addition. Furthermore, Mexican students have difficulties with the multiplication of a vector by a scalar and more advanced addition/subtraction operations using that product operation even after instruction in which vectors were part of the course curriculum. This report includes a discussion of implications for instruction, preliminary results of the development of a worksheet as instructional strategy and the diagnostic test used in the study.

CP.785: **The Dynamics of Small Group Verbal Interaction: A Case Study in Mechanics Problem Solving**

*Sangwoo Ha, Seoul National University, hswgcb3@snu.ac.kr*
*Yong Wook Cheong, Seoul National University*
*Taijin Byun, Seoul National University*
*Gyoungho Lee, Seoul National University*

Students construct their knowledge together as they talk to each other. Thus, many researchers have studied group interaction as a crucial method for learning & teaching. Recently, group interaction has also been emphasized in physics education. Previous studies have revealed diverse types of interactions between groups; however, it is difficult to find the types of dynamic interactions within group. In this study, we tried to investigate the dynamics of students' small group verbal interaction (within group) when they solved mechanics problems. In this study, three students in an upper-level mechanics class participated. Students' group verbal interactions were videotaped and audiotaped, and analyzed. We discovered several types of group interactions within group. We will discuss our findings and educational implications.

CP.787: **Identifying and Addressing Partial Differentiation Difficulties in Calculus and Thermodynamics**

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

We have reported previously that upper-level thermodynamics students demonstrate an inability to correctly equate the mixed second-order partial derivatives of the state function of volume (nonzero quantities in general), arguing instead that these derivatives must identically equal zero.[1] Here we document the presence of this difficulty among students enrolled in a multivariable calculus course. Data were gathered via diagnostic questions structurally identical to those administered in the thermodynamics course, yet devoid of physical context. We additionally present a guided-inquiry tutorial sequence that was specifically developed to address this and related student difficulties with partial derivatives encountered in our research. The sequence uses a graphical interpretation of partial derivatives in the context of an ideal gas P-V-T surface to bridge the abstract mathematical concepts with concrete physical properties. Preliminary results indicate that the sequence effectively addresses the above difficulty, and also positively impacts student performance on related topics.

Research supported in part by NSF Grants #PHY-0406764 and #REC-0633951, and by the Maine Academic Prominence Initiative

[1] B.R. Bucy et al., 2006 Phys. Educ. Res. Proc. 883, 157 (2007).

CP.788: **All Roads Lead to Palinscar and Brown**

*Evan Richards, North Carolina State University, etrichar@ncsu.edu*
*Ruth Chabay, North Carolina State University*

The poster will present two frameworks from Palinscar and Brown[1] that strikingly encompass decades of research on worked examples. First, their framework of beneficial learning behaviors from the reading comprehension literature will be aligned with the observed learning behaviors from the worked example literature. Second, their four propositions guiding the design of their training scheme will be used to categorize attempts to modify the design and implementation of worked examples.

[1] Palinscar, A. S. & Brown, A. L. (1984). Reciprocal Teaching of Comprehension-Fostering and Comprehension-Monitoring Activities. Cognition and Instruction, 1(2), 117-175.

CP.789: **Which One is Right? How Students Choose between Problem Solutions**

*Evan Richards, North Carolina State University, etrichar@ncsu.edu*
*Jon D. H. Gaffney, North Carolina State University*
*Ruth Chabay, North Carolina State University*

In an on-going research study, we present the following task to current and former introductory physics students: given a problem statement and three possible solutions, only one of which is correct, identify the correct solution and the errors in the other solutions. By investigating how the students make their selection, we seek to address two different research questions. First, what specific actions do the students use to arrive at their conclusions? Second, how do students use deductive reasoning in their choices and justifications? Preliminary results suggest that students do exhibit beneficial learning behaviors but with varying levels of sophistication. Additionally, they use a variety of justifications for their selections and do not always ensure that their selection is deductively sound. In this poster, we will present our preliminary coding scheme and a few notable examples from our pilot study.

CP.790: **Southwest Ohio Science Institutes: A Partnership Model for Professional Development**

*Jennifer Blue, Miami University, bluejm@muohio.edu*

I am in the third year of an Ohio Math Science Partnership (OMSP) called the Southwest Ohio Science Institutes (SOSI). I am working with faculty from several area universities and curriculum specialists from many school districts to plan and deliver professional development to hundreds of teachers each summer. The Math Science Partnerships are funded by the No Child Left Behind Act and administered by the states. They require partnerships between science, technology, engineering and mathematics (STEM) faculty and school districts. I will describe the partnership we have as we run SOSI, paying special attention to the contributions of STEM faculty. Faculty help plan the institutes, review curriculum, help deliver instruction, and participate in Ask a Scientist and Ask a Mathematician programs during the school year.

CP.791: **From Physics Major to Physics Teacher and From Elementary Teacher to Elementary Physics Teacher**

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

Two complementary, nationally recognized programs in PER are designed to capitalize on students' identities in efforts of recruiting and preparing more and better elementary, middle, high school, and college physics teachers and their students. The CU Boulder Learning Assistant (LA) Project is designed to help students expand their identities from physics majors to physics teachers. The Physics and Everyday Thinking Project is designed to help non-majors expand their identities from elementary teachers to elementary physics teachers. Both programs have demonstrated success in facilitating change among students. These data will be presented and discussed. Inferences will be made about which elements of each program seem to be effecting change. Emphasis is placed on how we help future teachers recognize and capitalize on their own students conceptual, cultural, linguistic, and social resources.

CP.792: **Reasoning Modes, Knowledge Elements, and Their Interplay in Optics Problem-Solving**

*Adriana Undreiu, Western Michigan University, adriana.undreiu@wmich.edu*
*David Schuster, Western Michigan University*
*Betty Adams, Western Michigan University*

We have investigated how students tackle problems in geometric optics involving ray construction, to try to understand the nature and origin of the surprisingly wide variety of students solution attempts. We find that students use various reasoning modes and knowledge elements in conjunction. Their thinking may usefully be described as an interplay of principle-based and case-based reasoning, drawing on a knowledge mixture of basic principles, procedures, specific cases and recalled result features. Even though we usually present solutions and teach problem-solving as a systematic application of principles, real cognition is more complex. Associative thinking in terms of prior cases seems to be a strong natural tendency of both novices and experts. However novices are not easily able to discriminate the specific from the general, and tend to lack epistemic awareness and metacognitive skills. Our research findings will be illustrated by examples of student thinking on a basic reflection problem. Implications for learning and instruction will be discussed.

CP.793: **Curricular Process and Communicative Conception in Physics Education**

*Pavol Tarabek, Educational Publisher Didaktis (European Educational Publishers Group), didaktis@t-zones.sk*

This poster describes a curricular process and its comparison with the communicative conception of physics education.

The curricular process of physics is a sequence of variant forms of curriculum mutually interconnected by six transformations, starting with the non-curricular member of the sequence the scientific system of physics:

CT1 = scientific system to conceptual curriculum,
CT2 = conceptual curriculum to intended curriculum,
CT3 = intended curriculum to project curriculum,
CT4 = project curriculum to operational curriculum,
CT5 = operational curriculum to implemented curriculum,
CT6 = implemented curriculum to attained curriculum.

The subject of physics education in the communicative conception is the educational communication of physics, which is defined as a continuous process of transfer of the scientific physical knowledge and methods into the minds of learners.

Details: Educational&Didactic Communication 2007, http://www.didaktis.sk

CP.794: **Triangular Model of Concept Structure**

*Pavol Tarabek, Educational Publisher Didaktis - member of EEPG (European Educational Publishers Group), didaktis@t-zones.sk*

The triangular model of physical concept structure and its four developmental levels will be presented:

1. Primitive,
2. Empirical,
3. Symbolical,
4. Formal.

The model is built upon Vygotsky’s theory and derived from a semantic modeling. The basic components of the model are: core C, meaning M, meaning layers M1, M2, M3, sense S and their relationships. This model also distinguishes the concept’s meaning and sense like two disjunctive sets.
The triangular model of concept force on Aristotelian (empirical) and Newtonian (symbolical) cognitive level will be presented.
The Vygotian phases of concept formation will be presented by the triangular model.

[1] The details of the model see: Tarábek, P. (2007) Cognitive Analysis and Triangular Modeling of Concept in Curricular Process, in Educational & Didactic Communication 2007, Vol.2, ISBN: 987 80 89160 56 3, www.didaktis.sk

CP.795: **Resources Students Use to Understand Quantum Mechanical Operators**

*Elizabeth Gire, Oregon State University, giree@physics.oregonstate.edu*
*Leonard Cerny, Oregon State University*
*Corinne Manogue, Oregon State University*

The Paradigms team at Oregon State University has developed a quantum mechanics curriculum aimed at middle division students that begins with a strong emphasis on using matrices and Dirac notation to describe quantum systems. This content ordering relies on students being able to understand quantum mechanical operators, eigenstates and quantum measurement without prior instruction on wave functions. We have analyzed classroom video and student interviews to identify resources students use when considering these quantum ideas. Identification of these resources will inform introductory curricula that are prerequisite to the quantum Paradigms and inform the development of Paradigms materials that will guide students to use these resources productively.

CP.796: **Physics Education Research with Diverse Student Populations**

*Homeyra Sadaghiani, Cal Poly Pomona, hrsadaghiani@csupomona.edu*

In the last decade, the results of Physics Education Research (PER) and research-based instructional materials have been disseminated from traditional research universities to a wide variety of colleges and universities. Nevertheless, the ways in which different institutions implement these materials depend on their students and their circumstances. Despite the fact that the use of these materials is so prevalent there is little research on the effectiveness of these materials with different populations of students. This poster compares pretest data on different topics of mechanics for students in elite research universities and underprepared students in four-year colleges and universities. I seek to identify effective practices as well as continuing challenges to improve physics education for diverse undergraduate students.

CP.798: **Pre-Service Teachers' Conceptual Understanding of and Attitudes toward Physics**

*Stan Jones, The University of Alabama, stjones@bama.ua.edu*
*Charlotte E. Horton, The University of Alabama*

We report on a preliminary study of pre-service education majors, their conceptual understanding of physics principles, and their attitudes toward science. About 50 students participated in an intensive three-week interim course on descriptive physics. Participants included elementary education, special education, and multiple abilities majors, but no secondary education majors. Teaching methods were highly interactive. Topics covered included forces and motion, energy, electricity, sound and light. Although students had a very low FCI score on the pretest, their gains after just a week of instruction were impressive (Hake gain = 0.28). Results of a post-course attitude survey (CLASS) will be presented, and plans for further study of this important set of students will be outlined.

CP.799: **A Design and Evaluation Study for Teaching Science Safely in South Dakota**

*Cathy Mariotti Ezrailson, University of South Dakota, Cathy.Ezrailson@usd.edu*
*Rachel Kludt, University of South Dakota*
*Phillip Millard, University of South Dakota*

The National Science Teachers Association guidelines for preparing science teachers emphasize competent science safety knowledge. Best Practice dictates increasing the amount of student-centered hands-on science instruction which also increases the possibility of accident, especially in the classrooms of uninformed or untrained teachers. Phase I of this study sampled the science practice and classroom safety knowledge of a cross-section of K-12 science teachers in South Dakota to ascertain if teachers are aware of and trained in safe science practice. Are the teachers who have been trained in science safety practicing those procedures when they teach science? This study's data show that this may not be the case. Subsequent to this study, an analysis of the results from the safety survey will inform the design of a safety training certificate program for pre- and in-service teachers in South Dakota with the intent that teachers, once informed will practice science more safely.

CP.802: **The Gender Gap on the FCI - Question by Question**

*Richard D. Dietz, University of Northern Colorado, rdietz@unco.edu*
*Matthew Semak, University of Northern Colorado*
*Courtney W. Willis, University of Northern Colorado*

The existence of a gender gap in performance on the Force Concept Inventory has been established by several studies. Those studies have focused on the total score achieved by students on the FCI and subsequent gains in the total score when the instrument is administered again after instruction. Here we analyze the gender gap for each of the 30 questions in the FCI to determine if particular questions present greater difficulty for females.

CP.803: **Archiving Student Solutions with Tablet PCs in a Discussion-Based Introductory Physics Class**

*Edward Price, California State University - San Marcos, eprice@csusm.edu*
*Charles De Leone, California State University - San Marcos*
*Robin Marion, California State University - San Marcos*
*John Saunders, California State University - San Marcos*

Many active learning based physics courses use whiteboards as a space for groups to respond to prompts based on short lab activities, problem solving, or inquiry-oriented activities. Whiteboards are volatile; once erased, the material is lost. Tablet PCs and software such as Ubiquitous Presenter can be used as digital whiteboards in active learning classes. This enables automatic capture and archiving of student work for online review by students, instructors, and researchers. We studied the use of digital whiteboards in an active-learning introductory physics course at California State University, San Marcos. In this poster we examine the archival features of digital whiteboards, and characterize the use of these features by students and researchers.

CP.804: **Latent Response Times and Cognitive Processing on the FMCE**

*Scott Bonham, Western Kentucky University, scott.bonham@wku.edu*

Latent response analysis of students answering questions on an on-line administration of the Force and Motion Conceptual Evaluation (FMCE) provides information on student reading patterns and the role of mental models. Regression analysis shows that response times are related to group and specific question text, but not to text or graphs in answer choices, indicating that students consistently read through the former but not the later. Response times also provide information on student use of mental models. Instruction reduced response times on responses consistent with Newton s laws while alternative concepts were unchanged. Among students who utilized both Newtonian and alternative concepts, no evidence was seen for activation of both models on the same question.

CP.805: **An Investigation of Student Ability to Connect Particulate and Macroscopic Representations of a Gas**

*Kereen Monteyne, California State University - Fullerton, kmonteyne@fullerton.edu*
*Barbara L. Gonzalez, California State University - Fullerton*
*Michael E. Loverude, California State University - Fullerton*

This interdisciplinary project assessed the extent to which students in general education courses across two departments understood the assumptions of small-particle models and the ways in which these models relate to measurable properties. Many general education courses are surveys of a wide body of material, but spend relatively little time on fundamental issues such as the particulate nature of matter. Students are increasingly exposed to small particle models through animations on websites and visualizations in science textbooks, however relatively little time is spent on the interpretation and use of these models. The implicit assumption is that students have little difficulty with an idea as basic as the particulate nature of matter and are able to use small-particle models to explain the behavior of the observable, macroscopic world. As part of this project, we embedded conceptually-oriented questions on written assessments in general education courses in physics and chemistry. Questions were drawn from the published literature in chemical and physics education and developed by the research team. The results of this project provide a baseline measurement of the extent to which a diverse population of students in introductory physical science courses was able to develop and use particulate models to reason about macroscopic observables.

CP.806: **College Students' Lunar Phases Concept Domain**

*Rebecca S. Lindell, Southern Illinois University Edwardsville, rlindel@siue.edu*

Previous research [1] showed that college students' lunar phases concept domain consisted of eight dimensions: Period of Moon's orbit, Period of Moon Phases, Direction of Moon's orbit around the Earth, Motion of the Moon in the sky, Phase and Sun-Earth-Moon relationship, Phases-Location in the Sky-Time of Observation relationship, Cause of Phases and Effect of Location on Earth on observed phase. Each dimension uncovered has a number of facets, each representing the scientific correct answer, as well as the different alternative models possible. In a follow-up study, interview data was collected from 25 pre-service elementary education majors. This additional study uncovered previously undiscovered difficulties students had with lunar phases. The discovery of these new difficulties resulted in the need to revise the original concept domain. The new revised concept domain will be presented.

[1] Lindell, R. S. 2001, "Enhancing College Students' Understanding of Lunar Phases," Unpublished doctoral dissertation, University of Nebraska, Lincoln

CP.808: **Studio Physics at the Colorado School of Mines: Studying the Implementation**

*Patrick B. Kohl, Colorado School of Mines, patkohlcsm@gmail.com*
*H. Vincent Kuo, Colorado School of Mines*
*Todd G. Ruskell, Colorado School of Mines*

Over the past year we have converted the second semester of our calculus-based introductory physics course course to a Studio Physics format, starting from a traditional lecture-based format. This process is taking place in two stages. First, the curriculum was redistributed to fit our part Studio/part lecture course structure. Second, and based on the results of a variety of assessments, we continue to refine the course on a semester-by-semester basis. In this poster, we describe the conversion process from traditional to studio format, discuss the PER-based improvements that we have implemented, and identify areas of interest for further study. We characterize our progress via several metrics, including pre/post Conceptual Survey of Electricity and Magnetism (CSEM) scores, Colorado Learning Attitudes about Science Survey (CLASS) scores, solicited student comments, failure rates, and exam scores. Initial results are positive: Despite maintaining course standards, students are less likely to fail and are performing better on certain course tasks.

CP.811: **Students' Use of Structure Maps to Facilitate Problem Solving in Algebra-Based Physics**

*Fran Mateycik, Kansas State University, mateyf@ksu.edu*
*David H. Jonassen, University of Missouri*
*N. Sanjay Rebello, Kansas State University*

In this study we explore the use of expert-designed structure maps by students in an algebra-based physics course and the evolution of these maps based upon students reactions and feedback collected over one semester. Eleven participants were trained to use structure maps while solving problems sharing similar deep-structure elements. The 11 participants were divided into two groups of six and five students each. Each group met for one hour every week to work on the problems. We report here on the ways in which students used the structure maps during the interviews, the difficulties faced by students as they attempted to use these maps as well as the feedback offered by students regarding the maps. We also report on how we changed the maps based on feedback from the students and to facilitate their use during problem solving.

CP.812: **Students' Understanding of Inclined Planes Using the CoMPASS Curriculum**

*Jacquelyn J. Haynicz, Kansas State University, haynicz@phys.ksu.edu*
*N. Sanjay Rebello, Kansas State University*
*Sadhana Puntambekar, University of Wisconsin-Madison*

We discuss how students enrolled in a conceptual physics class for future elementary school teachers progress through the CoMPASS (Concept Map Project-based Activity Scaffolding System) curriculum for inclined planes. The curriculum challenges students to design the best inclined plane to lift a pool table into a van. We have found that students typically predict the correct type of board (long and smooth) to complete the challenge, but their responses include evidence of both physics and everyday reasoning. After working through the materials, the majority of students understand the relationship between distance and force in the inclined plane as well as why the inclined plane is useful to lift heavy objects. However, students have difficulty both relating a plane s steepness to the force required to pull an object and discussing work in a scientifically correct manner.

CP.813: **A Study of Peer Instruction Methods with High School Physics Students**

*Karen Cummings, Southern Connecticut State University, cummingsk2@southernct.edu*
*Stephen G. Robert, Staples High School*

This paper reports on the results of an experiment to test the use of a Peer Instruction (PI) in a high school environment. The study reports findings based on a population of 213 high school students attending algebra-based physics courses, both Honors and A level, taught by 5 different instructors. The results show a correlation between use of Peer Instruction and improved student conceptual understanding, as demonstrated by gains on a pre/post assessment instrument (FCI). However, there also appears to be a number of other factors that strongly influence the resulting gains. In addition to instructor differences, the data seem to indicate that students who are more physics-inclined and can answer questions correctly prior to instruction and prior to any Peer Instruction discussion subsequently achieve higher gains as measured by the FCI. While this is to be expected, the use of normalized gains is intended to mitigate this result, but it appears to be prevalent nonetheless. This raises questions as to what degree the FCI gains can be attributed to the use of Peer Instruction, to teacher differences, to student ability level or to simply increased familiarity with the question types presented on the FCI.

CP.820: **Effect of Initial Conditions and Discussion on Predictions for Interactive Lecture Demonstrations**

*Jeffrey Marx, McDaniel College, jmarx@mcdaniel.edu*

Over the past eight years at McDaniel College, students predictions to various Interactive Lecture Demonstrations (ILDs) have improved markedly. One explanation is that students have become increasingly sophisticated in their understanding of kinematics and dynamics. Another possible explanation is that the class as a whole is only slightly more sophisticated, and during the discussion phase of an ILD the correct prediction is very successfully transmitted within groups and between groups. To help begin to address this idea, I created a preliminary, computer-based simulation of classroom discussion.

CP.821: **Learning Problem-Solving Using Formative Assessment Rubrics**

*Sahana Murthy, Massachusetts Institute of Technology, sahana@mit.edu*

In our introductory calculus based physics class, students learn to solve and assess problems using rubrics. The problems are complex, involving multiple concepts and stages (for example, using conservation of momentum and conservation of energy, in different stages). The rubrics have detailed but generic descriptors for different categories: physics concepts, representations, modeling the situation, problem-solving machinery, and reasonableness of answer. At previous meetings, we have shown that students improve upon evaluation abilities and learn to successfully use the rubrics for peer- and self-assessment, if they are also provided with taxonomies that connect the rubric items with a specific problem. In this poster, we first explore the effects of making the assessment more formative: how do students perform if they have to solve a problem, write a taxonomy, self-assess their work, and then revise their solution based on their taxonomy and self-assessment? We also discuss students' perceptions of the rubrics.

The 2008 PERC organizers would like to thank Tiffany Hayes and Charlie Holbrow at AAPT for logistical support, and Bruce Mason, Lyle Barbato, and Mathew Riggsbee for technical support of the PERC 2008 website/database/etc. on COMPADRE. Also, our colleagues Chandralekha Singh, Steve Kanim, Mike Loverude, and Noah Finkelstein provided much needed advice and support.

We would also like to thank all the organizers at the University of Alberta.