

Contributed and Targeted Posters

A case study on reflective writing

Type: Contributed Poster

It has been shown in studies on the subject that many students view science as weakly connected pieces of information to be separately learned in contrast to the web of interconnections perceived by the instructors. Kalman pointed out that developing a scientific mindset may not simply be a conceptual change from personal scientific concepts to scientifically accepted concepts. It may also be a change in attitude from a view that study in science is a matter of solving problems using as independent set of tools, classified according to problem type, to a view that a science subject consists of a web of interconnected concepts. He has developed a toolbox to bring about the change. Reflective writing is one of these tools. In this study, we use the tradition of case study to explore the relationship among students' writing processes, products and attitude to physics and science courses.

Primary Contact: Xiang Huang, Concordia University

A Conceptual Analysis Approach to Physics Problem Solving

Type: Contributed Poster

Students in introductory physics courses treat problem solving as an exercise in manipulating equations, symbols, and quantities with the goal of obtaining the correct answer. Although this approach is efficient for getting answers, it is far from optimal for learning how conceptual knowledge is applied in the problem solving process. The goal of this study is to refine and evaluate an approach that encourages students to begin by writing a strategic analysis of a problem based on principles and procedures, and then to follow with a documented problem solution that exhibits, side-by-side, how concepts and equations go together in a solution. We will discuss the implementation and effectiveness of this approach in four local high school classrooms.

Primary Contact: Jennifer L. Docktor, Beckman Institute and Department of Physics, University of Illinois at Urbana-Champaign,

Co-authors: Natalie E. Strand, Beckman Institute and Department of Physics, University of Illinois at Urbana-Champaign, Jose P. Mestre, Beckman Institute and Department of Physics, University of Illinois at Urbana-Champaign, Brian H. Ross, Beckman Institute and Department of Psychology, University of Illinois at Urbana-Champaign

A New Use for Multimedia Learning in Introductory Physics

Type: Targeted Poster

We have recently created multimedia learning modules for use in an introductory calculus-based electricity and magnetism course. We have designed these modules in accordance with multimedia learning principles in order to reduce the cognitive load students experience during their first interaction with new physics material. In particular, we present the material as narrated animations under student control. Offloading the presentation of basic content to these multimedia presentations has, in turn, allowed the lectures to focus on active learning and concept refinement. The idea behind the multimedia modules is to create visual representations that reinforce the words as they are spoken so that the student can use the information from both their auditory and visual short-term memories to construct their understanding. We will present "in vitro" and "in vivo" studies of the effectiveness of this learning environment, as well as survey data on students' attitudes toward this approach to covering basic content.

Primary Contact: Jose Mestre, University of Illinois Urbana Champaign,

Co-authors: Gary Gladding and Tim Stelzer, Department of Physics, University of Illinois Urbana Champaign

Targeted Poster Session: Facilitating thinking and learning in the physics classroom

A resource framework can support a respectful perspective towards TAs

Type: Targeted Poster

Physics education has learned the benefits of respecting the ideas students bring into the classroom, an attitude that we think can and should be applied to beginning physics instructors. We advocate for a perspective of respect towards TAs when conducting TA research and instruction. Such a perspective sees TAs as partners in the endeavor of educating students and seeks productive seeds in their beliefs. A resource framework supports a respectful perspective by focusing the attention of researchers and instructors of TAs on what resources TA already have available to them. It also discourages a view of novice TAs that primarily focuses on their deficiencies as reform instructors. Thus, a resource framework helps instructors of TAs and researchers approach TAs with a respectful perspective that can foster long-term change as well as help build a more productive relationship between TAs and the PER community.

Primary Contact: Renee Michelle Goertzen, Florida International University,

Co-authors: Rachel E. Scherr, Department of Physics, Seattle Pacific University, Andrew Elby, Department of Physics, University of Maryland, College Park

Targeted Poster Session: The influence of theoretical frameworks on researchers' attitudes towards students

Addressing Student Difficulties with Statistical Mechanics: The Boltzmann Factor

Type: Contributed Poster

As part of research into student understanding of topics related to thermodynamics and statistical mechanics at the upper division, we have identified student difficulties in applying concepts related to the Boltzmann factor and the canonical partition function. With this in mind, we have developed a guided-inquiry worksheet activity (tutorial) designed to help students develop a better understanding of where the Boltzmann factor comes from and why it is useful. The tutorial guides students through the derivation of both the Boltzmann factor and the canonical partition function. Preliminary results suggest that students who participated in the tutorial had a higher success rate on assessment items than students who had only received lecture instruction on the topic. We present results that motivate the need for this tutorial, the outline of the derivation used, and results from implementations of the tutorial.

Primary Contact: Trevor I. Smith, Department of Physics & Astronomy, University of Maine,

Co-authors: John R. Thompson,, Department of Physics & Astronomy, University of Maine, The Maine Center for Research in STEM Education, University of Maine, , Donald B. Mountcastle, Department of Physics & Astronomy, University of Maine

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Addressing Student Needs in Instruction on the Expansion and Age of The Universe

Type: Contributed Poster

Recent scientific discoveries have bolstered the Hot Big Bang and Inflation cosmological models for the origin of the universe. At Chicago State University we endeavor to bring these new findings to the introductory astronomy course through interactive tutorials and hands-on inquiry-based laboratory activities. We have used science data-based resources as instructional aides to teach students about the expansion and age of the universe. Student pre-course essays indicate that students enter the class with a wide range of ideas regarding the age of the universe. Their essays and responses to pre-course surveys reveal that their ideas and the evidence they cite to support it are often incorrect. We have begun to use analysis of student essays, pre-course surveys, pre and post laboratory assessments, course examinations, and interviews to investigate the extent to which the laboratory activities and tutorials are helping students overcome initial ideas and gain an understanding of this topic.

Primary Contact: Geraldine L. Cochran, The Science House,

Co-authors: Kim Coble, Virginia Hayes, Melissa Nickerson, Chicago State University; , Janelle M. Bailey, University of Nevada Las Vegas; Lynn Cominsky, Kevin McLin, Sonoma State University

An Evaluation of the Effectiveness of Short Science Workshops for K-12 Teachers*

Type: Contributed Poster

We compare the effectiveness of brief science workshops that we have conducted for K-12 teachers with the in depth Physics by Inquiry Programs also conducted at University of Cincinnati. A four-week 120-hour Physics by Inquiry course is held for teachers in grades 5-12 and a separate two-week 60-hour course for teachers in grades K-5. Both courses use Physics by Inquiry¹ modules developed by Lillian McDermott and the Physics Education Group at the University of Washington. Due to requests from local school districts, we have also offered short science workshops with durations of from one-half to five days in length. We compared pretest and posttest data for similar physics topics, which were covered using Physics by Inquiry materials, for both the short and longer programs. The gains in conceptual understanding were much greater for the teachers in the more in depth Physics by Inquiry programs.

* Supported by The Improving Teacher Quality Program administered by the Ohio Board of Regents.

1. *Physics by Inquiry*, L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

Primary Contact: Robert J. Endorf, University of Cincinnati,

Co-authors: Kathleen M. Koenig, Wright State University

An Inquiry-Oriented Assessment Tool for Exploring Students' Reasoning

Type: Contributed Poster

As a part of a study on the science preparation of elementary school teachers, we are studying students' reasoning skills as they apply scientific concepts. We have devised content questions, which are open-ended with the distinguishing feature of applying recently learned concepts in a new context. This requires that students recognize and generalize the relevant facts or concepts and their interrelationships to suggest an applicable or plausible theory. To evaluate students' answers, we developed a rubric based on Bloom's taxonomy as revised and expanded by Anderson. We coded the

students' answers in terms of knowledge types and cognitive process components, and for each component we have defined three levels of accomplishment. This method fulfills our primary objective of constructing a method for comparing students' reasoning across different disciplines. In this paper, we will present an example of a content question and the method of analysis for this case.

Primary Contact: Mojgan Matloob Haghnikar, Kansas State University,

Co-authors: Sytil K. Murphy, Kansas State University, Dean A. Zollman, Kansas State University

Applying ISLE ideas to Active Engagement in the Spins Paradigm

Type: Targeted Poster

Oregon State University's (OSU) upper-division physics courses rearrange the traditional content to center around conceptual and mathematical ideas, with the aim of having students engage in authentic practices of physics in an interactive environment. The physics majors' introduction to Quantum Mechanics is the Quantum Measurements and Spin Paradigm (Spins). I am heavily influenced by the Investigative Science Learning Environment (ISLE) curriculum that mirrors the goals of these upper-division courses in having students engage in authentic practices of physics. Having spent two years implementing ISLE in the lower-division courses, when I taught the Spins course I modified some activities to align with ISLE methodology. The constructivist, scientific abilities approach of ISLE helped me strengthen the Spins course by providing connectivity between activities and a stronger emphasis on the goals surrounding preparing our students to think like physicists. My poster will focus on a specific activity sequence I implemented in this course.

Primary Contact: Dedra Demaree, Oregon State University

Targeted Poster Session: Upper-division activities that foster "Thinking like a Physicist"

Are Learning Assistants Better Secondary Science Teachers?

Type: Contributed Poster

This study investigates how the Learning Assistant (LA) experience affects teachers' first year of teaching. The LA Program provides interested science majors with the opportunity to explore teaching through weekly teaching responsibilities, an introduction to physics education research, and a learning community within the university environment. Some of these LAs are recruited to secondary science teacher certification programs. We hypothesized that the LA experience would enhance the teaching practices for the LAs who ultimately become teachers. To test this hypothesis, LAs were compared to a matched sample of teachers who completed the same teacher preparation program as the LAs but did not have the LA "treatment." LAs and "non-LAs" were compared through interviews, classroom observations, artifact packages, and observations made with Reformed Teacher Observation Protocol (RTOP) collected within the first year of teaching. Some differences were found, I will discuss these findings and their implications.

Primary Contact: Kara E. Gray, School of Education University of Colorado – Boulder,

Co-authors: Valerie K. Otero, School of Education University of Colorado – Boulder

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Assessing Student's Ability to Solve Textbook-Style Problems

Type: Contributed Poster

Development of students' "problem solving ability" is commonly cited as one of the primary goals in introductory physics courses. However, there is no broadly agreed upon definition of what is meant by "problem solving". Most physicists ultimately want students to be able to successfully apply a logical yet flexible approach to solving real world problems significantly different from any they have seen before. Still, many introductory instructors are first and foremost concerned with how successfully and thoughtfully students solve standard textbook-style problems. We have developed a 15-item survey to help assess students' abilities at solving textbook-style problems. In the Fall of 2009, we beta-tested this instrument on introductory physics students (pre-instruction and post-instruction) at several institutes and on a pool of "experts." In this poster, we will present details of the survey instrument, its administration, and some results from our first round of testing.

Primary Contact: Jeffrey Marx, McDaniel College,

Co-authors: Karen Cummings, Southern Connecticut State University

Assessing students' attitudes in a college physics course in Mexico

Type: Contributed Poster

Considering the benefits of modeling instruction in improving conceptual learning while students work more like scientists, an implementation was made in an introductory Physics course in a Mexican University. Recently Brewster, Kramer and O'Brien have observed positive attitudinal shifts using modeling instruction. These results are contrary to previous observations on other methodologies that promote active learning. Inspired in those results, the Colorado Learning Attitudes about Science Survey (CLASS) was applied as pre and post tests in two courses with modeling. In comparing the different categories of the CLASS, we have determined positive shifts in all the categories and significant differences in Overall and Applied Conceptual Understanding for a sample of 44 students. Given the characteristics of the sample, this study has required non-parametric methods.

Primary Contact: Hugo Alarcon, Tecnologico de Monterrey,

Co-authors: Jorge de la Garza, Tecnologico de Monterrey

Assessing the Effectiveness of the Upper-Division Physics Advanced Laboratory Course

Type: Contributed Poster

While much work has been done assessing lower-division undergraduate physics courses, there is a dearth of work in upper-division courses. This study was performed to begin this process in an upper-division advanced laboratory course at the Colorado School of Mines. A Global Concept Assessment (GCA) was developed and then administered at the beginning and end of the semester to assess student retention of important course concepts. Additionally, short "mini-quizzes" were developed for each lab and then administered either directly before or directly after that day's lab to investigate whether previewing or reviewing lab content resulted in more effective learning as measured by the GCA. Results indicate that the lab course is effective at teaching target concepts to a high degree of statistical certainty with negligible differences between preview and review effects.

Primary Contact: David Schuster, Colorado School of Mines,

Co-authors: Vince Kuo, Colorado School of Mines, Lawrence Wiencke, Colorado School of Mines

Assessment of Scientific Reasoning: A Case in Proportional Reasoning

Type: Targeted Poster

Proportional reasoning is one of six dimensions assessed by the Lawson's classroom test of scientific reasoning. Mastering of proportional manipulations is also a basic requirement for students to do well in STEM areas. Therefore, valid assessment of proportional reasoning is crucial for researchers and teachers to develop and implement effective instructions in all STEM education areas. There are four questions in the Lawson's test on proportional reasoning, with which multiple validity issues have been observed in large scale applications of the instrument. In this presentation, we will report our research on validating the questions and the development of new questions aimed to address the validity issues of the Lawson's test.

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Primary Contact: Lei Bao, The Ohio State University,

Co-authors: Jing Han, The Ohio State University, Kathy Koenig, Wright State University

Targeted Poster Session: Proportional Reasoning in Physics: What are students thinking? How can we help?

Benefit In Electricity And Magnetism From Prior Instruction Using The Modeling Applied to Problem Solving Pedagogy in Mechanics

Type: Contributed Poster

We examine the performance of a group of students in Introductory Electricity and Magnetism following a ReView course in Introductory Mechanics focusing on problem solving employing the MAPS pedagogy [1]. The group consists of students who received a D in the fall mechanics course (8.01) and were given the chance to attend the ReView course and take a final retest. Improvement to a passing grade was qualification for the Electricity and Magnetism course in the spring. The ReView course was conducted twice - during January 2009 and January 2010. As a control, we applied a similar procedure to a group of students with similar z-scores in 8.01 in Fall 2007 that were not offered the ReView course. We show that the ReView students perform ~ 0.5 standard deviations better than what is expected based on their performance on the fall exams ($p < 0.05$).

[1] "Modeling Applied to Problem Solving," Andrew Pawl, Analia Barrantes, and David E. Pritchard. AIP Conference Proceedings vol.1179, pp. 51-54, 2009 PHYSICS EDUCATION RESEARCH CONFERENCE.

Primary Contact: Saif Rayyan, Physics Department and Research Lab of Electronics, Massachusetts Institute of Technology,

Co-authors: Andrew Pawl, Physics Department and Research Lab of Electronics, Massachusetts Institute of Technology, Analia Barrantes, Physics Department and Research Lab of Electronics, Massachusetts Institute of Technology, Raluca Teodorescu, Physics Department and Research Lab of Electronics, Massachusetts Institute of Technology, David E. Pritchard, Physics Department and Research Lab of Electronics, Massachusetts Institute of Technology.

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But Does It Last? Sustaining a Research-Based Curriculum in Upper-Division Electricity & Magnetism

Type: Contributed Poster

We report on the process and outcomes from a three-year, six-semester project to develop, establish, and maintain a new course approach in junior-level electricity and magnetism (E&M). The course outcomes – improved learning gains and positive student attitudes – were sustained over five semesters of transfer between 5 different instructors of our E&M course. Additionally, the vast majority of the developed materials (i.e., clicker questions, interactive tutorials, modified homework, and documented student difficulties) were used by these instructors as well as being used at other institutions. These results indicate a high rate of sustainability of the course structure over time, between instructors, and between institutions. We describe the factors enabling this transfer to date, including instructors' personal experiences based on detailed longitudinal interviews.

Primary Contact: Stephanie V. Chasteen, University of Colorado - Boulder,

Co-authors: Rachel E. Pepper, Steven J. Pollock, Katherine K. Perkins, University of Colorado - Boulder

Can some wrong answers be more right than others?

Type: Contributed Poster

The Force Concept Inventory (FCI) has been efficiently used to assess conceptual learning in mechanics. Each FCI question has one Newtonian answer and four wrong answers (distracters). Researchers and practitioners most frequently use measures of total score to assess learning. Yet, are all wrong answers equivalent? We conducted Latent Markov Chain Modeling (LMCM) analyses of all choices (right and wrong) on a subset of four FCI questions. LMCM assesses whether there are groups of students sharing similar patterns of responses. We infer that students sharing similar patterns also share similar reasoning. Our results show seven reasoning-groups. LMCM also computes probabilities of transition from one reasoning-group to another following instruction. When examining transitions between groups, we note a clear hierarchy. Groups at the top of the hierarchy are comprised of students that use Newtonian thinking more consistently. Furthermore, proficient students choose some wrong answers more frequently.

Primary Contact: Helena Dedic, Vanier College,

Co-authors: Steven Rosenfield, Vanier College, Nathaniel Lasry, John Abbott College

Can Spatial Skills Training Improve Achievement in Introductory Mechanics?

Type: Contributed Poster

Although frequently neglected in traditional K–16 instruction, 3-D spatial skills are critical to success in science and engineering fields, especially physics. We investigated whether formal spatial skills training can improve achievement in an undergraduate calculus-based mechanics course. Participants (28 female, 49 male) were randomly assigned to either a training group that completed six two-hour spatial training sessions, or a control group that did not. The training group consistently outperformed the control group on the course's exams/quizzes with an effect size of $d = 0.38$ for the examination composite score. However, the groups did not differ on a Force Concept Inventory (FCI) post-test. Nevertheless, common measures of spatial skills predicted students' normalized FCI gains independent of FCI pre-test scores. These results illustrate that developing spatial

skills is an important goal of physics instruction, and that improving these skills can improve problem-solving (although not necessarily conceptual understanding) in introductory mechanics.

Primary Contact: David I. Miller, Harvey Mudd College,

Co-authors: Diane F. Halpern, Claremont McKenna College, Peter N. Saeta, Harvey Mudd College

Changes in Students: Conceptual Understanding of Force, Velocity, and Acceleration

Type: Contributed Poster

We have developed a multiple-choice test designed to probe students' conceptual understanding of the relationships among the directions of force, velocity, and acceleration. We report here on student data taken over the course of instruction in introductory mechanics and electricity and magnetism. This data suggests that honors students move from the common incorrect response, for example that velocity must be in the direction of the acceleration or net force, through a "partially correct" response, that velocity can be either opposite to or in the direction of the acceleration or net force but not zero, before arriving at a correct model. This data is in agreement with previously reported results that showed these patterns among different levels of students but was not a within student study. In addition, we report on the effectiveness of different small computer based training sessions given shortly before students take this quiz.

Primary Contact: Rebecca Rosenblatt, The Ohio State University,

Co-authors: Andrew Heckler, The Ohio State University

Changing Participation through Formation of Student Learning Communities

Type: Targeted Poster

Differences in learning gains between interactive engagement and lecture instructional practices have been well documented and yet the ways in which students participate in each of these learning environments are not clearly established. We use social network analysis as one way to establish differences the participation of students in lecture sections and students in Modeling Instruction, a curriculum that uses interactive engagement. One primary difference in the way students participate in the two instructional practices is that students in Modeling Instruction classes form learning communities and students in lecture classes remain isolated. Students in Modeling Instruction sections report 10x greater numbers of ties between students than those in lecture sections, forming richer and more deeply connected networks. We interpret these differences in terms of a participationist view on learning and as an explanatory mechanism for understanding documented differences in learning gains in the two settings.

Primary Contact: Eric Brewé, Florida International University,

Co-authors: Laird H. Kramer, George E. O'Brien, Department of Teaching and Learning & Department of Physics, Florida International University

Targeted Poster Session: Characterizing Participation in and around the Physics Classroom

Characterizing Complexity of Computer Simulations and Implications for Student Engagement

Type: Contributed Poster

Interactive simulations can be engaging tools for student learning, allowing students to explore phenomena by asking questions and seeking answers by interacting with the simulation and interpreting the effects. PhET simulations allow this process to happen

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dynamically so that students can continuously probe and explore the underlying science. For students to use simulations productively, understanding the science in the simulation must be challenging enough to maintain students' interest, but not so challenging that students are overwhelmed. A key aspect of achieving a good balance is the complexity of the simulation for students. We have formulated an initial model to quantify complexity based on the number, range, and effects of controls and representations within a simulation. We account for students' prior knowledge by adjusting the measured complexity depending on how students interpret the representations and conceptual connections within the simulation. Implications for simulation design and student engagement will be discussed.

Primary Contact: Noah Podolefsky, University of Colorado,

Co-authors: Wendy K. Adams, University of Colorado, Katherine K. Perkins, University of Colorado

Characterizing Participation in and around the Physics Classroom

Type: Targeted Poster Session

A major aspect of educational reform in college physics has been the design of learning environments that improve student understanding and attitudes toward science. One of the most direct impacts that these reforms have is in how they restructure students' participation in and around the physics classroom, including how and where students interact with peers, instructors, technology, and curricular materials. This session focuses on research approaches that aim to capture and characterize the nature of students' participation within various educational spaces, which represent reforms common to physics education. In discussing their studies, presenters will be asked to reflect upon how their research frameworks, methodologies, and findings contribute to conceptualizations of students' progress and successful programs in ways that go beyond traditional measures.

Primary Contact: Brian Frank, University of Maine

Children's Attitudes about Science as a Result of Informal Science Education

Type: Contributed Poster

The JILA Physics Frontier Center Partnerships for Informal Science Education in the Community (PISEC) provides informal after-school inquiry-based science teaching opportunities for university participants with children typically underrepresented in science. PISEC is in the process of validating the Children's Attitude Survey (CAS), which is based on the Colorado Learning Attitudes about Science Survey (designed to measure college students' attitudes about science and the nature of science.) The CAS measures children's attitudes about science and the nature of science. We present pre- and post-semester results for several semesters of the PISEC program, and demonstrate that, unlike most introductory physics courses in college, after-school informal science programs support and promote positive attitudes about science. This work is supported, in part, by NSF # 0551010, the JILA AMO PFC.

Primary Contact: Rosemary P. Wulf, University of Colorado Physics,

Co-authors: Laurel M. Mayhew, University of Colorado Physics, Noah D. Finkelstein, University of Colorado Physics

Clickers or flashcards: An activity theory interpretation

Type: Contributed Poster

Physics educators and researchers have recently begun to distinguish between pedagogical approaches and educational technologies used to implement them. For instance, peer instruction has been shown to

be equally effective, in terms of student learning outcomes, when implemented with clickers or flashcards. In such a situation, technological tools (clickers and flashcards) can be viewed as mediating pedagogical techniques (peer instruction or traditional instruction). In this paper, we use activity theory to understand peer instruction, with particular attention to the role of tools. This perspective helps clarify clickers' and flashcards' differences, similarities, impacts in the classroom, and utility to education researchers. Our analysis also suggests improvements and new uses. Finally, we propose activity theory as a useful approach in understanding and improving the use of technology in the physics classroom.

Primary Contact: Edward Price, California State University San Marcos,

Co-authors: Charles De Leone, California State University San Marcos, Nathan Lasry, John Abbott College

Closing the Feedback Loop: Assessment in an Introductory Physics Course for Nonmajors

Type: Contributed Poster

Effective teaching requires that instructors are aware of what students know and how they learn. Assessment, particularly formative assessment, plays a key role in supporting student learning when it is used to inform instruction. Though the research literature has many examples of innovative science course reform efforts, few studies have examined assessment within these courses, particularly in courses that employ multiple components (e.g., lecture, laboratory, recitation) in which assessment is carried out by different instructors. The purpose of this study was to understand the way in which information about student learning is disseminated among faculty and teaching assistants (TAs) undertaking course reform efforts in an introductory physics course for nonmajors. Data were gathered through observations of class sessions and interviews with students, professors, and TAs. We will share a model "feedback loop" through which assessment data can be used to inform instruction in introductory science courses.

Primary Contact: Nilay Muslu, University of Missouri Columbia,

Co-authors: Dr. Deborah Hanuscin, University of Missouri Columbia

Constructing a Model of Physics Expertise

Type: Contributed Poster

Research on physics expertise has predominantly focused on cognitive differences between physics experts and novices where the novices are high school or introductory college students and the experts are university physics professors or graduate doctoral students. Most physics expertise studies declare the experts to be physics faculty without justifying this decision. To establish more clearly the characteristics of physics experts, we conducted a qualitative interview pilot study of three university physics professors. The professors each had an hour-long interview where they were about their experiences of becoming a physics expert. We present the analysis of the question, "What makes a physics expert?" Analysis of the data resulted in the construction of a model of physics expertise, which indicates that one is a specific physics expert first, acquires general physics expert characteristics and then becomes an expert in physics or a boundary crosser.

Primary Contact: Idaykis Rodriguez, Florida International University,

Co-authors: Eric Brewé, Florida International University, Laird Kramer, Florida International University

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Constructing Definitions as a Goal of Inquiry

Type: Contributed Poster

In a class on perception, students, over the course of 3 weeks, constructed an account of “blurriness” with respect to vision, describing blurriness as occurring when “more than one ray from two separate points out in space are hitting the retina at one point.” This account of blurriness, however, was just one of many introduced early on in our investigations of the eye. As students worked to model the eye and developed a consensus description of how lenses and pinholes create images, the “the separate points in space to one point on the retina” idea was refined, gained prominence in discussions and became a stable, useful, and precise concept. This paper explores one student’s progressive understanding of blurriness, and the activities and interactions that supported the development of this definition.

Primary Contact: Leslie J. Atkins, CSU, Chico,

Co-authors: Irene Y. Salter, CSU, Chico, Department of Science Education

Copying the lab key, or: How to apply the Algebra Project to science teacher professional development

Type: Targeted Poster

The Algebra Project, led by R. Moses, provides access to understanding of algebra for middle school students and their teachers by guiding them to participate actively and communally in the construction of regimented symbolic systems. We have extended this work by applying it to the professional development of science teachers (K-12) in energy. As we apply the Algebra Project method, the focus of instruction shifts from the learning of specific concepts within the broad theme of energy to the gradual regimentation of the interplay between learners’ observation, thinking, graphic representation, and communication. This approach is suitable for teaching energy, which by its transcendence can seem to defy a linear instructional sequence. The learning of specific energy content thus becomes more learner-directed and unpredictable, though at no apparent cost to its extent. Meanwhile, teachers seem compelled by this method to reclaim the rightful place of their students in the scientific process.

Primary Contact: Hunter Close, Seattle Pacific University

Targeted Poster Session: Taking Responsibility for the Hidden Curriculum: Practices and Challenges in addressing the broader goals in physics education

Creating Classroom Reform Using a Sociocultural Mediation Process

Type: Contributed Poster

We propose a process designed to help actors (instructors and students) reflect on their classroom learning environments, and negotiate social action to modify those environs. Usually actors implicitly negotiate their roles in, and expectations of, their classrooms. However, an explicit process whereby actors list, rank, and discuss their important learning elements, and then rate their classroom with respect to those elements, can shape this negotiation into a cogenerative goal setting activity. This mediation is useful for continuously identifying and addressing specific targets for classroom reform. Furthermore, all community members can have the opportunity to be collectively engaged in building a unique learning environment. Benefits to students and instructors include a concrete method for negotiating a frame shift toward student-centered learning modes. Advantages to educational researchers include new

opportunities to analyze artifacts produced as a result of a collective process.

Primary Contact: Natan Samuels, Florida International University,

Co-authors: Eric Brewé, Florida International University, Laird Kramer, Florida International University

Critical and Scientific Thinking for Pre-service Elementary Teachers

Type: Targeted Poster

The objectives of K-12 teacher education science courses often focus on conceptual learning and improving students overall attitude towards science. It is often assumed that with the use of research-based curriculum material and more hands on inquiry approaches, without any explicit instruction, student scientific and critical thinking skills would also be enhanced. I have been investigating student scientific and evidence-based reasoning abilities in a K-8 pre-service science course at Cal Poly Pomona in the last three years. After recognizing student specific difficulties, I have provided explicit feedback using rubrics to assist students to become more rigorous and reflective thinkers; to use appropriate and accurate vocabulary; exercise evidence-base reasoning; and develop skepticism with respect to their own views. I will share the preliminary rubrics and report the results.

Primary Contact: Homeyra Sadaghiani, California State Polytechnic University Pomona

Targeted Poster Session: How to think and talk like a physicist?

Cultivating multiple sensitivities to student thinking

Type: Targeted Poster

As researchers and instructors, we use observations of actions, statements, and written work to make what inferences we can about student thinking. Recent work in PER has emphasized the importance of explicit theoretical frameworks in how and what we attend to when considering such observations. This presentation will offer the perspective of a “physics-oriented” PER practitioner for whom theoretical frameworks principally offer informed modes of uncovering student thinking. In this view, a given framework is a tool for listening (or, more generally, observing) students in a certain way. The value of the framework rests in large part in its ability to contribute to the design of instructional environments and strategies that move students toward desired learning goals. This perspective will be illustrated through the analysis of video data from a Physics and Everyday Thinking class.

Primary Contact: Andrew Boudreaux, Western Washington University

Targeted Poster Session: Out of One, Many; Five Researchers Analyze the Same Student Video

Curriculum Development Addressing Multiplicity, Probability and Density of States in Statistical Physics

Type: Contributed Poster

In research on teaching and learning in upper-division statistical physics, we created a guided-inquiry activity (tutorial) addressing the discrete binomial distribution and its approximation by the continuous normal distribution. The curriculum emphasizes the distribution dependence on N , the number of binary trials, making extensive use of computational software with graphical displays, allowing N to span more than six orders of magnitude. These activities provide excellent motivation for examining the increasing

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density of states toward the limit where integration of a continuous density function is required. Thus, we have an ideal opportunity for students to engage the summation to integration transition of integral calculus. The tutorial and a revised version were implemented during the past two years. Findings include improvement in recognition that the distributions become increasingly narrowed about the mean with increasing N . However, significant confusion remains between microstates and macrostates and their roles in determining probability.

* Support: NSF

Primary Contact: Donald B. Mountcastle, University of Maine,

Co-authors: John R. Thompson, Department of Physics and Astronomy, Maine Center for Research in STEM Education, University of Maine

Design of a Synthesizing Lecture on Mechanics Concepts

Type: Contributed Poster

Within the context of traditional physics problem solving instruction, major concepts are mentioned but often marginalized by the focus on equation manipulation, resulting in students perceiving concepts as unimportant in problem solving. Additionally, since topics are covered as isolated pieces, students also perceive concepts as unrelated. In response to this disconnect, we discuss the development of a short, animated, web-delivered synthesizing presentation modeled after the “common learning resource” from the preparation for future learning construct. In the presentation, major concepts of introductory mechanics are structured hierarchically. More specifically, the presentation is an overview of major theorems and conservation laws in mechanics and the conditions under which they are applied. It is linked to previous problems solved by the student and intended to prepare students for future learning by illustrating how concepts guide problem solving processes.

Primary Contact: Natalie E. Strand, Beckman Institute, University of Illinois at Urbana-Champaign,

Co-authors: Jennifer L. Docktor, , Gary E. Gladding, , Jose P. Mestre, , Brian H. Ross, University of Illinois at Urbana-Champaign

Detecting Differences in Changes to Physics Diagrams

Type: Contributed Poster

Constructing a useful mental representation of physics situations is integral to success in problem solving. It is known that experts identify/perceive meaningful patterns and/or changes in visual stimuli related to their domain of expertise. We present data from an experiment using the “flicker” technique, in which teaching assistants for introductory physics courses, students who had finished a calculus-based mechanics course, and physics-naïve students viewed nearly identical pairs of diagrams that are representative of typical mechanics situations. The two diagrams in each pair contain a subtle difference that either does, or does not change the underlying physics depicted in the diagram. We present results on how the speed of noticing physics-relevant changes in the diagram pairs depends on physics experience and discuss the cognitive implications of our findings.

Primary Contact: Natalie E. Strand, Beckman Institute, University of Illinois at Urbana-Champaign,

Co-authors: Jose P. Mestre (Departments of Physics and Educational Psychology, University of Illinois at Urbana-Champaign, Urbana, IL 61801)

Developing Thinking & Problem Solving Skills in Introductory Mechanics

Type: Targeted Poster

We report on the Thinking in Physics (TIP) project, which helps students with weak scientific reasoning skills, as measured by low preinstruction scores on the SAT and on the Lawson Test of Scientific Reasoning Ability. We describe methods used to improve students’ thinking and problem solving skills in TIP introductory mechanics classes. The project is supported by NSF grant 0633353.

Primary Contact: Vincent P. Coletta, Loyola Marymount University,

Co-authors: Jeffrey A. Phillips, Department of Physics, Loyola Marymount University

Targeted Poster Session: How to think and talk like a physicist?

Developing, Deploying, and Evaluating Computer Modeling Homework

Type: Contributed Poster

Computer modeling is taught in few introductory physics courses. For those in which computer modeling is taught, the student experience is generally limited to the laboratory. We have worked to extend this experience to other aspects of the introductory course, including homework and exams. We present our experiences in developing and deploying this homework sets and the subsequent evaluation of students computer modeling abilities in a set of large introductory courses ($N \sim 500$). This work is supported by NSF DUE-0942076.

Primary Contact: Marcos D. Caballero, Georgia Institute of Technology,

Co-authors: Michael F. Schatz, Georgia Institute of Technology, Matthew A. Kohlmyer, North Carolina State University

Development and evaluation of a large-enrollment, active-learning physical science curriculum

Type: Contributed Poster

We report on the initial field tests of Learning Physical Science (LEPS), a new curriculum adapted from Physical Science and Everyday Thinking (PSET). PSET is an inquiry-based, hands-on, physical science curriculum that includes an explicit focus on nature of science and nature of learning. PSET was developed for small enrollment discussion/lab settings. The Learning Physical Science (LEPS) curriculum maintains the same research-based learning principles as PSET but is suitable for classes taught in lecture format. LEPS has been field tested by eight instructors at different universities. In this paper, we describe the adaptation process, the resulting LEPS curriculum, and present student learning outcomes for LEPS and PSET.

Primary Contact: Fred Goldberg, San Diego State University, Center for Research in Mathematics & Science Education,

Co-authors: Edward Price, California State University San Marcos, Danielle Boyd Harlow, University of California Santa Barbara, Steve Robinson, Tennessee Technical University, Rebecca Kruse, BSCS, Michael McKean, San Diego State University, Center for Research in Mathematics & Science Education

Contributed and Targeted Posters

Development of functional understanding in physics: Promoting ability to reason

Type: Invited Talk

A functional understanding of a concept in physics connotes the ability to interpret and apply it appropriately. The need to help students learn how to do the requisite reasoning is often ignored in introductory physics, a neglect that often continues in upper division courses. The emphasis in most recent research at the university level has been on the qualitative understanding of concepts, models of student thinking, and problem solving ability. These are all important, but there is also a need to conduct research to guide the development of instructional materials that promote the development of basic scientific reasoning skills (e.g., interpretation of proportions, construction of proper analogies, control of variables, use of limiting arguments, deductive and inductive logic). Examples will illustrate how the study of physics can cultivate ability in scientific reasoning. The research and related curriculum development discussed in this presentation have been supported, in part, by a series of NSF grants, of which the most recent are: DUE #0618185 and DR-K12 #0733276.

Primary Contact: Lillian C. McDermott, University of Washington

Dignifying the human condition. How PhET sim design respects student agency.

Type: Targeted Poster

As a researcher, I place a high value on feeling empowered as a key agent of my own learning. As an educator, I place a high value on empowering students as agents of their own learning. In this poster I will ask: how can educational tools be designed and used such that students take credit for what they do and learn? I will use PhET interactive simulations as an example. Educational tools re-structure the world in order to make student learning more efficient. There is always a balance between how much re-structuring is pre-determined for students, and how much is left to student choice. My theoretical bias aims to help students feel both responsible for and capable of exploring and re-structuring the world, hence seeing themselves as key agents of their own learning. I will describe this theoretical framework and how it aligns with my values and respects student agency.

Primary Contact: Noah Podolefsky, University of Colorado at Boulder

Targeted Poster Session: The influence of theoretical frameworks on researchers' attitudes towards students

Direct and Indirect Approaches to Increasing Conceptual Survey Gains

Type: Contributed Poster

Conceptual surveys like the FCI and CSEM are common, and course reforms often have the goal of improving student gains on these surveys. There exist various approaches to improving said gains, and while some approaches have been accused of "teaching to the test", such accusations have generally been well-refuted. To our knowledge, however, there has been little direct experimentation on whether teaching to the test, even intentionally, has the expected result. In this poster, we report on a two-semester experiment involving ~900 students where we tried two different approaches to improving CSEM gains in an introductory E&M class. In the first trial, we gave students many of the questions from the CSEM as Peer Instruction-style clicker questions in lecture. In the second, we redeveloped parts of our Studio physics curriculum to target CSEM

concepts without replicating CSEM questions. We compare the data from each experimental semester to previous years' data.

Primary Contact: Patrick B. Kohl, Colorado School of Mines,

Co-authors: Patrick B. Kohl, Colorado School of Mines, Department of Physics, , Vince Kuo, Colorado School of Mines, Department of Physics

Documenting and Interpreting Ways to Engage Students in 'Thinking Like a Physicist'

Type: Targeted Poster

The Paradigms in Physics Program at Oregon State University has adapted a variety of interactive pedagogies to engage students in "thinking like a physicist." Video recordings of class sessions document what the students and instructor say and do. This paper discusses development of narrative interpretations of such videos. Examples are drawn from two detailed narratives of wrap-up discussions during which the main ideas emerged during the discussions rather than during the tasks that the students had been doing in their small groups. The goal of these "compare and contrast" wrap-up discussions was to help the students envision connections among geometric and algebraic representations of the mathematics they would be using during the coming weeks of instruction in quantum mechanics. The purpose of the narratives is to provide examples of wrap-up discussions with commentary about ways in which the instructor was choosing to guide this process.

This material is based upon work supported by the National Science Foundation under Grant No. DUE 0618877

Primary Contact: Emily van Zee, Oregon State University,

Co-authors: Corinne Manogue, Department of Physics, Oregon State University

Targeted Poster Session: Characterizing Participation in and around the Physics Classroom

Effects of a Prior Virtual Experience on Students' Interpretations of Real Data

Type: Contributed Poster

Our previous work has shown that experimentation with virtual manipulatives supports students' conceptual learning about simple machines differently than experimentation with physical manipulatives [1]. This difference could be due to the "messiness" of physical data from factors such as dissipative effects and measurement uncertainty. In this study, we ask whether the sequence of experimentation with physical and virtual manipulatives affects how students interpret the data from the physical experiment. Students enrolled in a conceptual-based physics laboratory performed both physical and virtual experiments to learn about pulleys and inclined planes. Approximately half of the students performed the physical experiments before the virtual experiments, and the other half completed the virtual experiments first. We find that using virtual manipulatives before physical manipulatives promotes an interpretation of the physical data that is more productive for conceptual learning.

This work is supported by the U.S. Department of Education, Institute of Education Sciences Award R305A080507.

Primary Contact: Jacquelyn J. Chini, Department of Physics, Kansas State University,

Co-authors: Adrian Carmichael, Department of Physics, Kansas State University, Elizabeth Gire, Department of Physics, Kansas State University, N. Sanjay Rebello, Department of Physics, Kansas State University, Sadhana Puntambekar, Dept. of Educational Psychology, University of Wisconsin, Madison

Contributed and Targeted Posters

Electric Field Concept: Effect of the Context and the Type of Questions

Type: Contributed Poster

We administered open-ended questions to students in an electricity and magnetism class at a private Mexican university to elucidate difficulties with the electric field concept. In the first part of this report, the objective is to compare students' responses to electric field questions in the presence of charges and conductors to those in the presence of charges and insulators. In the second part, the objective is to analyze the difference in responses when the context is changed by comparing responses to electric field questions with reference to abstract objects, i.e., point charge, non-conducting sphere; to those with reference to already-used real materials in lab, i.e., charged tape, non-conducting pencil. In the last part, the objective is to analyze whether a guided question helps students to better answer electric field questions by comparing students' responses to questions with no guidance to responses to guided questions and the degree of guidance.

Primary Contact: Genaro Zavala, Tecnológico de Monterrey,

Co-authors: Alejandro Garza, Tecnológico de Monterrey

Elements of a College-Level Inquiry-Based Physics Classroom

Type: Contributed Poster

Components of a college-level introductory physics course at a large Midwestern university were investigated for the purpose of obtaining a better understanding of the elements that contribute to success of the student in an inquiry-based setting. More explicitly, this course offers students the ability to learn physics concepts through carefully designed laboratory instructions without a lecture component, as opposed to the more traditional setting where lecture is the teaching method of focus. A structural Equation Model (SEM) was utilized both to aid in the definition of and relate course elements such as quizzes, exams, narrative learning reflections, and diagnostic tests to interconnections that promote achievement in inquiry-based physics. Initial findings suggest latent components of inter-student communication and physics aptitude play a strong role in the success of the inquiry-based physics student.

Primary Contact: Jennifer Esswein, The Ohio State University, School of Educational Policy and Leadership,

Co-authors: Bruce R. Patton, Professor of Physics, , The Ohio State University, Columbus, OH 43210, 614-292-8210, patton.1@osu.edu

Encouraging Scientific Discourse in the Introductory Physics Classroom

Type: Targeted Poster

One of the goals of the active-learning based introductory physics sequence for biologists at California State University San Marcos is to improve the students' ability to engage in scientific discourse. Structuring a class to promote such interaction, and facilitating the resulting student-student and instructor-student discourse is not trivial, as the role of the instructor and student is far from traditional. This poster will consider issues associated with teaching in such an environment, including a focus on instructor's role in best facilitating such discourse.

Primary Contact: Charles De Leone, California State University San Marcos

Targeted Poster Session: How to think and talk like a physicist?

Energy in action: The construction of physics ideas in multiple modes

Type: Contributed Poster

In a course organized around the development of diverse representations, no single mode of expression offers a complete picture of participants' understanding of the nature of energy. Instead, we argue, their understanding is actively constructed through the simultaneous use of a range of quite different kinds of representational resources (Goodwin, 2000), including not only words but also gestures, symbolic objects, participants moving their bodies in concert, and whatever other communicative modes the course invites them to use. Examples are provided from a teacher professional development course on energy.

Goodwin, C., Action and embodiment within situated human interaction. *Journal of Pragmatics*, 2000. 32: p. 1489-1522.

Primary Contact: Eleanor Close, Seattle Pacific University,

Co-authors: Hunter G. Close, Seattle Pacific University; Sarah B. McKagan, McKagan Enterprises; Rachel E. Scherr, Seattle Pacific University

“Energy Theater”: Using the body symbolically to understand energy

Type: Contributed Poster

The essential characteristics of energy are not typically an explicit topic of physics instruction. Nonetheless, participants in physics courses that involve energy are constantly saying what kinds of thing they think energy might be, both verbally and nonverbally. The premise of an embodied-cognition theoretical perspective is that we understand the kinds of things that may exist in the world (ontology) in terms of sensory-motor experiences such as object permanence and movement. We offer an example of an “embodied learning activity” about energy: that is, an activity in which we deliberately arrange for human bodies to symbolize entities in physical phenomena involving energy transfers and transformations. Our observations suggest that this “Energy Theater” uniquely promotes engagement with deep conceptual questions about energy.

Primary Contact: Rachel Scherr, Seattle Pacific University,

Co-authors: Sarah B. McKagan, McKagan Enterprises, Hunter G. Close, Eleanor W. Close, Seattle Pacific University

Enhancing problem-solving abilities by repeated training with scaffolded synthesis problems

Type: Contributed Poster

Based on learning by analogical encoding, we designed and implemented conceptually scaffolded synthesis problems to induce students to rely on fundamental concepts for problem-solving, an approach frequently employed by experts. These synthesis problems combine multiple topics that are broadly separated in the teaching timeline, militating against novice-like formula-based solutions. Moreover, each synthesis problem is sequenced with two preceding concept questions that share with it the same deep structure. After answering the concept questions and before solving the synthesis problem, students are explicitly reminded to seek the underlying connections. These concept questions, together with the explicit reminder, are used as guided scaffolding.

A series of studies have been conducted. Specifically, this paper comparatively investigates the sustained effects of repeated training using scaffolded synthesis, un-scaffolded synthesis and textbook-like problems. Results are reported and

Contributed and Targeted Posters

the advantage and/or potential issues of each treatment are discussed.

Primary Contact: Lin Ding, Department of Physics, The Ohio State University,

Co-authors: Neville W. Reay, Department of Physics, The Ohio State University

Epistemological Framing and Exterior Knowledge in Physics Problem Solving

Type: Contributed Poster

Despite instructors' best efforts to encourage the use of common sense in physics problem solving, students often treat physics as unrelated to the rest of their lives. However, students have access to a wealth of relevant physical knowledge that is not explicitly taught in physics class. I label this "external knowledge". Here, I present a semester-long study examining students' use of external knowledge in solving context-rich physics problems. The data set consists of in-situ audio recordings of students working in groups during the weekly problem-solving session of their introductory algebra-based physics course. My analysis highlights how the students' problem solving strategies and epistemological framing during problem-solving sessions correlate with their use of external knowledge. The results suggest ways to maximize opportunities for students to use external knowledge in problem solving.

Primary Contact: Mathew "Sandy" Martinuk, Department of Physics and Astronomy, University of British Columbia

Epistemology in the hidden curriculum: Why should anyone care?

Type: Round Table Discussion

The evidence is unequivocal: physics courses influence students' epistemological beliefs whether we intend this or not. Unfortunately the influence is often negative in that students seem to move further away from the epistemic perspective of a physicist. We suggest that the physics curriculum, materials, learning activities, learning environment and assessments all send epistemic messages to our students. These are messages about the nature of physics and physics learning, and how physicists have come to know what they know. Such tacit messages form part of the hidden curriculum (Lin, 1982). Science instructors often lament that science is too often presented as a 'rhetoric of conclusions' (Schwab, 1962) – but why should we care? Why should instructors concern themselves about anything beyond students' understanding of physics content and ability to solve problems? The purpose of this round table discussion will be to explore why one should care about students' epistemological development.

Primary Contact: David T. Brookes, Florida International University,

Co-authors: Saalih Allie, University of Cape Town, Eugenia Etkina, Rutgers, The State University of New Jersey, David Hammer, University of Maryland, College Park, Yuhfen Lin, Florida International University, Edward F. Redish, University of Maryland, College Park, David Schuster, Western Michigan University

Examining the Beliefs and Practice of Teaching Assistants: Two Case Studies

Type: Contributed Poster

In an effort to study the impact of teaching experience and preparation on the pedagogical beliefs of physics Teaching Assistants (TAs), we investigate the beliefs expressed by TAs following one or more semesters of teaching with the Tutorials in Introductory Physics. The beliefs of TAs mediate the actions they take in working

with students, as well as the classroom norms they set for participation in the Tutorial activity. In this work, we build upon existing analytic frameworks to characterize two distinct sets of TA beliefs gathered from pre- and post-semester interviews. We present preliminary indications of coordination between these beliefs and the in-classroom practice of these TAs. We then conclude with implications for training TAs in order to promote more pedagogically sophisticated beliefs at a potentially critical time in their professional development.

Primary Contact: Benjamin T. Spike, University of Colorado at Boulder,

Co-authors: Noah D. Finkelstein, University of Colorado at Boulder

Experimental methods for studying student Metacognition and Affect

Type: Workshop

This workshop will focus on the use of intelligent tutor systems in a classroom setting to study student meta-cognition and affect. We have been using a tutoring system to study gaming behavior (that is, attempting to succeed in a learning environment by exploiting properties of the system rather than by learning the material) as students work on introductory physics homework problems. Gaming behavior can be explained by either student affect (e.g., frustration or lack of motivation) or meta-cognition (e.g., "reading hints won't help me learn").

Join us as we: 1) survey research methodologies for studying affect and meta-cognition, listing their strengths and weaknesses; 2) present some relevant studies of meta-cognition and affect using intelligent tutor systems as an experimental probe; 3) conduct a hands-on introduction of the new version of our physics tutoring system, Andes, that allows natural language conversation through chat; and, 4) brainstorm possibilities for future studies.

Primary Contact: Brett van de Sande, Arizona State University

Exploring student understanding of atoms and radiation

Type: Contributed Poster

While developing inquiry materials on radioactivity, we uncovered substantial student difficulties with thinking of atoms as both sources and victims of ionizing radiation. Most students in a survey level physics course initially had only vague ideas about the structure of atoms and the roles of protons, neutrons, and electrons. None invoked electrostatic attraction to explain why electrons stay near nuclei. Developing new, productive ideas about atoms was nontrivial.

We created inquiry-based activities that employ a new simulator (Atom Builder) that allows students to manipulate one atom at a time and observe its behavior. Student knowledge of atomic structure and ionization improved dramatically but certain basic ideas remain elusive for many students.

We will present ways of thinking about atoms that students brought to the classroom, and that they developed using the simulator.

Primary Contact: Andy Johnson, Black Hills State University,

Co-authors: Anna Hafele, Black Hills State University

Contributed and Targeted Posters

Exploring the Transition Between Quantum and Classical Physics Using Compelling Graphical Representations

Type: Targeted Poster

One physics BIG Idea is cognitive engagement of the transition from discrete to continuum, from quantum to classical physics. Probability, statistics and entropy are also challenging curriculum components for students. Some of the issues above are reflected in the mathematical processes of discrete Riemann summation morphing into the integration of continuous functions; e.g., normalization accomplished via integration over probability density. To help students master these concepts, I developed and twice implemented in upper-level statistical mechanics a guided-inquiry in-class tutorial with assessment homework. Students are assigned specific tasks prior to the scheduled in-class activity, using MATHEMATICA® (code provided) for calculations and distribution plots to display probabilities for $10 < N < 107$ coin flips. We will engage part of the activity in the graphical sequence intended to help students model an outcome state of overwhelming probability, in spite of decreasing probability as N increases. Supported by NSF Grants: PHY-0406764, DRL-0633951, DUE-0817282.

Primary Contact: Donald B. Mountcastle, University of Maine

Targeted Poster Session: Upper-division activities that foster “Thinking like a Physicist”

Facilitating Students’ Problem Solving across Multiple Representations in Introductory Mechanics

Type: Targeted Poster

Solving problems presented in multiple representations is an important skill for future physicists and engineers. However, such a task is not easy for most students taking introductory physics courses. We conducted teaching/learning interviews with 20 students in a first-semester calculus-based physics course on several topics in introductory mechanics. These interviews helped identify the common difficulties students encountered when solving physics problems posed in multiple representations as well as the hints that help students overcome those difficulties. We found that most representational difficulties arise due to the lack of students’ ability to associate physics knowledge with corresponding mathematical knowledge. Based on those findings, we developed, tested and refined a set of problem-solving exercises to help students learn to solve problems in graphical and equational representations. We present our findings on students’ common difficulties with graphical and equational representations, the problem-solving exercises and their impact on students’ problem solving abilities.

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

Primary Contact: Dong-Hai Nguyen, Kansas State University,

Co-authors: Elizabeth Gire and N. Sanjay Rebello, Kansas State University

Targeted Poster Session: Facilitating thinking and learning in the physics classroom

Facilitating thinking and learning in the physics classroom

Type: Targeted Poster Session

Learning physics is challenging. There are only a few fundamental principles of physics that are condensed in compact mathematical forms. Learning physics requires unpacking

these fundamental principles and understanding their applicability in a variety of contexts. Cognitive theory can be employed to design instruction and facilitate thinking and learning in the physics classroom. In this session, we will showcase examples of instructional strategies based upon the principles of learning that have been effective in improving students’ learning. These approaches include helping students learn physics via analogical reasoning, helping students reflect upon problem solving with peers, a new use of multimedia learning in introductory physics, “nTIPERS” to help students unpack aspects of Newtonian dynamics and facilitating students’ problem solving across multiple representations in introductory mechanics.

Primary Contact: Chandrekha Singh, University of Pittsburgh,

Co-authors: Session President: , Jose Mestre, University of Illinois Urbana Champaign

Faculty perspectives on using Peer Instruction: A national study

Type: Contributed Poster

We have previously reported on the results of a national web survey of physics faculty about their instructional practices [1]. A subset of 72 survey respondents were interviewed to better characterize how faculty interact with research-based instructional strategies (RBIS), use RBIS, and perceive their institutional contexts. Drawing from 16 interviews with self-reported users of Peer Instruction [2], we describe what faculty mean when they identify themselves as users of Peer Instruction. Meanings range from professors adopting the general philosophy of the instructional strategy (or what they believe to be the general philosophy) while inventing how it concretely applies in their classrooms to professors who use the instructional strategy as is, without significant modification. We describe common modifications that are made to Peer Instruction and the associated prevalence of these modifications.

[1] C. Henderson and M. Dancy, Phys. Rev. ST Physics Ed. Research 5,020107 (2009).

[2] E. Mazur, Peer Instruction (1997).

Primary Contact: Chandra Turpen, Western Michigan University and University of Colorado, Boulder,

Co-authors: Charles Henderson, Western Michigan University, Melissa Dancy, Johnson C. Smith University

Flat as a pancake: a pseudo-longitudinal study of attitudes and beliefs at the University of Edinburgh using CLASS

Type: Contributed Poster

We present an extensive ‘snapshot’ survey of student attitudes and beliefs towards the study of physics in the UK, using the CLASS instrument. Data was gathered from a wide range of respondents, from students in their final year of high school prior to university admission, through the range of undergraduate levels at the University of Edinburgh, postgraduate students, postdoctoral researchers and faculty, with a total sample size of $N=638$.

Our data indicates a statistically significant increase in the proportion of expert-like responses only at major transitions: those between school and university and the upper undergraduate-postgraduate transition. Both of these increases may be due to strong selection effects. By contrast, the extent to which student attitudes and beliefs change during the course of their undergraduate study (typically 4 years) is much less,

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with no significant changes between the first and final years of students studying undergraduate degrees.

Primary Contact: Simon Bates, University of Edinburgh,

Co-authors: Ross Galloway, Kate Slaughter, , University of Edinburgh

Fluctuations in Students' Understanding of Newton's 3rd Law

Type: Contributed Poster

We use a between-student testing methodology to assess student understanding of Newton's 3rd Law concepts on a weekly time scale. Students were tested both in Mechanics, the quarter in which the material was introduced, and in Electricity & Magnetism. A significant increase in the number of students correctly answering conceptual questions is seen around the time of instruction, but it disappears by the end of the quarter. More interestingly, a decrease in the number of correct responses is seen in the subsequent quarter precisely when instruction centers around the scalar topics of electric potential and voltage. Once instruction returns to vector-based topics (Gauss' Law, magnetic fields, etc...), response scores relax back to their initial values

Primary Contact: Scott Franklin, Rochester Institute of Technology,

Co-authors: Jessica W. Clark, Rochester Institute of Technology, , Eleanor C. Sayre, Wabash College

Force Concepts in Different Student Groups: FCI With Variations and Extensions

Type: Contributed Poster

The engineering physics program in Göteborg attracts very strong students, who consistently (since 2004) score an average around 80% on the FCI during the first week at the university. We have also administered the FCI for number of other programs, where the entrance results typically have been around 55-60%. Although female students are among top scorers in all groups, on the average, they score lower. The gap was unchanged when the original FCI was replaced by the "gender-adapted FCI". To investigate the possibility of a selection bias, the test was also given to a couple of high-school classes. For the engineering physics students we are now experimenting with a selection of 15 FCI items combined with additional questions aiming to lower the entrance score. Post-testing after an introductory course, including amusement park projects, showed a normalized gain around 50% for all parts of the test.

Primary Contact: Ann-Marie Pendrill, University of Gothenburg,

Co-authors: Linda Gunnarsson, Hulebäcksgymnasiet, Idrottsvägen 2, SE 435 80 Mölnlycke, Sweden, , Jonn Lantz, 1) Department of Physics, University of Gothenburg, SE 412 96 Göteborg, Sweden

Fostering Scientific Thinking by Prospective Teachers in a Course that Integrates Physics and Literacy Learning

Type: Contributed Poster

The National Research Council has suggested that students should develop four proficiencies in science: know, use, and interpret scientific explanations of the natural world; generate and evaluate scientific evidence and explanations; understand the nature and development of scientific knowledge, and participate productively in scientific practices and discourse. We emphasize these aspects of scientific thinking in our inquiry-based physics course for prospective elementary and middle school teachers. Because the elementary school curriculum focuses heavily on literacy, we also explicitly

integrate physics and literacy learning in this course. By integrating physics and literacy learning we mean learning to speak clearly, listen closely, write coherently, read with comprehension, and make and critique media resources competently in physics contexts. In this paper we discuss students' perceptions of ways they have developed their abilities to think scientifically in this context. This material is based upon work supported by the National Science Foundation under Grant DUE0633752

Primary Contact: Emily H. van Zee, Oregon State University,

Co-authors: Henri Jansen, Department of Physics, Kenneth Winograd, Department of Teacher and Counselor Education, Adam Devitt, Department of Science and Mathematics Education, Michele Crowl, Department of Science and Mathematics Education, Oregon State University, Corvallis, OR

Frame analysis as a way to understand the complex dynamic of classroom teaching practice.

Type: Contributed Poster

From one moment to the next, what and how a teacher teaches may change. In this paper, I discuss two examples from one teacher, showing shifts in her practice from one moment to the next, within the same activity. These shifts are characterized by different ways in which she attended to her students' ideas. Common accounts that attempt to explain teachers' practice as the result of a unified set of beliefs, knowledge, and goals (e.g., teacher-type) cannot account for these two examples. While these broad generalizations may be useful for studying broader patterns in large populations, they assume a consistency in teacher cognition that is not born out by the data. I argue that frame analysis (Hammer, Elby, Scherr, & Redish; 2005) can provide insight into how teacher cognition may be organized—namely that consistency is local and depends on what is going on in that moment.

Primary Contact: Matty Lau, University of Pennsylvania

Fun and Gaming with Andes

Type: Contributed Poster

We present results from an analysis of students' shallow behaviors, i.e., gaming, during their interaction with an Intelligent Tutoring System. We have developed a method for detecting gaming based on timings of student actions. We use this method to analyze student log data taken from six college classes that used the Andes tutor system for homework and test preparation. Our findings show that contrary to other research, student features are a better predictor of gaming than problem features. We also find that students engaged in gaming for a significant fraction of their work.

Primary Contact: Brett van de Sande, Arizona State University,

Co-authors: Kasia Muldner, Winslow Bursleson, and Kurt VanLehn, Arizona State University.

Gender Differences in Physics 1: The Impact of a Self-Affirmation Intervention

Type: Contributed Poster

Prior work at CU-Boulder has shown that a gender gap (difference in male and female performance) exists in both the pre- and post-course conceptual surveys, despite the use of interactive engagement techniques [Kost, et. al., PRST-PER 5, 010101]. A potential explanation for this persistent gap is that stereotype threat, the fear of confirming a stereotype about one-self, is inhibiting females' performance. Prior research has demonstrated that stereotype threat

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can be alleviated through the use of self-affirmation, a process of affirming one's overall self-worth and integrity [Cohen, et. al., *Science* 313, 1307]. We report the results of a randomized experiment testing the impact of a self-affirmation exercise on the gender gap in Physics I. The gender gap on a conceptual post-survey is reduced from 19% for students who did not affirm their own values, to 9% for students who completed two 15-minute self-affirmation exercises at the beginning of the semester.

Primary Contact: Lauren E. Kost, Department of Physics, University of Colorado at Boulder,

Co-authors: Steven J. Pollock, Department of Physics, University of Colorado at Boulder, Noah D. Finkelstein, Department of Physics, University of Colorado at Boulder, Geoffrey L. Cohen, School of Education, Stanford University, Tiffany A. Ito, Department of Psychology, University of Colorado at Boulder, Akira Miyake, Department of Psychology, University of Colorado at Boulder

Gender gaps in upper division physics courses at the Colorado School of Mines

Type: Contributed Poster

In previous work, we replicated studies of gender gaps in introductory physics courses using the Colorado School of Mines general population. CSM also has one of the largest collections of physics majors in the country, providing us with an opportunity to extend our work into non-introductory courses, including longitudinal tracking in some cases. While our introductory courses are taught in a Studio physics mode, the other courses in our physics major are mostly traditional. In this poster, we report on the character of the gender gaps in courses throughout our physics major. Performance gaps are small or non-existent throughout the major, consistent with results from introductory Mines physics courses. On many occasions, women outperform men on homework assignments. Despite this generally strong showing, females remain underrepresented among physics majors as compared to the general Mines science and engineering population.

Primary Contact: Patrick Kohl, Colorado School of Mines,

Co-authors: Patrick B. Kohl, Vince Kuo, Colorado School of Mines Department of Physics

Gender, Mental Rotations, and Introductory Physics

Type: Contributed Poster

In this poster we examine an often-cited claim for gender differences in STEM participation: cognitive differences on tests of spatial ability explain achievement differences in physics. We specifically investigate the role of mental rotations in physics achievement and problem-solving, viewing mental rotations as a tool that students can use on physics problems. We first look at student survey results for lower-level introductory students, finding a small, but significant correlation between performance on a mental rotations test and course achievement. In contrast, we find no such relationship for students enrolled in the honors introductory course. To understand the role that mental rotations plays in physics problem-solving, we examine how students use this tool on highly spatial physics problems in student interviews and find that mental rotation is neither necessary nor sufficient. These results suggest that the robust sex differences on mental rotation tests are of little relevance for achievement in introductory physics.

Primary Contact: Jessica Watkins, Harvard University and University of MD,

Co-authors: Jason Dowd, Harvard University, Eric Mazur, Harvard University

Generating Explanations for an Emergent Process: The Movement of Sand Dunes

Type: Contributed Poster

The movement of sand dunes in the desert is an emergent process; the overall movement of a dune is influenced both by the random interactions among individual sand particles and by the process of wind adding and subtracting sand. People often misconstrued emergent processes as deterministic processes containing central causality. I present a case study of how one person, an adult, who was not an expert in physics, articulated and refined her explanation of the movement of sand dunes. She began with centralized causality but ended with an explanation containing the cogent emergent ideas. This case study is noteworthy in exemplifying the dynamic process of generating an explanation. The interviewee went through four different explanations at three different levels (macro, micro and mid-level) and concluded with an explanation that simultaneously addressed the movement of sand dunes at all three levels.

Primary Contact: Lauren Barth-Cohen, University of California, Berkeley

Helping students learn effective problem solving strategies by reflection with peers

Type: Targeted Poster

We describe a study in which introductory physics students engage in reflection with peers about problem solving. The recitations for an introductory physics course with 200 students were broken into the "Peer Reflection" (PR) group and the traditional group. Each week in recitation, students in the PR group reflected in small teams on selected problems from the homework and discussed why solutions of some students employed better problem solving strategies than others. The graduate and undergraduate teaching assistants (TAs) in the PR group recitations provided guidance and coaching to help students learn effective problem solving heuristics. In the recitations for the traditional group, students had the opportunity to ask the graduate TA questions about the homework before they took a weekly quiz. The traditional group recitation quiz questions were similar to the homework questions selected for "peer reflection" in the PR group recitations.

As one measure of the impact of this intervention, we investigated how likely students were to draw diagrams to help with problem solving.

On the final exam with only multiple-choice questions, the PR group drew diagrams on more problems than the traditional group, even when there was no external reward for doing so. Since there was no partial credit for drawing the diagrams on the scratch books, students did not draw diagrams simply to get credit for the effort shown and must value the use of diagrams for solving problems if they drew them.

We also find that, regardless of whether the students belonged to the traditional or PR groups, those who drew more diagrams for the multiple-choice questions outperformed those who did not draw them.

Primary Contact: Andrew Mason, University of Pittsburgh,

Co-authors: Chandralekha Singh, Department of Physics and Astronomy, University of Pittsburgh

Targeted Poster Session: Facilitating thinking and learning in the physics classroom

Helping Students to Think Like Physicists in SDI Labs

Type: Contributed Poster

Socratic Dialogue Inducing (SDI) labs are relatively effective in promoting students' conceptual understanding of Newtonian mechanics, as judged by relatively large (~0.6) average pre-to-posttest *normalized* learning gains on the FCI. In addition, SDI Labs are designed to help students *think like physicists*, e.g., to: (1) appreciate the need for operational definitions; (2) use and interpret pictorial, graphical, vectorial, mathematical, and written representations; (3) design experiments and control variables; and (4) consider thought experiments and limiting conditions. Two examples: (A) In a pre-Newton's-Second-Law-lab assignment, students indicate in words and/or sketches *operational definitions* of crucial kinematic terms such as position, displacement, time, and instantaneous acceleration. (B) For the tablecloth-slip-out trick, students derive an expression for the distance moved by a plate in terms of the time required to pull the cloth out from under it, and are then asked "Is the expression physically reasonable? - consider dimensions and limiting conditions."

Primary Contact: Richard Hake, Indiana University Emeritus

Hidden benefits of engaging students in experimental design and invention of physics concepts

Type: Targeted Poster

Innovation and efficiency – the dilemma between these two aspects of learning is at the heart of our perception of what good teaching or learning are. We wish to streamline, speed up, shorten, and simplify both student learning and classroom assessment. If some curriculum "takes too long to get to X," we are unlikely to adopt it. Despite the research on the benefits of engaging students in innovation, there is very little room left for student innovation (including experimental design) in the current educational system, which is primarily based on efficiency.

In this poster we challenge conventional wisdom that prefers efficiency. We show evidence that design and innovation that take a lot of time not only engage students in constant sense-making and prepare them to learn on their own later but, most importantly, help them develop one of the crucial skills that they will need in the future: intellectual perseverance.

Primary Contact: E. Etkina, Rutgers University,

Co-authors: A. Karelina, M. Ruibal-Villasenor, and G. Suran, Rutgers University

Targeted Poster Session: Taking Responsibility for the Hidden Curriculum: Practices and Challenges in addressing the broader goals in physics education

How do the students perceive the reasons for their success in a modern physics course?

Type: Contributed Poster

In this study, our goal was to determine how students in modern physics course perceived their success and the reasons for the success. We view this through attribution theory. In this theory, "Perception or inference of cause" is called "attribution" and focuses on perceived causes of behavior (Försterling, 2001; Kelley & Michela, 1980; Weiner, 1974). In classroom settings, examination of students' attributions about their success and failure helps to both identify students' metacognition and to predict their future success in specific tasks. From a set of 27 interviews at the University of Maryland and the Middle East Technical University, we discuss the

attributions of 6 students (3 from each venue) in terms of locus of control and stability. We selected the students to show the range of variation. It was observed that how students make sense of "success" shapes the characteristics of their attributions.

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Kelley, H. H., & Michela, J. L. (1980). Attribution theory and research. Annual Review of Psychology, 31, 457-501.

Weiner, B. (1974). An attributional integration of expectancy-value theory. In B. Weiner (Ed.), Cognitive Views of Human Motivation (pp. 51-69). New York: Academic Press.

Primary Contact: Nilufer Didis, Middle East Technical University,

Co-authors: Edward F. Redish, University of Maryland, College Park, 20742, MD.

How does visual attention differ between experts and novices on physics problems?

Type: Contributed Poster

Research in many disciplines has used eye-tracking technology to investigate the differences in the visual attention of experts and novices. For example, it has been shown that experts in art and chess spend more time than novices looking at relevant information. Thus, it may be helpful to give novices more direct access to the way experts allocate their visual attention, for example using attentional cueing techniques. However, not much is known about how experts allocate their attention on physics problems. More specifically, we look at physics problems where the critical information needed to answer the problem is contained in a diagram. This study uses eye movements to investigate how the allocation of visual attention differs between experts and novices on these types of physics problems. We find that in problems that deal with energy, experts spend more time looking at thematically relevant areas of the figure than novices do.

Primary Contact: Adrian Carmichael, Department of Physics, Kansas State University,

Co-authors: Adam Larson, Department of Psychology, Kansas State University, Elizabeth Gire, Department of Physics, Kansas State University, Lester Loschky, Department of Psychology, Kansas State University, N. Sanjay Rebello, Department of Physics, Kansas State University

How students make sense of functional, but incomplete computer programs.

Type: Contributed Poster

Computational activities in the Matter & Interactions[1] curriculum for calculus-based introductory physics promote the tenets of the curriculum: mainly, the deterministic view of classical mechanics. For systems that are too complex to calculate analytically, computers perform an iterative calculation of the fundamental principles of physics to predict the system's dynamics. An ongoing research project[2] analyzes video data of groups of students who completed restructured computational activities with VPython[3] in a lab setting. These activities were designed to guide student attention on using fundamental principles to repair functional, but incomplete programs. Borrowing a framework from reading comprehension[4], tasks were developed to ask students to read the program code in these minimally working programs (MWP) and create predictions of the 3D visualization produced by the program. We present an analysis of how students interpreted the program code and created predictions of the visualization for three separate activities distributed throughout the semester.

Contributed and Targeted Posters

[1] <http://www.matterandinteractions.org>
[2] Supported by NSF Grant DUE-0618504
[3] <http://www.vpython.org>

[4] Palinscar, A.S. and Brown, A.L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition & Instruction*, 1(2), 117-175.

Primary Contact: Shawn A. Weatherford, North Carolina State University,

Co-authors: Ruth Chabay, North Carolina State University

How Students Structure Argument through the Interplay of Claims Made about Phenomena and Instruction

Type: Targeted Poster

Understanding how specific learning environments influence student participation in science classrooms is fundamentally important to physics education research and its efforts at educational reform. Over the past few decades, science education researchers have shown an increased interest in the role that scientific argumentation plays in school science, both as an aspect of authentic scientific practice and as an instructional approach to learning. We report on an ongoing investigation to understand how curricular structures common to physics education shape student participation in scientific inquiry, using student argumentation as a window into classroom participation. In this paper, we provide a brief analysis of students' collaborative arguments during an inquiry lesson on the nature of light in order to illustrate how students' arguments about the physical phenomena interact with the specific claims students make about the lesson, and discuss the impact this has on students' opportunities to participate and learn.

The research has been funded in part by the National Science Foundation under Grant No. REC-0633951.

Primary Contact: Brian W. Frank, University of Maine

Targeted Poster Session: Characterizing Participation in and around the Physics Classroom

How students' conceptual understanding is influenced by the grammatical structure of physics equations

Type: Contributed Poster

In physics equations, each symbol stands for a physical quantity, and mathematical expressions define relationships between these physical quantities. How do physicists and physics students make sense of these abstract equations? We suggest a theoretical approach to this question that marries ideas and methods of functional grammar and perceptual symbol systems. In short, we propose that mathematics, as used in physics, shares many identifiable elements with those of the grammar of human languages. Moreover, these elements seem to play a similar cognitive/symbolic purpose to their equivalent linguistic structures. Consequently, although many mathematical expressions may validly describe a given physics situation, few are contextually appropriate. We present a study revealing how physics students interpret mathematical structure. For example, different forms of the same equation influence students' models of the physical reality that the equation describes. We discuss the implications of this research for how students interpret mathematics in physics.

Primary Contact: David T. Brookes, Florida International University,

Co-authors: David H. Landy, University of Richmond, Jose P. Mestre, University of Illinois at Urbana-Champaign

How the Aesthetic Experience Engage in Understanding of Science?

Type: Contributed Poster

The Nobel Prize winning physicist Chandrasekhar(1990) argues that beauty is relevant to the process of science: beauty is a guide, a value that scientists use in their work. This perspective places an aesthetic experience at science teaching and learning in class. This also emphasizes the artful side of science. Our conception of aesthetic experience has relevance to understand nature of science. This study is designed to explore students' understanding of science and analyze relevance between aesthetic experience and understanding of science. In this study, two hundred two Korean high school students, who enrolled in school of art, participated and answered open ended questionnaire. The findings revealed that students understand science as an aspect of culture and they tend to explain science based on their experiences in art.

Primary Contact: Sung-Youn Choi, Ewha Womans University, Korea,

Co-authors: Hee-Jung Kim and Sung-Won Kim (Ewha Womans University, Korea)

How to think and talk like a physicist?

Type: Targeted Poster Session

This Targeted Poster Session will focus on projects involving the use of curriculum materials as well as class discussion techniques that will enhance student critical and reflective thinking skills. How can we facilitate a learning environment to assist student to think and talk like a physicist: pursue relevant and reliable knowledge, ask insightful questions, gather relevant information, reason logically from this information, and come to scientific conclusions about the world? We will report on our efforts, success, and challenges in engaging students in such activities.

Primary Contact: Homeyra Sadaghiani, California State Polytechnic University Pomona

Improving Students' Understanding of Electric Flux

Type: Contributed Poster

A good understanding of the concept of electric flux is important for developing a functional understanding of Gauss's law. We investigate the difficulties that students in the calculus-based introductory physics courses have with the concept of electric flux and discuss the development and evaluation of a research-based tutorial to help students learn this concept. During the investigation of difficulties and development of the tutorial, we gave students written tests in the free-response and multiple-choice formats, interviewed a subset of students and also obtained feedback from physics instructors who teach introductory physics regularly. We discuss the performance of students on the pre-/post-tests given before and after the tutorial. We find that classes in which students used the tutorial outperformed those in which the tutorial was not used.

*Supported by NSF.

Primary Contact: Jing Li, University of Pittsburgh,

Co-authors: Chandralekha Singh, University of Pittsburgh

Improving Students' Understanding of Quantum Measurement

Type: Contributed Poster

We describe the difficulties advanced undergraduate and graduate students have with quantum measurement and the development and

Contributed and Targeted Posters

implementation of research-based learning tools such as the Quantum Interactive Learning Tutorials (QuILTs) and peer instruction tools to reduce these difficulties. The preliminary evaluation shows that these learning tools are effective in improving students' understanding of concepts related to quantum measurement. * Supported by NSF

Primary Contact: Guangtian Zhu, University of Pittsburgh,
Co-authors: Chandralekha Singh, University of Pittsburgh

Influence of learning styles on conceptual learning of physics

Type: Contributed Poster

Several studies have reported the influence of scientific reasoning on the conceptual learning of students in courses developed with methodologies that promote active learning. Given that learning styles may also influence conceptual learning of physics, it has been conducted a correlational study which has used two different approaches of Learning Styles, the Honey-Alonso and Felder-Silverman models. This quantitative study was conducted in groups using the methodology of modeling in a course of introductory mechanics in college. To assess the conceptual learning it has been used the Force and Motion Conceptual Evaluation (FMCE) test. The results confirm the strong dependence of learning styles on conceptual learning of physics.

Primary Contact: Hugo Alarcon, Tecnologico de Monterrey,
Co-authors: Teresita Marin-Suarez, Tecnologico de Monterrey

Instructional explanations as an interface - The role of explanatory primitives

Type: Contributed Poster

What makes an instructional sequence in physics meaningful to students? Why do some explanations seem more plausible than others? Why is it that an explanation can appear plausible to one student but not to another? We present a model that addresses these questions. Elaborating on diSessa's (1993) concept of p-prims, we develop a model of explanatory primitives, and argue that different individuals have different sets of explanatory primitives, or assign different priority to the same explanatory primitives in certain contexts. We use this idea to argue that this difference between individuals can account for differences in reactions to a specific instructional explanation, and present empirical data to support this claim. We then use the model to analyze Jim Minsrell's (1982) instructional sequence on the existence of a normal force to explain how an effective learning sequence addresses the differences between individuals by evoking a rich set of explanatory primitives.

Primary Contact: Shulamit Kapon, Graduate School of Education,
University of California Berkeley,
Co-authors: Andrea A. diSessa, Graduate School of Education,
University of California Berkeley

Interpretation in Quantum Physics as Hidden Curriculum

Type: Contributed Poster

Prior research has demonstrated how the realist perspectives of classical physics students can translate into specific beliefs about quantum phenomena when taking an introductory modern physics course. Student beliefs regarding the interpretation of quantum mechanics often vary by context, and are most often in alignment with instructional goals in topic areas where instructors are explicit in promoting a particular perspective. Moreover, students are more likely to maintain realist perspectives on quantum mechanics when instructors are less explicit in addressing interpretive themes, thereby

making such issues part of a hidden curriculum. We discuss various approaches to addressing student perspectives and interpretive themes in a modern physics course, and explore the associated impacts on student thinking.

Primary Contact: Charles Baily, University of Colorado, Boulder,
Co-authors: Noah D. Finkelstein, University of Colorado, Boulder,
Department of Physics

Introducing students to the culture of physics: explicating elements of the hidden curriculum

Type: Invited Talk

When we teach physics to prospective scientists and engineers we are teaching more than the "facts" of physics – more than the methods and concepts of physics. We are introducing them to a complex culture – a mode of thinking and the cultural code of behavior of a community of practicing scientists. This culture has components that are often part of our hidden curriculum: epistemology – how we decide that we know something; ontology – how we parse the observable world into categories, objects, and concepts; and discourse – how we hold a conversation in order to generate new knowledge and understanding. In order to understand these often-tacit components of our teaching, we need an understanding of how students' minds work, how they perceive the activities of science, and how we perceive those activities. To teach our hidden curriculum we must pay attention to students' intuition and perception of physics, not just to their reasoning.

Primary Contact: Edward F. Redish, University of Maryland

Inventing-with-Contrasting-Cases: An instructional method that improves students' uptake of big ideas

Type: Targeted Poster

Inventing-with-Contrasting-Cases (ICC) is an instructional method that helps students perceive critical deep structures underlying problems. This poster delineates three essential ingredients of ICC. First, the instruction must focus on a deep structure or "big idea" that runs through many areas of physics. In the examples of ICC we provide, ratio is the big idea. An understanding of proportional reasoning is necessary for learning many physical concepts such as density, speed, and acceleration. A second element of ICC is that students "invent" or generate a single representation that captures the big idea. This representation could take the form of a formula, theory, or graph. Third, optimal contrasting cases support invention. Contrasting cases are examples of phenomena that are designed to highlight critical deep features through contrast. These three design points are illustrated with instructional and empirical examples in the domain of proportional reasoning.

Primary Contact: Catherine C. Chase, Stanford University, School of Education,
Co-authors: Daniel L. Schwartz, Stanford University, School of Education

Targeted Poster Session: Proportional Reasoning in Physics: What are students thinking? How can we help?

Invention of Physical Quantities as an Underpinning for Proportional Reasoning

Type: Targeted Poster

Mathematical reasoning skills are fundamental tools for understanding physics, and proportional reasoning is perhaps the most familiar skill. Physicists reason this way in the context of nearly every physical quantity. It is rudimentary, yet we know our students

Contributed and Targeted Posters

often leave our courses without having mastered this important skill. In an ongoing collaboration between Rutgers University, Western Washington University and New Mexico State University we have developed curricular materials and methods for using invention as a preparation for instruction, building the foundation for proportional reasoning in the context of physics. This poster describes “invention sequences” that are based on inventing-with-contrasting-cases piloted at Stanford University School of Education*. We present the materials and how their existence has affected the emphasis of the teachers and students that use them.

Abstract Footnotes: * <http://aalab.stanford.edu/>

Primary Contact: Suzanne White Brahmia, Rutgers University
Department of Physics and Astronomy

Targeted Poster Session: Proportional Reasoning in Physics: What are students thinking? How can we help?

Investigating student understanding for a statistical analysis of two thermally-interacting solids

Type: Contributed Poster

As part of an ongoing research and curriculum development project for upper-division courses in thermal physics, we have developed a sequence of tutorials in which students apply statistical methods to examine the behavior of two interacting Einstein solids. In the sequence, students begin with simple results from probability and develop a means for counting the states in a single Einstein solid. The students then consider the thermal interaction of two solids, and observe that the classical equilibrium state corresponds to the most-probable distribution of energy between the two solids. As part of the development of the tutorial sequence, we have developed several assessment questions to probe student understanding of various aspects of this system. In this poster, we describe the strengths and weaknesses of student reasoning, both qualitative and quantitative, to assess the readiness of students for one tutorial in the sequence. Supported in part by NSF CCLI grant DUE-0817335.

Primary Contact: Michael Loverude, California State University
Fullerton

Investigating student understanding of thermodynamics concepts and underlying integration concepts

Type: Contributed Poster

As part of work on student understanding of concepts in advanced thermal physics, we are exploring student understanding of the mathematics underlying physics concepts. One area in which we have done this is with integration in the contexts of thermodynamic (P-V) work, which is process-dependent, and changes in internal energy, a (process-independent) state function. Physics majors answered paired questions, one in a physics context and the other an analogous integration question stripped of physical context, to investigate whether some of the difficulties identified as physics conceptual difficulties could have origins in the mathematics. We found similar difficulties in the work and one-dimensional integral questions. With state functions, student performance strongly favored the physics version. We also asked the math questions to calculus students, with similar results. Our findings have implications for mathematical roots of some physics conceptual difficulties and for student understanding of, and the overlooked sophistication of, canonical representations.

Primary Contact: John R. Thompson, University of Maine,

Co-authors: Donald B. Mountcastle, University of Maine

Investigating the perceived difficulty of introductory physics problems

Type: Contributed Poster

We present two studies investigating factors that correlate with students' and instructors' perceptions of problem difficulty. In the first study, introductory physics students and instructors were asked to rate the difficulty of textbook-style work-energy problems. These difficulty ratings are compared and we look for correlations between the difficulty ratings and a measure of problem complexity. We find differences between students' and instructors' ratings and a correlation between instructors' ratings and problem complexity but no significant correlation between students' ratings and problem complexity. In the second study, we asked introductory physics students and instructors to rate the difficulty of textbook-style kinematics problems. Additionally, we asked students to provide ratings of their familiarity with these problems and complete solutions. We explore the relationship between difficulty ratings, problem complexity, problem familiarity, and the rate at which students solve the problems correctly. Supported in part by US National Science Foundation Grant #0816207.

Primary Contact: Elizabeth Gire, Kansas State University,

Co-authors: N. Sanjay Rebello, Kansas State University

Is explanation enough to assess student understanding?

Type: Contributed Poster

There is a strong emphasis in physics education research on the use of multiple representations to help students solve physics problems. Students who learned kinematics from the Physics Union Mathematics curriculum* answered a qualitative test question which required them to use multiple representations to explain their answer. Depending on the representation used for grading, different students showed understanding. When we looked at pairs of representations (motion diagram and graph), we found that students were often consistent but not necessarily correct. Based on the patterns in the data we argue that to fully assess student understanding we need to provide students with problems that require them to use at least three different representations to explain their answer.

*Work supported by NSF grant DRL-0733140

Primary Contact: Tara Bartiromo, Rutgers University,

Co-authors: James Finley, Rutgers University; Eugenia Etkina, Rutgers University

Kinesthetic Activities in Upper-Division Physics Courses

Type: Targeted Poster

Kinesthetic activities are powerful tools for physics instruction. These activities require students to interpret a physical situation or concept with movement and postures - like acting out the motion of a particle based on a graph of its motion. They provide memorable classroom experiences and allow students to embody their conceptual physics knowledge. We will present kinesthetic activities that are used in junior level physics courses and lead a discussion about their implementation and affordances for student learning. In particular, we will discuss the relationship of these activities with sense-making, representational competence, spatial reasoning, and building a community of practice. This material is based upon work supported by the National Science Foundation under Grant No. DUE 0618877.

Primary Contact: Elizabeth Gire, Kansas State University

Targeted Poster Session: Upper-division activities that foster “Thinking like a Physicist”

Laptop Usage In An Introductory Physics Class: A Tale Of The Haves And The Have-Nots

Type: Contributed Poster

Recently, some attention has been paid in the literature to the advantages and disadvantages of allowing students to use laptop computers in a classroom setting. Previous studies have shown that laptops or tablet PCs can be used to promote active learning, but can also be a distraction to students. [1] If approximately half of students have access to a laptop and half do not, what impact will there be on student learning in an introductory physics class? During a recent study, DyKnow software was utilized to facilitate increased student interaction with the professor, to share group work, and to push notes to the students using laptops during class. The authors then utilized data from student surveys, a focus group session, and student performance data in order to compare the impact of utilizing laptops on student performance measures, and on student perceptions of the course.

[1] Barak, M., Lipson, A. and Lerman, S., Wireless Laptops as Means for Promoting Active Learning in Large Lecture Halls, *Journal of Research on Technology in Education*, 38 (2006) 245-263.

Primary Contact: Kimberly A. Shaw, Columbus State University,

Co-authors: Zdeslav Hrepic, Columbus State University

Learning gains on Newtonian conceptual reasoning in an iterative, project-based course design

Type: Contributed Poster

I compare the normalized gain on conceptual Newtonian reasoning in a course based on iterative design projects (Learning by Design - TM) to a linear non project based course design in middle school. In addition to pre/post gains, I also measure incremental changes over time and detect a degradation of performance at intermediate times. This is interpreted as an example of U-shaped development, which I argue implies a fairly stringent criticism of stand-alone pre/post testing as an assessment strategy.

Primary Contact: Paul J. Camp, Spelman College

Learning the concept of energy quanta through a portfolio.

Type: Contributed Poster

The motivation for studying physics decreases towards the end of high school, especially for students who do not want to work or pursue higher education in the technical, which involves the use of teaching and evaluation methods to stimulate interest in physics studies. One of the methods that require deeper thinking, high capacity for interpretation of physical phenomena, great creativity and readiness to study physics than average, is portfolio. For example, learning the concept of energy quanta becomes much easier and more enjoyable for students, if they made a portfolio for this purpose. The student portfolio will lead to another vision of natural light, through the study of interesting physical phenomena, such as external photoelectric effect or Compton effect, revealing light corpuscular's aspect.

Knowledge, through their own effort and will, is sustainable and help achieve the ultimate goal of teaching: student's academic success.

Primary Contact: Gelu Maftai, Faculty of Physics, Bucharest University, Romania

Losing it: The influence of losses on individuals' normalized gains

Type: Contributed Poster

Researchers and practitioners routinely use the normalized gain (Hake, 1998) to evaluate the effectiveness of instruction. Normalized gains (g) have been useful in distinguishing active engagement and traditional instruction. Recently, concerns were raised about the normalized gain because it implicitly neglects retention (or equivalently "losses"). That is to say, the Hake gain assumes no right answers become wrong after instruction. We analyze individual standardized gains (G) and losses (L) from data collected at Harvard University during the first five years that Peer Instruction was developed. Over the first five years, we find that gains increased and losses decreased. Furthermore, we find that the difference between g and $G-L$ is negligible for students with higher normalized gains but sizable for students with lower normalized gains. The usefulness of looking into metrics of loss over the course of a semester warrants further research, particularly with different student populations.

Primary Contact: Kelly Miller, McGill University,

Co-authors: Nathaniel Lasry, John Abbott College, Orad Reshef, McGill University, Eric Mazur, Harvard University

Maximum Likelihood Estimation of students' understanding of vector subtraction

Type: Contributed Poster

We are engaged in a large project to understand the evolution of student understanding throughout the introductory calculus-based sequence. In this poster, we report on the impact that slight changes in question format have on student response to vector subtraction tasks. We use Maximum Likelihood Estimation (MLE) analysis to analyze students' responses on six very similar questions which vary in context (physics or mathematics), vector alignment (both pointing to the right or opposed), and operation (left-right subtraction or right-left subtraction). Responses on all questions are generally correct and do not vary by instructional week or even by course. Context and specific operation do not show significant differences. However vector alignment is significantly different, indicating that perception or sloppy thinking is a bigger cause of failure than conceptual deficit.

Primary Contact: Tianren Wang, Wabash College,

Co-authors: Eleanor Sayre, Wabash College

Modeling Instruction curriculum and pedagogy: what is exposed and what is hidden within the 'hidden curriculum'

Type: Targeted Poster

No instruction is free from the 'hidden curriculum.' Modeling Instruction developed to explicitly uncover the underlying physical models hidden in a standard physics curriculum. Associated with this curricular reform is a pedagogical reform that enacts the epistemological belief system that Modeling is the central process in science. As with all belief systems, Modeling embeds features in the instructional practice that are 'hidden'. In this poster, we consider the implications of exposing elements from the hidden curriculum by focusing through Modeling Instruction, and also what has been hidden by implementing a curriculum and pedagogy with a modeling epistemological foundation.

Primary Contact: Eric Brewster, Florida International University,

Co-authors: Laird H. Kramer, George E. O'Brien, Florida International University

Contributed and Targeted Posters

Targeted Poster Session: Taking Responsibility for the Hidden Curriculum: Practices and Challenges in addressing the broader goals in physics education

Models for seeing colored objects: A case study progression

Type: Contributed Poster

We document the experience of a single participant in a course for secondary teacher professional development in order to track the changes in her thinking about how light interacts with colored objects. Our two main interests in conducting this analysis are first, to better understand learners' ideas about light and color, and second, to observe changes in learners' thinking as they occur in real-time classroom events.

Primary Contact: Emma C. Kahle, Seattle Pacific University,

Co-authors: Rachel E. Scherr, Seattle Pacific University, Hunter G. Close, Seattle Pacific University

Multimedia PreLab Tutorials in Conservation Laws

Type: Contributed Poster

Physics laboratories are intended to provide students an opportunity to investigate physical phenomena by making observations, collecting and analyzing data, and presenting their findings clearly. However, most students lack an adequate preparation and conceptual background to achieve these objectives. As a pilot study at Cal Poly Pomona, we designed a 20-minute online prelab tutorial on the topics of conservation laws using flash animations, narration, and videos, which contains a brief lesson on the theory, as well as introduction to laboratory procedure and apparatus. It also includes embedded assessment questions and solutions. The preliminary data shows improvement in student overall preparation, quiz scores, lab reports, time efficiency, and attitude.

Primary Contact: Homeyra Sadaghiani, California State Polytechnic University

Newton's Third Law in middle school

Type: Contributed Poster

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

Primary Contact: Gordon Aubrecht, Ohio State University,

Co-authors: Eleanor C Sayre, Wabash College, Wabash, IN
le@zapos.com

Novice Implementation of the Impulse-Momentum Theorem in VPython Programs

Type: Contributed Poster

One of the goals in introductory mechanics is to help students understand the Impulse-Momentum theorem to the point where they can successfully apply it in many different circumstances. Typically, these are limited to analytic applications of Newton's second law or the conservation of linear momentum. Difficulties arise, however,

when computational modeling is introduced to students who then must focus on the numerical integration of an open-ended form of the Impulse-Momentum theorem, rather than a closed form solution. Even ten weeks into an introductory lab sequence which prominently features programming tasks, students are found to have lingering difficulties in reframing their application of the Impulse-Momentum theorem to productively generate computational models. We will present preliminary data demonstrating the difficulties that emerge as students work to complete VPython programs during a first semester Matter and Interactions lab.

Primary Contact: Brandon R. Lunk, North Carolina State University

Now you can compare them all !

Type: Contributed Poster

The purpose of this paper is to present a comparative analysis of more than 118 science and education instruments used to measure constructs in the learners' cognitive and affective domains, as well as learning progression and learning contexts. The instruments are compared on the following criteria: (a) the construct that the instrument is reported to measure, (b) the number of items in each instrument, (c) the number of dimensions (or factors) each instrument is composed of, (d) the targeted population, (e) internal consistency, (f) reliability, and (g) popularity of use (measured in number of citations). The results show the variability between the different instruments measuring the same or different constructs for each of the compared criteria. The comparison is useful for helping researchers easily choose the appropriate instruments for measuring their constructs of interest.

Primary Contact: Ahmed Ibrahim, McGill University

nTIPERS: Tasks to Help Students "Unpack" Aspects of Newtonian Dynamics

Type: Targeted Poster

This poster will present examples of tasks, focused on the concept of force, that can be used to identify students' initial (natural) thinking and then facilitate comparing and contrasting their ideas with the physically accepted ideas. Doing this with these TIPER tasks can help students make sense of the physics they are studying, rather than just memorizing the physically accepted ideas. We will present several related tasks that deal with different aspects of the force concept, e.g., force proportional to velocity, force as a property of an object, force calculated from mass times acceleration and examples of student responses that indicate such thinking. We will also present ideas for how to use nTIPERS.

Primary Contact: David P. Maloney, Indiana University-Purdue University Fort Wayne,

Co-authors: Curtis Hiegelke, Joliet Junior College, Steve Kanim, New Mexico State University

Targeted Poster Session: Facilitating thinking and learning in the physics classroom

Observing scientific reasoning processes in the classroom: Qualitative analysis of video-recorded interaction

Type: Workshop

Scientific, critical, and reflective thinking are processes that unfold as students learn together. Ideally, students collaboratively construct ideas through the use of a wide range of representational resources. At Seattle Pacific University, "embodied learning activities," in which we deliberately arrange for human bodies to symbolize entities in physical phenomena, are playing an increasingly important role in

Contributed and Targeted Posters

the instruction that we design and study. Students communicate their ideas not only through talk, but also body positions, movements, uses of objects, gestures, looks, and so on. Video documentation of such dynamic multi-modal representations offers the chance to develop our professional vision as well as our understanding of what constitutes scientific reasoning processes. In this workshop, participants will work closely with short episodes of videotaped classroom activity in order to engage with the theoretical and practical issues that are raised by fine-grained qualitative analysis. Please bring a laptop and headphones if it's convenient.

Primary Contact: Rachel E. Scherr, Seattle Pacific University

Opportunities for Learning: Hybrid Spaces, Vygotsky, and the Endorsed Narrative

Type: Targeted Poster

This study seeks to answer the question, "How does learning happen?" The context was a Physics and Everyday Thinking course, a highly interactive physics curriculum in which students collect and analyze data as a means by which to establish scientifically accepted ideas. Two focus students were video taped throughout a unit on magnetism as they transitioned through 7 different representations of their model of magnetism. Evidence also shows that their discourse and model-building practices developed greatly throughout the unit. The findings of this study are framed in terms of Sfard and Laive's (2005) notion of the objectification of discourse as a definition of learning. I will demonstrate that the learning of physics that was observed in this study resulted from the students objectifying their discourse away from the self and its communication with other people and toward the self in relation to the human-independent world of magnetic phenomena. Evidence is used to demonstrate how elements of the curriculum, classroom norms, and the discourse itself were instrumental in the learning that took place for these students.

Primary Contact: Valerie Otero, University of Colorado at Boulder

Targeted Poster Session: Characterizing Participation in and around the Physics Classroom

Our best juniors still struggle with Gauss's Law: Characterizing their difficulties

Type: Contributed Poster

We discuss student conceptual difficulties with Gauss's law observed in an upper-division Electricity and Magnetism course. Difficulties at this level have been described in previous work; we present further quantitative and qualitative evidence that upper-division students still struggle with Gauss's law. This evidence is drawn from analysis of upper-division E&M conceptual post-tests, traditional exams, and formal student interviews. Examples of student difficulties include difficulty with the inverse nature of the problem, difficulty articulating complete symmetry arguments, problems visualizing the electric field, and trouble recognizing that in situations without sufficient symmetry it is impossible (rather than "difficult") to calculate the electric field using Gauss's law. One possible explanation for some of these conceptual difficulties is that students at the upper level may struggle to connect mathematical expressions to physical meanings.

Primary Contact: Rachel E. Pepper, University of Colorado,

Co-authors: Stephanie V. Chasteen, Steven Pollock, Katherine Perkins, University of Colorado.

Out of one, many; five researchers analyze the same student video

Type: Targeted Poster Session

This session brings together five experts with different theoretical perspectives for an in-depth conversation centered on a single classroom video. Focused discussion will highlight how the experts' analyses compare, contrast, and compliment one another, and enable participants to see some of the strengths and limitations of these different perspectives in a specific context.

Want to know more? Go to <http://public.me.com/ddykstra> and open the "Different Perspectives" folder to watch the actual classroom video, read it's transcript, and view what each researcher will present. Come prepared to contribute to the discussion!

Primary Contact: Brant Hinrichs, Drury University,

Co-authors: Dewey Dykstra, Boise State University, Physics Department, 1910 University Drive, Boise, Idaho 83725-1570 USA, (208) 426-3105, voice and voice-mail, (208) 426-4330 fax

Pedagogical Concepts and Strategies Evidenced in Learning Assistant Teaching Reflections

Type: Contributed Poster

We report results from a qualitative analysis of weekly teaching reflections written by first-semester undergraduate physics Learning Assistants (LAs) at Florida International University. First semester physics LAs enroll in an introductory science pedagogy seminar and concurrently work in reformed physics I or II labs. LAs provide weekly teaching reflections that describe strategies implemented, student interactions, and observations from the lab. This study assessed instructional strategies developed in the LA Seminar as indicated by the teaching reflections. A coding schema was developed and applied to student reflections by two raters. Inter-rater reliability was established and differences were discussed to arrive at consensus. Evidence indicates that most strategies persisted throughout the semester after introduction. However, data show that strategies including differentiated instruction and cooperative learning are present throughout the semester, even occurring prior to instruction. Results also point to possible revisions in the instruction of seminar topics.

Primary Contact: Diane Crenshaw, Florida International University,

Co-authors: Leanne Wells, Florida International University, Laird Kramer, Florida International University, Eric Brewé, Florida International University

Personal epistemologies as barriers and facilitators to learning by Science and Engineering undergraduate students

Type: Round Table Discussion

I am the principal investigator of a SSHRC grant with the above title. I have developed a suite of activities that seem to get students to evaluate their understanding in terms of two alternative frameworks; Aristotle, and Galileo & Newton. Students become aware that the frameworks relate concepts from different parts of the course and learn to evaluate the frameworks. We plan to develop and deploy instruments that can measure changes in students' learning before and after using the array of activities.

Data will be collected in several post-secondary institutions. Interviews will be conducted by research assistants under the supervision of professors on the team. The first year of the program (2010-11) is to involve development and testing of

Contributed and Targeted Posters

the instruments to be used to examine changes in student epistemologies.

In this roundtable, I and one of my co-applicants, Tetyana Antimirova would like to discuss what instruments should be used.

Primary Contact: Calvin S. Kalman, Physics/Concordia University,

Co-authors: Tetyana Antimirova, Physics Department, Ryerson University, Toronto, Ontario, M5B 2K3, Tel: (416) 979-5000 ext. 7416, Fax: (416) 979-5343, E-Mail: antimiro@ryerson.ca

Physics Learning as the Objectification of Discourse

Type: Targeted Poster

In research on disciplinary knowledge, language is often treated as a communication medium rather than as a legitimate part of cognition. Both language and concepts are involved in the learning process, yet they are almost impossible to analytically distinguish from one another. I tackle this problem head-on using the notion of objectification of discourse to define the development of conceptual understanding. Objectification of discourse is the process that begins as an interpersonal affair and as a result, turns into a matter of one's relation with the human-independent world. This Vygotskian perspective integrates elements of a behaviorist perspective and can shed light on how learners come to understand, and participate in, the Discourse of physics. Using a video snippet from a Physics and Everyday Thinking class, I will illustrate early phases of this learning process and demonstrate the interpersonal focus of students' discourse and highlight how this leads to scientific, mechanistic reasoning.

Primary Contact: Valerie K. Otero, University of Colorado at Boulder

Targeted Poster Session: Out of One, Many; Five Researchers Analyze the Same Student Video

Physics Teacher Characteristics and Classroom Practices

Type: Contributed Poster

One hundred eighteen high school and college teachers in Southern California completed a web-based survey designed to better understand the differences in physics classrooms and the reasons behind the teachers' choices. Survey topics included teachers' familiarity and use of research-based instructional strategies, amount of student-student interaction in their classes, their views teaching and interactions with the physics teaching community. Partial results from the survey will be presented. Among the findings was that while increased interactions with colleagues correlated with more student-student interactions, increased participation in conferences or reading of journals related to physics teaching did not.

Primary Contact: Jeffrey A. Phillips, Loyola Marymount University,

Co-authors: Melissa A. Taylor

Physics thinking in complex analytical calculations

Type: Targeted Poster

The ability to carry out complex analytical calculations is an important skill for a physicist. As an activity in a first semester, upper division electricity and magnetism course, students work in groups during class to develop an integral expression for the magnetic field in all space due to a ring of charge rotating about its axis. This is a direct but complex application of the Biot-Savart Law, requiring students to break the problem into pieces and employ a number of physics concepts. The problem also presents an opportunity for

students to draw on analogous earlier work, including finding the electrostatic potential and field due to a ring of charge. This poster will explore the "physics thinking" required to solve this problem, and how the activity and instructor engage students in that thinking.

Primary Contact: Edward Price, California State University San Marcos

Targeted Poster Session: Upper-division activities that foster "Thinking like a Physicist"

Pilot Testing of the Pathway Active Learning Environment

Type: Contributed Poster

We present an initial analysis of data taken to test the functionality and student usability of an interactive synthetic tutoring system administered online. The system allows students to ask questions and receive pre-recorded video responses from knowledgeable tutors in real-time. It logs student interactions with a timestamp and username to generate a time-resolved picture of students' use of the system. The tutoring interaction is structured by lessons covering Newton's laws. Time on-task estimates indicate that students spent about 2.5 hours working through our materials, about as much as intended. Data also show students' reluctance to query the tutor, or that their focus is on other aspects of the system. This suggests modifications to the system to encourage students to take advantage of its interactive capabilities. This system provides social and multimedia elements that may, when used as a supplement to classroom instruction, help students better learn physics.

Primary Contact: Christopher M. Nakamura, Kansas State University Physics Department,

Co-authors: Sytil K. Murphy, Kansas State University Physics Department, Dean A. Zollman, Kansas State University Physics Department, Michael Christel, Carnegie Mellon University Entertainment Technology Center, Scott Stevens, Carnegie Mellon University Entertainment Technology Center

Positive Impacts of Modeling Instruction on Self-Efficacy

Type: Contributed Poster

Analysis of the impact of Modeling Instruction (MI) on the sources of self-efficacy for students in Introductory Physics 1 will be presented. We measured self-efficacy through a quantitative diagnostic (SOSESC) developed by Fencil and Scheel [1] to investigate the impact of instruction on the sources of self-efficacy in all introductory physics classes. We collected both pre- semester data and post-semester data, and evaluated the effect of the classroom by analyzing the shift (Post-Pre). At Florida International University, a Hispanic-serving institution, we find that traditional lecture classrooms negatively impact the self-efficacy of all students, while the MI courses had no impact for all students. Further, when disaggregating the data by gender and sources of self-efficacy, we find that Modeling Instruction positively impacted the Verbal Persuasion source of self-efficacy for women. This positive impact helps to explain high rates of retention for women in the MI classes.

Primary Contact: Vashti Sawtelle, Florida International University, Department of Physics,

Co-authors: Eric Brewé, Florida International University, Department of Curriculum & Instruction, Department of Physics, Laird H. Kramer, Florida International University, Department of Physics

Contributed and Targeted Posters

Possibilities: A Framework for Modeling Students' Deductive Reasoning in Physics

Type: Contributed Poster

Students often make errors when trying to solve qualitative or conceptual physics problems, but the process of deduction that students use when solving physics problems has not been thoroughly studied. To better understand that reasoning, I have developed a framework, based on the "Mental Models" framework in psychology championed by P. N. Johnson-Laird. This "Possibilities Framework" allows us to interpret errors in reasoning as a failure to flesh out all of the possibilities that result from the underlying physical premises. By identifying this failure, potential interventions can be suggested for student difficulties that range from overlooking potentially relevant physical quantities to actively oversimplifying the situation of interest.

Primary Contact: Jon D. H. Gaffney, University of Kentucky

Pre-Service Physics Teachers and Physics Education Research

Type: Contributed Poster

Training pre-service teachers requires among other things, content knowledge, pedagogical skills and pedagogical content knowledge. Teacher preparation programs have little, if any spare time to add more courses/activities to their program. However, I argue in this paper that we, as educators, must enhance the amount of physics education research in our pre-service physics teacher training programs. In this study, I analyze the results of two different types of exposure to physics education research from two different groups of pre-service physics teachers in our masters of arts and teaching program. The preliminary results from both of these groups suggest that content specific education research can enhance our pre-service teachers' abilities in their classrooms.

Primary Contact: David Rosengrant, Kennesaw State University

Predicting FCI Gain with a Nonverbal Intelligence Test

Type: Contributed Poster

We have administered a commercial, nonverbal intelligence test (GAMA) to students in two introductory physics courses, one algebra-based and one calculus-based. We compare scores on that test with scores on Lawson's Classroom Test of Scientific Reasoning as predictors of gains on the Force Concept Inventory.

Primary Contact: Richard D. Dietz, University of Northern Colorado,

Co-authors: Matthew R. Semak, University of Northern Colorado, Courtney W. Willis, University of Northern Colorado

Preliminary Study of the Effects of the Use of Self Awarded Homework Extensions

Type: Contributed Poster

One of the results of advances in technology is an increased use of online homework delivery systems. These usually differ in the mechanics of question delivery, student input, grading, and feedback mechanisms. However, regardless of all the bells and whistles, our ultimate goal is to get the students to complete the homework to improve their learning. In this preliminary study, we investigate the usage patterns and the impact on homework completion and course grade of self awarded homework extensions. The homework delivery mechanism used in the study is a simple locally developed system. The course used is a second semester introductory physics course.

Primary Contact: Taha Mzoughi, Kennesaw State University

Preliminary Validation Data for an Assessment of Textbook Problem Solving Ability: An Argument for Right/Wrong Grading?

Type: Contributed Poster

We have developed an assessment of students' ability to solve standard textbook style problems and are currently engaged in the validation and revision process. The assessment covers the topics of force and motion, conservation of momentum and conservation of energy at a level consistent with most calculus-based, introductory physics courses. This tool is discussed in more detail in an accompanying abstract, poster and paper by Marx and Cummings. Here we present preliminary validation data collected from four schools during the 2009/2010 academic year. Data include both pre- and post-instruction results for introductory physics courses as well as results for physics majors in later years. In addition, we present evidence that right/wrong grading may well be a perfectly acceptable grading procedure for a course-level assessment of this type.

Primary Contact: Karen Cummings, Southern Connecticut State University,

Co-authors: Jeffrey Marx, McDaniel College

Promoting and Studying Deep-level Dialogue During Large-lecture Intro Physics

Type: Targeted Poster

At Oregon State University, the introductory calculus-based physics sequence utilizes social engagement as a learning tool. The reformed curriculum is modeled after the Interactive Science Learning Environment from Rutgers University, and makes use of Peer Instruction as a pedagogical tool to facilitate interactions. Over the past two years we have utilized a number of techniques to understand how to facilitate activities that promote productive discussion within the large lecture classroom. We specifically seek student discussion that goes beyond agreement on conceptual questions, encouraging deeper discussions such as what assumptions are appropriate, or how different assumptions would change the chosen answer to a given question. We have quantitative analysis of engagement based on video data, qualitative analysis of dialogue from audio data, and classroom observations by an external researcher. In this session we share a subset of what we have learned about how to engage students in deep-level discussions during lecture.

Primary Contact: Dedra Demaree, Oregon State University,

Co-authors: Sissi Li and Jennifer Roth, Physics Department, Oregon State University

Targeted Poster Session: How to think and talk like a physicist?

Proportional Reasoning in Physics: What are students thinking? How can we help?

Type: Targeted Poster Session

Despite a significant emphasis on ratio strategies in precollege mathematics, many students have difficulty reasoning about ratio quantities in college physics. Research shows that students who struggle with simple questions that involve proportional reasoning tend to be less successful in introductory physics classes. This should hardly be surprising: the introductory course makes extensive use of proportional relationships between physical quantities in increasingly abstract contexts, and we teach assuming that students understand the algebraic representations and the proportionalities they imply.

Contributed and Targeted Posters

This session brings together current work on student thinking and learning about proportions. We'll explore the mismatch between our expectations and how well students actually reason about proportions, some productive and unproductive ways students reason about ratio quantities in physics, an instructional method that promotes proportional reasoning, and its implementation in college physics courses.

1. Cohen, Hillman, and Agee, 1978; Griffith, 1985; Coletta & Phillips, 2005

Primary Contact: Suzanne White Brahmia, Rutgers, the State University of New Jersey

QUEST: Quality Elementary Science Teaching

Type: Contributed Poster

Quality Elementary Science Teaching (QUEST), a unique professional development program designed for K-6 teachers and special educators that focuses on both content and pedagogy. The program incorporates the 5E instructional model, seamless assessment, and Universal Design for Learning (UDL) as its key components for training K-6 classroom teachers to address physical science concepts in their curriculum.

Participants in QUEST learn content and pedagogical techniques during the first week of the summer institute, then implement what they learned by working with students during the second week. During the academic year, the program supports teachers through follow up sessions and classroom visits by QUEST staff to help them successfully implement what they learned in their actual classrooms. The program also has an online component for support where the teachers can share their experiences with fellow participants and staff.

Primary Contact: Dr. Deborah L. Hanuscin, Assistant Professor, University of Missouri Columbia, MO,

Co-authors: 1. Delinda van Garderen Assistant Professor, University of Missouri Columbia, MO, 2. Deepika Menon Graduate Student, University of Missouri, Columbia, MO

Radical transformation of an upper division Quantum Mechanics course; pointing to the superiority of a student centered highly interactive engagement

Type: Contributed Poster

A relatively large (N=100) upper level quantum mechanics course was transformed to eliminate pre-prepared lectures and ensure active engagement. Students would complete a pre-reading assignment and graded pre-reading quiz before each class. During class they would respond to clicker questions with peer discussion and carry out short (5-10 minute) small group problem solving tasks that introduced new material. There was regular instructor feedback based on observation of student work and questions, but very little prepared lecturing. All course activities were designed to address explicit learning goals. We measured student attendance, student engagement, and student performance on quantitative (and conceptual) problem solving. In all categories, students in the transformed course significantly outperformed those in the previous iterations of this course which was taught with conventional lectures.

Primary Contact: Louis Deslauriers, University of British Columbia,

Co-authors: Louis Deslauriers, UBC, Physics and Astronomy, Kirk W. Madison, UBC Physics and Astronomy, Carl E. Wieman, UBC and CU, Physics departments

Redefining the Instructor's Role as a "Transient" Group Member

Type: Contributed Poster

Abstract: Research-validated educational reform has led to classroom models that vastly differ from the structure of traditional lectures, requiring students to adapt to new educational frameworks. We present results of a pilot study that, through the lens of a socio-cultural theoretical perspective, examines the interaction between the instructor and students working in a group. We examined the differences in how students interact with the instructor when the instructor's appearance varied between casual and more formal. We found that when casually dressed an instructor more easily takes on the status of a "transient" group member, which promotes effective group interaction by engaging the group without interrupting their dynamic interaction. This role is achieved by explicit attention to the overt and covert messages the instructor sends students

Primary Contact: Jared Durden, Department of Physics Florida International University,

Co-authors: Renee Michelle Goertzen Dpt of Physics Florida International University, Eric Brewe Dpt of Instruction and Learning and Dpt of Physics, Florida International University, Laird Kramer Dpt of Physics Florida International University

Redesigning and restructuring classroom assessments to reflect a new set of learning goals

Type: Contributed Poster

There is a growing concern in the PER community that physics students should learn more than just physics concepts. Several research-based curricula have been designed to help students develop those higher-level thinking skills, which are not easily assessable by existing assessment instruments. In order to motivate students to focus more on those new learning goals, we need to make the classroom assessments more aligned with the new learning objectives. By restructuring the grading of homework and exams, and redesigning the type of questions given, we were able to convince students to be self-motivated learners rather than superficial grade chasers. At the same time, the new assessment format was able to provide the instructor timely feedback on the effectiveness of his instruction.

Primary Contact: Yuhfen Lin, Florida International University,

Co-authors: David T. Brookes, Florida International University

Reflective self-corrections of homeworks in a conceptual physics course: An experimental control-group design study

Type: Contributed Poster

In spite of using active-engagement techniques in our classes, big percentage of students can not answer straightforward questions of the type we have covered in class and assigned as homework. We believe that students lack one of the essential components of meaningful learning: self-reflection. How do we engage students in a meaningful self-reflection and measure its implications? We hypothesize that we can achieve that by having students reflect on their homework solutions and doing self-corrections. Incorporation of a state of the art software platforms such as ePortfolio can greatly facilitate the task, as well as create new lifelong learning skills. We have conducted an experimental control group design study in a conceptual physics course at Queensborough Community College to measure the impact of such reflective activities on students. We present the results of the study and discuss its implications.

Contributed and Targeted Posters

Primary Contact: Vazgen Shekoyan, Queensborough Community College,

Co-authors: Wenli Guo, Queensborough Community College

Research techniques for uncovering the hidden curriculum in the context of problem solving

Type: Workshop

Details of a hidden curriculum can be discovered by studying the intentions of the instructors and the actions of the students. This workshop will present research techniques that we use to target and uncover aspects of this curriculum in the context of problem solving. We will introduce the development, use, and analysis of interviews based on authentic artifacts to probe the factors that shape instructors' intentions. We will also introduce the use of an analysis rubric for written problem solutions to determine if student actions reflect these faculty intentions.

Primary Contact: Ken Heller, University of Minnesota, Twin Cities,

Co-authors: Pat Heller, Leon Hsu, Andrew Mason, Qing Xu, University of Minnesota, Twin Cities, Edit Yerushalmi, Weizmann Institute, Jennifer Docktor, University of Illinois, Urbana-Champaign, Charles Henderson, Western Michigan University

Research-based Exercises to Facilitate Students' Transfer of Problem Solving Across Representations

Type: Contributed Poster

Our previous research suggested that the major difficulty students have when solving physics problems posed in multiple representations is due to students' inability to appropriately activate the required mathematical knowledge in the context of a physics problem. Based on these results, we developed problem sets for each major topic in introductory mechanics. Each set consisted of one or two pairs of matched math and physics problems, debate problems, and problem posing tasks. We conducted focus group interviews with two groups of students working in pairs: a treatment group working on our research-based problem sets and a control group solving isomorphic textbook problems on the same topics. We present a problem set we developed and results from the transfer task designed to assess students' ability to solve problems in graphical and equational representations.

Supported in part by US National Science Foundation Grant 0816207.

Primary Contact: Dong-Hai Nguyen, Department of Physics, Kansas State University,

Co-authors: Elizabeth Gire, Department of Physics, Kansas State University, N. Sanjay Rebello, Department of Physics, Kansas State University

Rethinking our goals: What will our students remember when they forget everything?

Type: Invited Talk

The question of the purpose of education is similar to the question about the purpose of life: it is difficult to keep the answer in mind when one is submerged in everyday routines and minor distractions. But if we stop briefly while grading an exam, preparing a lab, or running a review session and ask ourselves what students will remember 20 years from now, the question and its answer might change completely what we do every day. Our PER group has tried to answer this question and as a result is changing our approach to teaching introductory physics. We still want students to understand electromagnetic induction and thin lenses; but a larger goal is to empower them with the understanding of reasoning processes that

help them make independent decisions and solve complex problems in their future lives. I will share the successes and challenges of this work.

Primary Contact: Eugenia Etkina, Rutgers University

REU students' initial perceptions of scientific ethics

Type: Contributed Poster

One goal of undergraduate research, particularly Research Experience for Undergraduates (REU) programs, is to help students learn to become aware of the importance of ethical conduct. The Survey of Undergraduate Research Experiences (SURE) indicates that biology students believe they learn more about ethical conduct from their research experiences than physics students. Motivated by this, we initiated a study of both biology and physics REU students at Kansas State University consisting of pre- and post-interviews regarding their understanding of ethics with results to be compared to the SURE. This paper presents the students' initial perceptions (from the pre-interview) of how ethical issues impact science in general as well as their own specific work. We also discuss the differences in the interview responses of the two groups.

Primary Contact: Sytil Murphy, Kansas State University,

Co-authors: Dean Zollman -- Kansas State University

“Seeing” the development of physical theory in students' minds

Type: Targeted Poster

We have only our experiences of students' behaviors, verbal, gestural, kinesthetic, affective, symbolic, diagrammatic, etc., from which to imagine what might be their understandings of the phenomena to which we direct their attentions. When students work alone, they are deprived of one of the necessary components for development, namely social interactions in an intellectually challenging situation. In these evidence rich settings of students constructing and mutually negotiating for meaning of physical theory for a phenomenon, we have a window on the development of physical theory in their minds. Through this window we can observe the students constructing and testing new explanations for experiences that do not fit their initial expectations about those experiences, the development of physical theory in students' minds. A video of students constructing new understanding will be used to illustrate this perspective.

Primary Contact: Dewey I Dykstra, Boise State University

Targeted Poster Session: Out of One, Many; Five Researchers Analyze the Same Student Video

Singapore secondary one students' preconceptions on speed

Type: Contributed Poster

We report on the research findings on Singapore secondary one (Grade 7) students' preconception of speed: 1) The idea of someone ahead being faster than the one behind is prevalent among students answering the open-ended question, 2) The idea becomes less prevalent when the question becomes more guided, streamlining students' thinking towards the distance apart between two moving objects, 3) While most students were able to choose the correct choice that states that two boys who are running have the same speed because they remain the same distance apart, their explanations do not invoke the concept of speed as distance moved per unit time, and 4) Many students were not aware that in the definition of the average speed of a journey, the resting time was included as part of the total time elapsed. The data were from two batches of students at a reputable school.

Contributed and Targeted Posters

Primary Contact: See Kit Foong, National Institute of Education, Nanyang Technological University,

Co-authors: S.K. Munirah and Loganantham Kuppan/National Institute of Education, Nanyang Technological University, Chor Yam Lau/Ministry of Education, Singapore

‘So you’re saying...’: Paraphrase and interpretation in peer physics interviews

Type: Contributed Poster

Learning Assistants (LAs) at Seattle Pacific University engage in a series of interviews with their non-LA peers to develop their listening and interviewing skills. In the first interview, the LA interviewers are asked to be guests at their interviewees’ thinking. In this poster, we focus on two LAs’ interpretations of being a guest: wedding guests who do not interfere with the proceedings, and cocktail party guests who contribute ideas to the conversation. We show how these interpretations are present in their ontological commitments, (in)formal use of language, and expectations about interviewing and listening.

Primary Contact: Eleanor C Sayre, Wabash College,

Co-authors: Rachel E Scherr, Hunter Close, Seattle Pacific University

Street-fighting mathematics: Teaching mathematical courage

Type: Targeted Poster

Mathematics, the queen of the sciences, rules its domains with a strict, deductive hand—at least, that is what our students get taught explicitly. Mathematics courses, for example, come packed with definitions, lemmas, and theorems. At best, students learn to follow proofs made by others. Seeing mathematics as a field where any mistake is fatal, students cannot imagine using mathematics to express or discover patterns in the world. The explicit focus on rigor teaches rigor mortis.

After years lamenting this problem, I created “Street-fighting mathematics”, an applied-mathematics course at MIT whose explicit lesson is courage. It teaches six reasoning modes useful across science and engineering: dimensions, extreme cases, lumping, pictorial reasoning, successive approximation, and reasoning by analogy. I will illustrate each reasoning mode with examples—and, as a pacifist, encourage you to use these tools, and others that you find, to produce bold mathematical street fighters.

Primary Contact: Sanjoy Mahajan, MIT and Olin College

Targeted Poster Session: Taking Responsibility for the Hidden Curriculum: Practices and Challenges in addressing the broader goals in physics education

Structuring Classroom Discussion Using Formative Assessment Rubrics

Type: Targeted Poster

There has been substantial research on students’ abilities to engage in a scientific discussion and think critically in a science class. I will discuss a view that scientific critical thinking is not something innate, but has to be learned through a socio-cultural process. It involves inductees (students) becoming increasingly involved in a specialized discourse that has fixed rules, but whose rules are seldom made explicit within the physics community that uses them. I will then discuss one method of making these “discourse rules” of physics explicit for students by using formative assessment rubrics. I will

provide some examples of how these rubrics can be implemented, and examine their effectiveness in a physics class.

Primary Contact: David T. Brookes, Florida International University

Targeted Poster Session: How to think and talk like a physicist?

Student and Teacher Understanding of Buoyancy

Type: Contributed Poster

We report on the findings of a research study on student and teacher understanding of concepts related to floating, sinking and density. The study reports findings based on 156 Grade 7 students and 46 in-service science teachers, teaching mainly at the secondary level. We present and discuss preliminary quantitative and qualitative data for this study obtained using self-developed and adapted pre-tests from the Properties of Matter module found in Physics by Inquiry. Our analysis will highlight difficulties that were more prevalent among students, as well as those that were common for both teachers and students. The implications for development of instructional materials for students and professional development of teachers on this topic will also be discussed.

Primary Contact: Darren Wong, National Institute of Education, Nanyang Technological University, Singapore,

Co-authors: Lim Chim Chai, CRPP, NTU, Singapore, Munirah Shaik Kadir, CRPP, NTU, Singapore, Foong See Kit, NIE, NTU, Singapore

Student Difficulties with non-Cartesian Unit Vectors in Upper Level E&M

Type: Contributed Poster

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. To assess how well students are able to do this integration and application I have developed several simple concept tests on position and unit vectors in non-Cartesian coordinate systems as they are used in upper level E&M. In this poster I describe these concept tests and present results that show students at different levels (pre-E&M course, post-E&M course, 1st year graduate students) and in different disciplines (physics, electrical engineering) have difficulty using non-Cartesian unit vectors appropriately.

Primary Contact: Brant Hinrichs, Drury University, Physics Department

Student difficulties with right hand rules

Type: Contributed Poster

Although there is much speculation about why students struggle with the use of right hand rules in physics, there is little data that directly addresses the issue. Starting from research in vector understanding and spatial cognition, several factors have been identified as possibly contributing to the difficulty of using physical right hand rules. We will present preliminary results of a study designed to address the degree to which these factors impact student use of a right hand rule.

Primary Contact: Mary Bridget Kustusch, North Carolina State University,

Co-authors: Robert J. Beichner, North Carolina State University

Contributed and Targeted Posters

Student responses to newly-implemented teaching methods in the advanced physics laboratory

Type: Contributed Poster

How do students in an advanced physics laboratory course respond when instructors incorporate different teaching methods? Physics education researchers have explored extensively how students respond (in the form of exhibited learning, attitudinal, and performance outcomes) to different instructional practices in introductory classrooms and laboratories. Studies of student responses to instruction in advanced laboratories, however, have primarily concentrated on the teaching of single physics experiments rather than broader pedagogical practices. In this poster, we describe three teaching methods faculty tried out for the first time in one advanced laboratory course, independent of specific physics experiments: oral assessments; multi-format written reports; and course wikis. We present results on student responses to the implementation of these methods. We engaged in qualitative analysis of multiple data sources, including student surveys, observations of laboratory activities, and student and faculty interviews. Investigating student responses to such instructional experimentation has implications for faculty aspiring to try new methods in advanced physics laboratory courses.

Primary Contact: Julie Schell, Harvard University,

Co-authors: Jason Dowd, Harvard University, Ives Araujo, Harvard University, Eric Mazur, Harvard University

Student Understanding of the Correlation between Hands-on Activities and Computer Visualizations of NMR/MRI

Type: Contributed Poster

This study utilizes the implementation of research-based learning materials designed to teach students about the physics of magnetic resonance imaging (MRI) in a concepts-based introductory-level physics course. A progression of activities using hands-on experiments and computer visualizations leads students through the basics of magnetism and resonance, and finally toward a model of MRI. Here we seek to describe how students understand the basics of resonance and then proceed to make correlations between the hands-on activities and visualizations. Results show that students had fundamental difficulties with the concepts surrounding resonance, and that it appears to have led to a rudimentary understanding of the visualization and how the two tasks were correlated. Based on student responses, we postulate what further scaffolding will be necessary for helping the students make more robust connections and a more comprehensive understanding of the phenomena associated with MRI.

Primary Contact: Dyan McBride, Mercyhurst College,

Co-authors: Sytil Murphy and Dean Zollman, Kansas State University, Manhattan KS

Students' Understanding of the Concepts of Vector Components and Vector Products

Type: Contributed Poster

In this work we investigate students' understanding of: 1) vector components and, 2) vector products. We administered a test to 409 students completing introductory physics courses at a private Mexican university. In the first part, based on the work of Van Deventer [1], we analyze the understanding of components of a vector. We used multiple choice questions asking for students reasoning to elaborate on the misconceptions and difficulties of graphical representation of the x- and y-component of a vector. In the

rest of this work, we analyze the understanding of the dot and cross products. We designed opened-ended questions to investigate the difficulties on the calculation and the misconceptions in the interpretation of these two products.

[1] J. Van Deventer, "Comparing student performance on isomorphic math and physics vector representations," Masters Thesis, The University of Maine (2008).

Primary Contact: Genaro Zavala, Tecnologico de Monterrey,

Co-authors: Pablo Barniol, Tecnologico de Monterrey

Students' and Instructor's Impressions of Ill-structured Capstone Projects in an Advanced Electronics Lab

Type: Contributed Poster

During the spring 2010 six students enrolled in an electronics advanced lab worked in pairs on ill-structured capstone projects. They designed electronic circuitry to automate experiments that were completed in a previous advanced physics lab. Some ill-structured features of these capstone projects included open-ended goals, limited guidance from the instructor and the possibility of multiple solution paths. Semi-structured interviews were conducted with both the students and the instructor of the class, before and after the students worked on these ill-structured capstone projects to gauge the participants' expectations of the projects before they began and their views about these projects after they were completed. We report on the pre- and post-project impressions of the students and instructors regarding this ill-structured learning experience and the insights it provides us for future implementations of such projects.

This work is supported by NSF grant # DUE-0736897.

Primary Contact: Nasser Juma, Department of Physics, Kansas State University,

Co-authors: 1. Elizabeth Gire, Kansas State University, 2. Kristan Corwin, Kansas State University, 3. Brian Washburn, Kansas State University, 4. N. Sanjay Rebello, Kansas State University

Students' responses to different representations of a vector addition question

Type: Contributed Poster

Students use multiple methods to add vectors graphically [1], some of them leading to correct solutions, some of them not. We discuss students' responses to four different representations of a single graphical vector addition question, designed to elicit different solution methods. These four questions have vectors arranged in either a head-to-tail or a tail-to-tail orientation and either with and without a grid. These questions were administered to several hundred students at two different universities. We present the prevalence of different methods in students' responses on the four different types of questions. Furthermore, we describe the types of language they used as well as inconsistencies between students' explanations and drawings.

References

[1] J. M. Hawkins, J. R. Thompson, and M. C. Wittmann, AIP Conf. Proc. 1179, 161 (2009)

Supported in part by NSF Grants REC-0633951

Primary Contact: Jeffrey M. Hawkins, The University of Maine,

Co-authors: Michael C. Wittmann, The University of Maine, John R. Thompson, The University of Maine, Eleanor C. Sayre, Wabash College, Jessica W. Clark, Rochester Institute of Technology

Contributed and Targeted Posters

Supporting Scientists Ability to Communicate About Science in Everyday Language

Type: Contributed Poster

The University of Colorado's Partnership for Informal Science Education in the Community (PISEC) program, in which undergraduate, graduate, and post doctoral volunteers to participate in after school informal science activities with children, allows volunteers to develop experience in teaching and expand their ability to communicate about science to nonscientists. The Communication in Everyday Language Assessment (CELA) has been used for several semesters to measure participants changing ability to communicate in these informal settings. We continue the process of validating this assessment and present preliminary data that demonstrates the potential of these environments to promote early-career scientists' abilities to communicate about science in everyday language.

Primary Contact: Jessica E. Bartley, University of Colorado Physics,

Co-authors: Laurel M. Mayhew, University of Colorado Physics,
Noah D. Finkelstein, University of Colorado Physics

Supporting Teacher Leadership for Physics Education Reform – Where Do We Begin?

Type: Contributed Poster

Teacher leadership is recognized as a necessary ingredient to support educational reform. Leaders provide the expertise needed to ensure that reforms promote student learning. The overarching goal of Leadership in Freshman Physics, a Math and Science Partnership (MSP), is to support a cadre of teachers-leaders who serve as advocates for excellence by developing their physics content and research-based pedagogical knowledge. In order to support teachers in developing effective leadership skills, we must first understand their views and prior experiences of leadership. We present results from the initial phase of our study in which we examined teacher' self-reported leadership experiences and responses to a Teacher Leadership Inventory. Results highlight areas of inconsistency between teachers' activities and what they view as leadership. Insights from our studies can be used to design differentiated professional development experiences to promote teacher leadership. This research is supported in part by NSF grant DUE 0928924.

Primary Contact: Carina M. Rebello, University of Missouri,

Co-authors: Somnath Sinha, University of Missouri, Deborah Hanuscin, University of Missouri

Survey development for assessing learning identity in an ISLE classroom

Type: Contributed Poster

Innovative STEM curricula such as the ISLE curriculum (Etkina et al., 2007) are centered on active engagement in social learning processes as a means to achieve curricular goals. Classroom practices are highly interactive to facilitate students' development of authentic scientist abilities. To the students, these classroom practices often seem very different from their previous learning experiences in terms of behavioral expectations, attitude, and what it means to learn. Consequently, students must modify their identity as learners in addition to physics conceptual understanding in order to participate productively in this learning environment. Using a survey we developed, we want to assess their 1) expectations of student and teacher roles, 2) self efficacy towards skills supported in ISLE and 3) attitudes towards social learning as well as how these change as a result of their experience in this curriculum. We will discuss the development, validation and preliminary findings of the survey.

Primary Contact: Sissi L. Li, Oregon State University,

Co-authors: Jennifer A. Roth, Oregon State University, Dedra Demaree, Oregon State University

Surveying Instructors' Attitudes and Approaches to Teaching Quantum Mechanics

Type: Contributed Poster

Understanding instructors' attitudes and approaches to teaching quantum mechanics can be helpful in developing research-based instructional tools. Here, we discuss the findings from such a survey in which 12 faculty members reflected on various issues related to quantum mechanics teaching. Topics included opinions about the goals of a quantum mechanics course, general challenges in teaching the subject, students' preparation for the course, difficulty of teaching various topics, the effectiveness of textbooks, comparison with their own learning of quantum mechanics vs. how they teach it, views about foundational issues, and to what extent contemporary topics are incorporated into the syllabus.

Primary Contact: Chandrekha Singh, University of Pittsburgh,

Co-authors: Shabnam Siddiqui, University of Pittsburgh

Surveying Students' Understanding of Quantum Mechanics in One Spatial Dimension

Type: Contributed Poster

Development of conceptual multiple-choice surveys related to a particular physics topic is important for designing research-based learning tools to reduce the difficulties. We explore the difficulties that the advanced undergraduate and graduate students have with quantum mechanics formalism in one spatial dimension. We developed a research-based conceptual multiple-choice survey that targets these issues to obtain information about the common difficulties and administered it to more than a hundred students from seven different institutions. The issues targeted in the survey include possible wavefunctions, bound and scattering states, quantum measurement, expectation values, Hamiltonian, time-dependence of wavefunction and time-dependence of expectation value. We find that the advanced undergraduate and graduate students have many common difficulties with these concepts but research-based tutorials and peer-instruction tools can significantly reduce these difficulties. The survey can be administered to assess the effectiveness of various instructional strategies.

Primary Contact: Chandrekha Singh, University of Pittsburgh,

Co-authors: Guangtian Zhu, Department of Physics and Astronomy,,
University of Pittsburgh

Sustainability of K-12 Afterschool Programs

Type: Contributed Poster

The University of Colorado Partnerships for Informal Science Education in the Community (PISEC) studies impacts on University and K-12 participants in an afterschool informal science education program. We continue to explore the sustainability of the University-Community Partnership Model (in which all participants act in their own self interests). To identify sustainable program characteristics, we reviewed all programs funded by the NSF Informal Science Education Grants in the last 10 years, identifying out of school K-12 programs that persisted beyond the term of the grant. While most NSF/ISE grants were awarded to museums /exhibits, television / radio / documentary programs, and conferences / symposiums, a few of the targeted out-of-school programs were sustained and provide insight to such programs' success. We present findings on funding statistics of NSF programs and the trends consistent with sustained

Contributed and Targeted Posters

programs. This work is supported, in part, by NSF # 0551010, the JILA AMO PFC.

Primary Contact: Laurel M. Mayhew, Univ. of Colorado Physics,
Co-authors: Maxwell Lichtenstein, University of Colorado Physics,
Noah D. Finkelstein, University of Colorado Physics

TA Beliefs in a SCALE-UP Style Classroom

Type: Contributed Poster

In Spring 2010, the Oregon State University physics department instituted a SCALE-UP (Student-Centered Active Learning Environment for Undergraduate Programs) style studio classroom in the introductory, calculus-based physics series. In our initial implementation, comprised of two hours lecture, two hours of studio, and two hours lab work, the studio session was lead by a faculty member and either 2 GTAs or 1 GTA and 1 LA. We plan to move to a model where senior GTAs can lead studio sections after co-teaching with the faculty member. It is critical that we know how to prepare and support the instructional team in facilitating student learning in this setting. We examine GTA and LA pedagogical beliefs through reflective journaling, interviews, and personal experience of the authors. In particular, we examine how these beliefs changed over their first quarter of instruction, as well as the resources used to adapt to the new classroom environment.

Primary Contact: George DeBeck V, Oregon State University,
Co-authors: S. Settelmeyer, Oregon State University, S. Li, Oregon State University, D. Demaree, Oregon State University

Taking Responsibility for the Hidden Curriculum: Practices and Challenges in addressing the broader goals in physics education

Type: Targeted Poster Session

An invitational interactive poster session

This interactive poster session will lead a community discussion around two major themes: 1) what are ways and models for us to enact and make explicit our efforts to address the hidden curriculum (beyond standard content learning) in physics classes, and 2) what barriers are faced in doing so. We will emphasize how we might take responsibility for what actually happens in the classroom, as well as the historical and institutional resources and barriers that we face. Four posters will highlight the variety of scales and approaches that may be used to address the hidden curriculum and serve as a focal point for our collective discussions. Be prepared to share your own successes and challenges. We will begin discussions by focusing on our roles and goals as educators, and will happily draw on theory and practice alike.

Primary Contact: Noah Finkelstein, University of Colorado at Boulder,
Co-authors: Chandra Turpen, University of Colorado at Boulder, and Western Michigan University

Teaching a Hybrid Online Course in Electricity and Magnetism Using Multimedia Learning Modules (MLM)

Type: Contributed Poster

As part of a hybrid course in a calculus-based introductory E&M at California State Polytechnic University, Pomona, we have implemented Multimedia Learning Modules through the blackboard learning management system. The integration of the web-based

Multimedia Learning Modules introduces students to basic physics content prior to class and allows instructors to focus on more in-depth application of the concepts. We will describe the research project and discuss the impact it had on student preparation, exam performance, and their attitude towards online material.

Primary Contact: Homeyra Sadaghiani, California State Polytechnic University Pomona

Teaching Pedagogy in Physics

Type: Contributed Poster

We report on an adapted version of the Physics and Everyday Thinking (PET) curriculum. A unique aspect of PET is its inclusion of special activities that focus on Learning about Learning (LAL) in which undergraduates analyze videos of children talking about science and explicitly consider the nature of science. To create a course that intentionally linked science content, children's ideas, and strategies for science instruction, we augmented the existing PET LAL activities with discussions about teaching and the design of the PET curriculum, and added activities focused on LAL from companion curricula such as Physical Science and Everyday Thinking (PSET) and Learning Physical Science (LEPS). To compensate for the additional time on LAL, we reduced the content activities to only those that directly supported LAL activities and goals. We found that students made significant gains on the C-LASS and expressed beliefs about teaching consistent with the PET pedagogy.

Primary Contact: Danielle Harlow, University of California, Santa Barbara,

Co-authors: Lauren Swanson Honeycutt, University of California, Santa Barbara, Hilary Anne Dwyer, University of California, Santa Barbara, Julie A. Bianchini, University of California, Santa Barbara

Test-Retest Reliability of the Force Concept Inventory (FCI)

Type: Contributed Poster

The FCI has influenced the development and acceptance of many research-based pedagogies. Although the FCI's external validity was studied, no data exists on test-retest reliability. We administered the FCI to students enrolled in an Electricity&Magnetism course in the first week of the semester and re-administered the FCI that same week. No mechanics review took place between test administrations. A total of 100 students completed the test and re-test. We find a correlation of $r=0.89$ between test and re-test total scores, suggesting strong reliability. We then looked at changes between Right and answers and Wrong answers in the test and re-test. We isolate five possible transitions: Right-Right, Right-Wrong, Wrong-Right, Wrong-Wrong_same, Wrong-Wrong_different. Students changed their choices on 31% of items, suggesting weak reliability. Chi-square analyses show the test to be neither completely random nor completely consistent. Using an iteratively constructed probabilistic model, we report the probability for each transition.

Primary Contact: Nathaniel Lasry, John Abbott College,
Co-authors: Kelly Miller, McGill University, Orad Reshef, McGill University, Ariel Dahan, McGill University, Helena Dedic, Vanier College, Steve Rosenfield, Vanier College

The Beginnings of Energy in Third Graders' Reasoning

Type: Contributed Poster

In this paper, we present evidence of elementary school students' resources for thinking about ideas that are foundational for learning

Contributed and Targeted Posters

about energy. Here we provide a case study of a third grade class that follows a responsive curriculum where the lesson is constructed around children's ideas, and we show that a learning environment focused on the children's inquiries rather than on their arrival at those conceptual objectives can support the activation of those productive resources. That is, their teacher guided them to express themselves clearly, to draw on their own tangible experience, and to make sense. She did not drive them toward particular ideas about energy, but guided them in discovering the beginnings of the concept in what the children invented for themselves. In this way, we suggest, the extended focus on children's inquiry could provide a means for their productive ideas to emerge.

Primary Contact: Jennifer Radoff, University of Maryland- College Park,

Co-authors: Fred Goldberg, San Diego State University, David Hammer, University of Maryland- College Park

The hidden curriculum in laboratory data analysis – development of a diagnostic test and initial results

Type: Contributed Poster

During the course of a Physics degree, our students spend a long time in the laboratory. As well as learning how to 'do' practical physics, we also expect them to pick up skills in processing, analysing and interpreting data. These skills frequently fall into the hidden curriculum: they may not be explicitly taught (instead being 'absorbed' as a side-effect of other activities) and are often not specifically assessed. So do our students really attain a solid grasp of them?

We have developed and validated a 23-item MCQ diagnostic test on data handling skills in the physical sciences, incorporating such concepts as precision and accuracy, quantitative error analysis, graphical representations and lines of best fit. The test instrument has been evaluated using a trial cohort of over 1200 students in 10 institutions across the UK and Ireland and has been found to perform satisfactorily on widely-used measures of reliability.

Our initial findings show that overall student attainment in these areas is surprisingly consistent across all institutions, disciplines and educational levels. In particular, there seems to be no clear development of student ability after the initial year of instruction, with widespread stagnation of student skill levels in the later years of the degree.

Primary Contact: Ross Galloway, University of Edinburgh,

Co-authors: Simon Bates, University of Edinburgh, Helen Maynard-Casely, University of Edinburgh, Hilary Singer, University of Edinburgh, Kate Slaughter, University of Edinburgh

The Impact of the History of Physics on Student Attitude and Conceptual Understanding of Physics

Type: Contributed Poster

The purpose of this study is to investigate student learning of Newtonian Mechanics through the study of its history and the development of the relevant ideas since the time of ancient Greece. The hypothesis is that not only will students learn the basic concepts of mechanics, but also will develop a more positive attitude and appreciation for physics. To assess the students' conceptual understanding, we administer the nationally known Force Concept Inventory (FCI) test and for the measurement of student attitude change, we employed the Colorado Learning Attitudes about Science Survey (CLASS); both were given as pre and post-tests. Additionally, at the end of the quarter, a survey was given out to see how students

perceived the different course components and which ones they found helpful in their learning. This paper will present our preliminary results on such a study.

Primary Contact: Homeyra Sadaghiani, Department of Physics, California State Polytechnic University, Pomona,

Co-authors: Sarah Garcia and April Hankins, Affiliation for both: California State Polytechnic University, Pomona: Physics Undergraduates

The influence of theoretical frameworks on researchers' attitudes towards students

Type: Targeted Poster Session

Education research is highly value laden. [1] This session focuses on the issue of respect for the subjects of research, for instance students. Theoretical frameworks in education can influence which data is collected and analyzed, as well as how that data is interpreted. We assert that both theories and methods in education research entail a variety of values, and hence attitudes toward students. We will ask: how do theoretical frameworks in PER align with our morals and personal values? And, how might morals and personal values influence our choice of theoretical framework? The presenters will illuminate and confront the relationship between their personal values and research, particularly attitudes toward and treatment of students.

1. Scientific Research in Education, NRC (2002)

Primary Contact: Renee Michelle Goertzen, Florida International University,

Co-authors: Noah Podolefsky, University of Colorado, Boulder

The Physics Van Program: Supporting the Needs of Chicago Area Physics Teachers

Type: Contributed Poster

During the past seven years, Chicago State University, through its Physics Van Program, has worked with many Chicago area high school physics students and their teachers. The Physics Van Program provides both intellectual support and access to laboratory equipment. Intellectual support is provided through a two-week summer in-service course that emphasizes research-based teaching methodology as well as instruction in the use of both basic and technology-based equipment. During the academic year, the Van Program allows teachers who have been participants to engage their students in the program activities by lending them the necessary equipment. Teachers who have been involved in the program have formed a network through which they can share common goals, discuss the conceptual difficulties of their students, and pass on valuable teaching tips. In this poster, we present a description of the program and discuss how the collaborative nature of the project has informed the program's evolution.

Primary Contact: Mel Sabella, Chicago State University,

Co-authors: Joel Hofslund, Chicago State University

The Use of a Web-based Classroom Interaction System in Introductory Physics Classes*

Type: Contributed Poster

A web-based system (InClass) interaction system was used in algebra-based and calculus-based physics classes to enhance students' classroom interaction. The teaching approach primarily incorporated elements of Mazur's Peer Instruction and Interactive Lecture Demonstration. In our implementation, students used personal digital assistants (PDAs) to interact with their instructor during lecture or classroom demonstration. In this paper, we will document the perceptions and attitudes of algebra-based and

Contributed and Targeted Posters

calculus-based physics students towards the interactive teaching approach and likewise present data on how this approach affected students' performance on the Force Concept Inventory.

*This work is supported in part by the National Science Foundation under grant DUE-0737375.

Primary Contact: Edgar Corpuz, University of Texas-Pan American,

Co-authors: Ma. Aileen Corpuz, University of Texas-Pan American, corpuzm@utpa.edu, Rolando Rosalez, University of Texas-Pan American, rollie_roses@yahoo.com

The use of concept tests and peer instruction in upper-division physics

Type: Targeted Poster

Many upper-division courses at the University of Colorado now regularly use peer instruction in the form of clicker questions during lectures. Particular attention has been paid to developing and implementing clicker questions in junior-level E&M and Quantum mechanics. These transformed classes are moderate in size (~20-60 students), and largely follow traditional local norms of syllabus and content coverage. However, our faculty have recently articulated broader learning goals (e.g developing math-physics connections) expected for physics majors in these courses. The design and use of concept tests is aligned with these goals, and has altered the dynamic of our classes. Coupled with other course transformations, we find measurable improvement in student performance on targeted conceptual post-instruments. Here, we discuss classroom logistics of upper-division clickers, design of clicker questions, aspects of student engagement facilitated by concept-tests, and measures of and challenges to sustainability of this activity. This material is based upon work supported by the National Science Foundation under Grant No. DUE 0737118.

Primary Contact: Steven Pollock, University of Colorado,

Co-authors: Katherine Perkins, Stephanie Chasteen, Michael Dubson, University of Colorado

Targeted Poster Session: Upper-division activities that foster "Thinking like a Physicist"

Thinking about energy with bodies and objects: Cognition as a sensorimotor and material activity

Type: Targeted Poster

The practice of using rich records of naturally occurring activities as evidence of student knowledge promotes and supports a particular point of view: that learning and expertise show best in what students do and say to learn together. The "cells" of this talk and action are events on the order of one second long. The meaning of such events is made evident in interactional sequences on the order of minutes. Our particular analytic interest is in the ways in which our sensorimotor systems shape, generate, display, and limit the kinds of things we think about, and in how material artifacts shape the substantive and interactional aspects of students' activity. In this view, students that just sit still and talk to each other aren't doing much. We analyze a sequence of medium richness, in which the construction of a whiteboard structures students' thinking about energy. In this sequence of a few minutes, the embodiment of cognition is apparent in what the participants say, but social constraints limit their use of their bodies.

Primary Contact: Rachel Scherr, University of Maryland,

Co-authors: Hunter Close, Sam McKagan

Targeted Poster Session: Out of One, Many; Five Researchers Analyze the Same Student Video

Toward an Integrated Online Learning Environment

Type: Contributed Poster

We are building in LON-CAPA an integrated learning environment that will enable the development, dissemination, and evaluation of PER-based material. The centerpiece of our environment is a collection of multi-level research-based problem sets organized by topic and cognitive complexity that are designed to help students learn physics problem solving. These sets are associated with learning modules that contain very short expositions of the content supplemented by integrated open-access videos, worked examples, simulations, and tutorials (some from ANDES). Our pedagogical emphasis is Modeling Applied to Problem Solving pedagogy [1], but these materials are editable and rearrangeable to accommodate any pedagogy. To assess students' performance accurately with respect to a system-wide standard, we plan to implement Item Response Theory to assess students accurately. Together with other PER assessments and purposeful solicitation of student feedback, this will allow us to measure and improve the efficacy of various research-based materials, while getting insights into teaching and learning physics.

1. A. E. Pawl, A. Barrantes and D. E. Pritchard, "Modeling applied to problem solving" in Proceedings of the 2009 Physics Education Research Conference, Ann Arbor, MI, 2009.

Primary Contact: Raluca E. Teodorescu, Department of Physics and Research Laboratory for Electronics, Massachusetts Institute of Technology,

Co-authors: Andrew Pawl, Department of Physics and Research Laboratory for Electronics, Massachusetts Institute of Technology,, Saif Rayyan, Department of Physics and Research Laboratory for Electronics, Massachusetts Institute of Technology,, Analia Barrantes, Department of Physics and Research Laboratory for Electronics, Massachusetts Institute of Technology and, David E. Pritchard, Department of Physics and Research Laboratory for Electronics, Massachusetts Institute of Technology

Toward meaning and scientific thinking in the traditional freshman laboratory: Opening the "idea space"

Type: Invited Talk

The physics freshman laboratory curriculum would appear to be a natural place for students to participate in activities related to critical thinking. However, several elements of the more traditional curriculum, such as an instruction driven recipe-like approach in order to reproduce well-known results, conspire together to send a message that is at odds with broad scientific thinking. It is postulated that this type of formulation of laboratory activities causes a closing of the student "idea space". For meaningful reflection and critique to be a natural part of the learning activities it is necessary to open the idea space by choosing suitable ways of framing the activities in terms of the parameters that control the idea space. In the talk we look at three such parameters that appear to control the idea space: metaphors, audience and language usage.

Primary Contact: Saalih Allie, University of Cape Town, South Africa

Transfer of Learning in the Context of an Inquiry-Based General Physics Laboratory

Type: Contributed Poster

This research investigated how several inquiry-based introductory physics laboratory activities facilitate students' knowledge construction and how they affect students' ability to apply physics

Contributed and Targeted Posters

principles in explaining real-life situations. In this paper, we will document the associations that students make as they go through hands-on activities designed to guide them to discover physics principles and relationships among physical quantities. Our results showed that most students do not readily transfer the target content knowledge learned through discovery-based laboratory activities into a transfer context (e.g. real-life situations).

Primary Contact: Edgar Corpuz, Department of Physics and Geology, University of Texas-Pan American,

Co-authors: Jennifer Rodriguez, University of Texas-Pan American, Rolando Rosalez, University of Texas-Pan American

Trends in the PERC Proceedings

Type: Contributed Poster

The number of papers published in the Physics Education Research Conference (PERC) Proceedings has increased dramatically in the past nine years, growing from 28 published papers in 2001 to 77 in 2009. This poster will present observed trends in published PERC papers and their topics, including differences in those submitted for peer review and those published as invited papers. This work is based in part on the PER-Central database, which has cataloged all PERC papers published from 2001-2009.

Primary Contact: Lyle Barbato, University of Oklahoma,

Co-authors: Vincent H. Kuo, Colorado School of Mines

Two years of testing long-term observation in middle school astronomy

Type: Contributed Poster

AAAS [1] has noted that “[m]iddle-school students may think experiments are a way to produce a desired outcome, rather than a way of testing ideas.” This predisposition is excruciatingly difficult to counter in both students and teachers. Our intent in an astronomy experiment was to address this problem directly by making and recording regular observations of Sun shadows that would occur over the school year and from which students would find and be able to articulate the annual pattern of the change of Sun’s position. Students engaged in long term observations of natural phenomena from which they could build understanding. We present the results of two yearlong investigations and speculate on whether this could be a useful way to address students’ general misconception of science as a series of 45-minute experiments. Measuring the change in students’ conceptions is an area for future research.

Primary Contact: Bill Schmitt, The Science Center of Inquiry,

Co-authors: Gordon Aubrecht, Ohio State University, Marion, aubrecht@mps.ohio-state.edu, (1) AAAS Science NetLinks, “Spontaneous Generation,”

<http://www.sciencenetlinks.com/lessons.cfm?DocID=126>, Research supported in part by grants from the Ohio Department of Education, #60018325 and 60021887, “Systemic Change Through Embedded Professional Development at a STEM+C Middle School (IMPACT II)”.

Uncovering the hidden decisions that shape curriculum

Type: *Invited Talk*

Developing explanatory models is a central practice to scientific inquiry. When students create and test explanatory models for scientific phenomenon, they develop content knowledge, knowledge of the nature of science, and creative thinking skills. Unfortunately, such instruction rarely occurs in K-12 science. This is, in part, because teachers do not have the opportunity to develop sophisticated

understandings of the process of modeling, but also because teaching in this way requires teachers to make real-time instructional decisions that are responsive to students’ ideas. This is challenging for new teachers, especially because this decision process is often invisible. In this talk, I will highlight the importance of providing opportunities for sophisticated science thinking for our youngest learners and consider how uncovering the decisions that shape physics courses for teachers may benefit their future students.

Primary Contact: Danielle Harlow, University of California, Santa Barbara

Understanding and Interpreting Calculus Graphs: Refining an Instrument

Type: Contributed Poster

The objective of this ongoing study is to refine an instrument to evaluate conceptual understanding and graphical interpretation of a function and its derivative. The instrument is based on a modified version of the Test of Understanding Graphs in Kinematics (TUG-K) which consists of 26 items (7 dimensions). In the new instrument, Test of Understanding Graphs in Calculus (TUG-C), the kinematics context has been removed from the items creating a new context-free version. To favor the translation from kinematics to Calculus, the focus is on 5 out of the 7 original dimensions of the test, giving a 16-item test. A total of 526 students from a university level Introductory Physics course participated in the study. Half of the students were administered the kinematics test and the other half took the calculus test. This work will present data showing preliminary results of the instrument and new directions on improving the instrument.

Primary Contact: Genaro Zavala, Tecnologico de Monterrey,

Co-authors: Nadia Perez-Goytia, Tecnologico de Monterrey, Angeles Dominguez, Tecnologico de Monterrey

Understanding Confusion: Is it as bad as it seems?

Type: Contributed Poster

Physics instructors, by and large, try to avoid confusing their students. However, the truism underlying this approach, “confusion is bad,” has been challenged by instructors dating as far back as Socrates, who asked students to question their assumptions and wrestle with ideas. This begs the question: Are confused students simply lost, or does their confusion indicate deeper, more critical thinking than less-confused learners? We evaluated student performance on assignments (i.e. correct and incorrect responses) in an introductory physics course that involved innovative methodologies (peer instruction, just-in-time teaching, and research-based materials) while simultaneously asking them to self-assess their confusion over the material. We probed whether students who said they were confused were correct more or less frequently than students who did not claim to be confused. In this poster, we highlight our results and draw some conclusions about confusion. Is it really as bad as it seems?

Primary Contact: Ives Araujo, Harvard University,

Co-authors: Jason Dowd, Harvard University, Julie Schell, Harvard University, Jessica Watkins, Harvard University, Eric Mazur, Harvard University

Understanding How Students Use Physical Ideas in Introductory Biology Courses

Type: Contributed Poster

The University of Maryland Biology and Physics Education Research Groups are investigating students’ views about the role of physics in

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introductory biology courses. The Bio 2010 report emphasized the value of integrating physics, mathematics, and chemistry into the undergraduate biology curriculum. This poster presents data from an introductory course that addresses the fundamental principles of organismal biology. This course incorporates several topics directly related to physics, including thermodynamics, diffusion, and fluid flow. We examine pre- and post-attitude survey, interview, and class observation data to establish how students consider and employ these physical ideas in the context of their biology course. These results have broad implications as physics instructors consider reforms to meet the interdisciplinary challenges of Bio 2010.

Primary Contact: Jessica Watkins, University of Maryland, College Park,

Co-authors: Kristi Hall, University of Maryland, College Park, E.F. Redish, University of Maryland, College Park, Todd J. Cooke, University of Maryland, College Park

Upper-division activities that foster “Thinking like a Physicist”

Type: Targeted Poster Session

In this Targeted Poster Session cum research working group, curriculum developers will each present their favorite upper-division activity to small groups of session participants. The participants will be asked to identify aspects of the activity that engage students in “thinking like a physicist”, the in-class actions of the instructor that foster this skill, and the types of resources that students must employ when working with the materials. Then we will compare the activities, looking for common curricular structures and hidden curriculum goals, the differing affordances of different activities, and hopefully, at the end, a rich description of what “thinking like a physicist” might mean and how we can foster this capability in our students. A research paper summarizing the session’s conclusions will be written for the proceedings. (Yep, expect videotaping and IRB forms!) This material is based upon work supported by the National Science Foundation under Grant No. DUE 0618877.

Primary Contact: Corinne A. Manogue, Oregon State University,

Co-authors: Elizabeth Gire, Kansas State University, Emily van Zee, Oregon State University

Usage of the Term “Force,” Reasoning Ability, and FCI Performance II

Type: Contributed Poster

Do students with the greatest FCI gains and reasoning abilities change how they delineate “force” from colloquial equivalents any differently than other students? 230 students enrolled in first semester algebra based physics completed FCI pre- and post-tests, Lawson’s Test of Scientific Reasoning Ability (TSR) and Mechanics Language Usage instrument (MLU) pre- and post-tests. The MLU measured changes in usages of the term “force” via multiple choice and free response items. Results of the quantitative data were consistent with prior research but also revealed that changes in performance on the MLU bear little correlation with FCI performance (gains, pre- or post-test) or TSR performance. Presented in this poster are the exploratory findings of the subset of students within this study who demonstrated high FCI gains (>0.60) and elevated TSR scores ($>8/12$) yet did not significantly change their usage of “force” as measured by the MLU.

Primary Contact: Steven Maier, NWOSU

Using analogy for learning Introductory Physics

Type: Contributed Poster

Identifying the physics principles involved in solving problems is a critical step in problem solving. A major goal in physics education is to help students discern the deep similarities between problems based upon the physics principles so that they can transfer what they learned by solving one problem to solve another problem based upon the same principle. We conducted an investigation in which algebra and calculus-based introductory physics students were asked explicitly in the quiz to browse over and learn from a solved problem and then solve another problem that has different surface features but the same underlying physics principles. Different interventions were implemented for different groups to help students process through the physics principles involved deeply. Students’ performance on the quizzes after the intervention was analyzed and compared. We will present the findings. This work is supported by NSF.

Primary Contact: Shih-Yin Lin, University of Pittsburgh,

Co-authors: Chandralekha Singh, University of Pittsburgh

Using analogy to help students learn Introductory Physics

Type: Targeted Poster

Identifying the physics principles involved in solving problems is a critical step in problem solving. A major goal in physics education is to help students discern the deep similarities between problems based upon the physics principles so that they can transfer what they learned by solving one problem to solve another problem based upon the same principle. We conducted an investigation in which more than 800 algebra and calculus-based introductory physics students were asked explicitly in the quizzes to browse over and learn from a solved problem and then solve another problem that has different surface features but the same underlying physics principles. Different interventions were implemented for different groups to help students process through the physics principles involved deeply. Students’ performance on the quizzes after the intervention was analyzed and compared. We will present the findings. This work is supported by NSF.

Primary Contact: Shih-Yin Lin, University of Pittsburgh,

Co-authors: Chandralekha Singh, University of Pittsburgh

Targeted Poster Session: Facilitating thinking and learning in the physics classroom

Variables that Correlate with Faculty Use of Research-Based Instructional Strategies

Type: Contributed Poster

During the Fall of 2008 a web survey was completed by a representative sample of 722 physics faculty across the United States. This poster describes how 20 predictor variables correlate with faculty knowledge about and use of research-based instructional strategies (RBIS). Profiles were developed for each of four faculty levels of knowledge about and use of RBIS. Logistic regression analysis was used to identify five significant predictor variables. High levels of knowledge and use of RBIS were associated with the following characteristics: attendee of the physics and astronomy new faculty workshop, attendee of at least one talk or workshop related to teaching in the last two years, satisfaction with meeting instructional goals, regular reader of one or more journals related to teaching, and being female. High research productivity and large class sizes were not found to be barriers to use of at least some RBIS.

Primary Contact: Charles Henderson, Western Michigan University,

Contributed and Targeted Posters

Co-authors: Melissa H. Dancy, Department of Physics, Johnson C. Smith University, Charlotte, NC 28216, USA, Magdalena Niewiadomska-Bugaj, Department of Statistics, Western Michigan University, Kalamazoo, MI 49008, USA

Vector Addition: Effect of the Context and Position of the Vectors

Type: Contributed Poster

In this work we investigate the effect of: 1) the context, and 2) the position of the vectors, on 2D vector addition tasks. We administered a test to 512 students completing introductory physics courses at a private Mexican university. In the first part, we analyze student responses in three isomorphic problems: displacements, forces, and no physical context. Students were asked to draw two vectors and the vector sum. We analyzed students' procedures detecting the difficulties when drawing the vector addition and proved that the context matters not only compared to the context-free case but also, between the contexts. In the second part, we analyze students' responses with three different arrangements of the sum of two vectors: tail-to-tail, head-to-tail and separated vectors. We compared the frequencies of the errors in the three different positions to inquire students' conceptions in the addition of vectors.

Primary Contact: Genaro Zavala, Tecnológico de Monterrey,

Co-authors: Pablo Barniol

Viewing the assessment of instructional reform through the eyes of the stakeholders

Type: Targeted Poster

The Physics Program at Chicago State University is engaged in projects that focus on student content understanding, attitudes, and reasoning skills. Assessment results are reported to a number of stakeholders, including the funding agency, the University, the physics faculty, the physics education community, and the CSU students. It is naive to think that each of these stakeholders shares a common vision about the goals and objectives of the project. In addition, it is naive to believe that each assessment focus serves the interests of our students. In many cases a focus on the interests of an individual stakeholder, or even multiple stakeholders can cause us to overlook the development of many of the qualities we value in our students. We present a variety of tools that focus on our diverse assessment goals. Participants at the session will discuss how the different stakeholders would view each of these tools and its results.

Primary Contact: Mel Sabella, Chicago State University

Targeted Poster Session: The influence of theoretical frameworks on researchers' attitudes towards students

What do students think about when they think about proportions?

Type: Targeted Poster

Physicists reason about proportions in a variety of contexts without conscious effort. Students, on the other hand, tend to reason about ratio operations based solely on memorized algorithms. They struggle to match the appropriate algorithm to the situation encountered. If asked to justify or explain an operation, they not only are unable to do so, but often do not even understand what is being asked. Further, students seldom reason consistently from context to context the way a physicist does. In light of these findings, describing the classroom work of students as "proportional reasoning" may be a misnomer. One strategy that can be used across contexts to justify mathematical operations and check them is "package reasoning," described by Arons, McDermott, and others. At Western Washington University,

we are investigating how students engage with package reasoning, including what productive footholds might be available to them, and what features present particular difficulty. In this poster, results from written questions will be used to illustrate student thinking.

Primary Contact: Andrew Boudreaux, Western Washington University

Targeted Poster Session: Proportional Reasoning in Physics: What are students thinking? How can we help?

What Does it Mean to Create a Community?

Type: Contributed Poster

In this poster I ask the question, "What do we mean by the word 'community' and what is its role supporting freshman physics majors?" I examine this question in the context of The Compass Project, a program that seeks to "build community" and develop physics critical thinking skills with freshman physics students at the University of California, Berkeley. Compass works on these dual goals through a summer program, semester-long class, mentoring program, and a number of other smaller components. Does community mean that our students work together and live together? Does it mean that we have a set of norms for our classrooms and study groups? I examine both student interviews and class work toward addressing these questions and consider some of the wider education literature surrounding the word "community."

Primary Contact: Angela Little, University of California, Berkeley

What factors lead to faculty trying research based strategies?

Type: Contributed Poster

As part of a larger ongoing study of physics faculty, we report on an analysis of 16 interviews with Peer Instruction (PI) users. The analyses presented here address the following two research questions 1) How did PI users come to know about PI? and 2) What reasons do PI users give for first trying PI? In this poster we describe how faculty were first exposed to PI, and the avenues faculty used to subsequently learn more about PI such as workshops, informal discussions with colleagues, reading journal articles, etc. We also describe reasons that faculty members give for initially trying PI such as dissatisfaction with lecture methods, easy trailability of PI, or their intuitive sense that PI was a better way to teach. Following a summary of our findings, we discuss implications for dissemination.

Primary Contact: Melissa Dancy, Johnson C. Smith University,

Co-authors: Charles Henderson, Western Michigan University, Chandra Turpen, Western Michigan University and University of Colorado, Boulder

What we learned by moving beyond content understanding and diversifying our research agenda

Type: Invited Talk

The Physics Program at Chicago State University has been investigating student learning for the past eight years in an effort to construct an effective instructional environment for the urban physics student. In our initial work, the targeted analysis on student content understanding caused us to miss the specific attitudes, thinking, and reasoning skills present in our students. As our research focus began to shift to identifying these other skills, we began to identify specific student resources that foster an active learning environment in the introductory physics course. In addition, we began to uncover a set of coherent, robust content knowledge that we had previously overlooked. Research studies on collaboration in the classroom and work on identifying intuitive and formal reasoning has since provided

Contributed and Targeted Posters

a rich, complex picture of student understanding and has informed the development of our instructional environment.

Supported by the NSF Course, Curriculum, and Laboratory Improvement Program and the NSF Robert Noyce Teacher Scholarship Program (0632563, 0618128, 410068, 0833251)

Primary Contact: Mel Sabella, Chicago State University

Which instrument to critically select (among so many)

Type: Contributed Poster

A plethora of measurement instruments in science and education are used to measure even the same construct in the cognitive or affective domains of learners. The dilemma occurs when the investigator is faced with limited resources, or is sensible to learners' fatigue, cognitive load or attrition. This leads the investigator to choose one instrument or another to measure the construct of interest. This paper presents the reasons for choosing a specific instrument among many competing ones. Based on another paper submitted to PERC 2010, the following reasons of selection are compared: (a) number of items in each instrument, (b) number of dimensions (or factors) each instrument is composed of, (c) targeted population, (d) internal consistency (e) reliability, and (f) popularity of use. The paper provides an examples of comparing four different instruments that aim at measuring learners' epistemological beliefs, and shows how one instrument is critically selected.

Primary Contact: Ahmed Ibrahim, McGill University

Who becomes a physics major? The role of students' beliefs about physics and learning physics

Type: Contributed Poster

Efforts to address the "hidden curriculum" within introductory physics courses aim – in part – to move students towards more expert-like beliefs about physics and learning physics. In this poster, we examine the correlation between students' beliefs upon entering college and their likelihood to continue on to become a physics major. Since 2004, we have collected CLASS survey and self-reported level-of-interest responses from students in the first-term, introductory calculus-based physics course (N>2500). Here, we conduct a retrospective analysis of students' incoming CLASS scores and level of interest, comparing those students who go on to become physics majors with those who do not. We find the incoming CLASS scores and reported interest of these future physics majors to be significantly higher than the class average, indicating that these students enter their first college course already having quite expert-like beliefs. The comparative differences are much smaller for grades, SAT score, and university predicted-GPA.

Primary Contact: Katherine Perkins, University of Colorado,

Co-authors: Mindy Gratny, University of Colorado

Who says what and when: How rules of discourse impact learning interactions

Type: Targeted Poster

When multiple people engage in conversational interaction, either casually or with an well-defined goal, that interaction is governed by a set of tacit rules that give rise to certain regularities in the conversation. There is a rich tradition of research that examines the moment-to-moment dynamics of naturally occurring talk-in-interaction - such as everyday conversation, tutoring, interviewing, and large group classroom discourse - to identify these rules of discourse. Knowing these rules for different interactions facilitates comparison across forms of talk and identification of continuities

between them. In this work I use techniques from Conversation Analysis to understand the rules of discourse that govern the interaction of two students as they generate an explanation for magnetic attraction. Doing so allows me to examine which other conversational forms the interaction resembles, and thus speculate about which patterns of participation may either support or inhibit their learning in this interaction.

Primary Contact: Rosemary S. Russ, Northwestern University School of Education & Social Policy

Targeted Poster Session: Out of One, Many; Five Researchers Analyze the Same Student Video

Why is it difficult to lead conceptual change by using a count-intuitive demonstration?: An example from the brachistochrone problem

Type: Contributed Poster

A considerable number of researchers argue that cognitive conflict is a necessary condition of the type of learning that is described as conceptual change. In light of this idea, many of teaching strategies use a count-intuitive demonstration as a means of facilitating a change in students' conceptions. However, other researchers argue that cognitive conflict strategies do not consistently lead to conceptual change. Even when students' ideas are confronted with contradictory information through instruction, frequently such contradictory information does not result in meaningful conceptual change for a learner. In order to understand this controversy in more detail, we set about exploring how students response to a count-intuitive demonstration. Participants in this study were 96 secondary school students (9th grade) from Seoul, S. Korea. We investigated students' preconceptions on the brachistochrone problem by administrating a written test. After the exam, we presented a demonstration that might contradict the current ideas of students who had answered the written test problem incorrectly. We then investigated students' responses to the count-intuitive demonstration by using a Cognitive Conflict Level Test (CCLT). Results show that there were diverse responses to the demonstration, especially, 'superficial theory change' was the major response. We discuss how those responses can make the difficulties in the process of conceptual change.

Primary Contact: Gyoungho Lee, Seoul National University,

Co-authors: Taejin Byun., Seoul National University

Yes, I can teach physics, but

Type: Contributed Poster

This paper presents a narrative qualitative research study that describes and analyzes the experience of the author as a first-time physics teacher who replaced an experienced physics teacher for a three months period in a high school in Canada. The paper discusses the difficulties faced by the author and the obstacles overcome to teach the physics course. The paper shows the importance of factors to be considered in taking a temporary physics teaching assignment, and factors to be considered by a school to facilitate the teaching assignment.

Primary Contact: Ahmed Ibrahim, McGill University