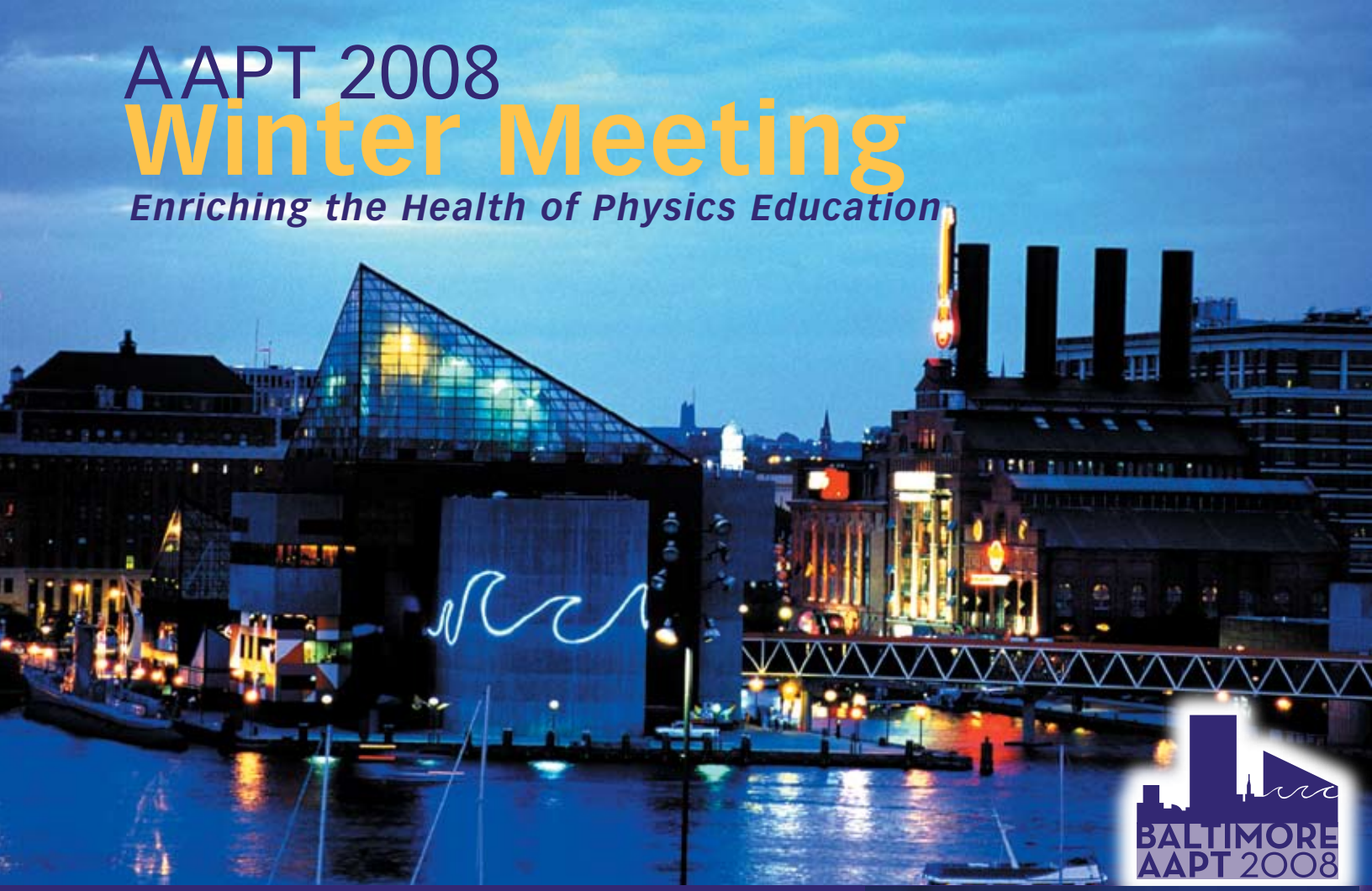
AAPT 2008 Winter Meeting

Enriching the Health of Physics Education



Academic Sessions and Abstracts Preview

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Preview of Sessions

AAPT Winter Meeting 2008
Baltimore, Maryland, USA
January 19-23

Overview

This e-booklet provides an advance look at the paper and poster sessions and abstracts for the upcoming AAPT Winter Meeting in Baltimore. The interactive scheduler and itinerary builder will soon be online. In the meantime, please use this booklet as a preview of the meeting's academic program. Note especially, that session order, days, and times are currently being finalized. This document provides session, paper, and poster titles; author names, and abstracts.

Not included: Plenaries, Award Lectures, Workshops, or Other Events

Using This E-Booklet

- See the Sessions List that begins below for an at-a-glance preview of session titles (Note, at the booklets end are the papers and posters that have yet to be assigned a session.). The list is organized alphabetically by Session name.
- Use the search feature in Adobe Acrobat Reader to search on keywords of your choosing.
- Visit the Winter Meeting Overview page for the latest information at: http://aapt.org/events/wm2008/

Sessions List

Session: Assessment of Educational Technologies
Assessing the Role of Modeling and Simulation Within TELS Projects
Shiladitya R. Chaudhury
Modeling and simulation play an important role in the design of the curricular projects available through the Technology Enhanced Learning of Science (TELS) Center. Students working in pairs interact with computational models of scientific phenomena, reflect on their virtual experiments and write about them in online journal notes. This talk presents examples of the use of modeling and simulation in two particular TELS projects—probing your surroundings and airbags. In each case, students have opportunities to build their own knowledge while engaged in an inquiry cycle. Examples of student work and feedback on learning with models will be presented.

Session: Assessment of Educational Technologies
Assessment of the Effectiveness of Instructional Technology Use in High School: A Cross-Discipline Comparison
Robert H. Tai
Instructional technology is at the forefront of innovation in physics teaching and learning. Recently, several large-scale studies have suggested that instructional technology use has no impact or even negative impact on student achievement. A vast body of research on instructional technology development suggests otherwise. We have conducted a study that includes three replicate analyses studying the relationship between technology use in high school and academic later college performance in introductory biology, chemistry, and physics.

Session: Assessment of Educational Technologies
Exploring the Science of Atoms and Molecules Using Molecular Workbench
Robert Tinker
The Molecular Workbench is an open source molecular dynamics application that permits students to explore the atomic scale. The software calculates the motion of atoms based on forces derived from Lennard-Jones potentials, electrostatic potentials, elastic bonds, and external fields. MW includes chemical bonding, light-matter interactions, and excited internal states, and can produce a very wide range of emergent phenomena such as phase changes, latent heat, diffusion, solubility, osmosis, black body radiation, and spectra.
MW includes an authoring environment for the design and delivery of interactive learning activities that support a broad range of core science concepts. In addition to setting the parameters of the model, the authoring environment allows the activity designer to provide instructions, scaffolding, and performance assessment instruments related to the model. More than 200 learning activities that use MW are available at no cost from a searchable database. One collection of activities has been designed to support a “Physics First” high school curriculum. All MW activities are computer-based, delivered online, and run on Macintosh, Windows, and Linux systems and have been downloaded more than 250,000 times. Numerous studies of student learning have been conducted using curriculum materials based on MW. These studies, extending over a range of content, with diverse students ranging from middle grades through college, demonstrate that students who use well-designed learning activities based on MW can understand atomic-scale phenomena and transfer this knowledge to new contexts. Furthermore, typical misconceptions can be dispelled by using these materials.

Session: Assessment of Educational Technologies
Freezing Time: Using New Video Technologies to Track Teacher Attention
Rosemary S. Russ
Science teachers today face the challenge coordinating multiple objectives—from preparing students for standardized tests to engaging students in meaningful inquiry to monitoring behavior. These multiple, and sometimes competing objectives force teachers to make choices in the moment about where they will focus their attention and instructional efforts. This work involves using wearable cameras to help teachers "freeze time;" teachers wear a tiny camera during class and with a simple button press instantly capture interesting or puzzling moments for later reflection. We discuss the technology itself and pilot work with one high school physics teacher. Interviews with him about his clip selection give insight into where and how teachers might focus their attention—insight that may differ from that gained only by after-class reflection. We describe future work that will involve using this technology with teacher "video clubs" designed to support on-the-fly reasoning about classroom events.

Session: Assessment of Educational Technologies
Learning Outcomes Assessment Study for Technology Rich Engineering Physics I
Russell A. Poch
The results of a three-year study of Engineering Physics I at Howard Community College in Columbia, MD, will be presented. This technology-rich course uses microcomputer-based labs, a supplemental WebCT site, Physics Cinema Classics DVD, homework solutions format for multi-step problems, and interactive web simulations for the material presented. The survey instruments used to measure student success included a Math Diagnostic Test for prerequisite skills, pre/post WebCT survey, lab check-off sheet, pre/post physics demographic survey, pre/post student attitude/perceptions survey, bimonthly survey to determine student's concept difficulties, Mechanics Baseline Test (MBT), and course grades. As a result of these teaching techniques, there was a significant gain on the MBT, student attitudes, and course grades.

Session: Assessment of Educational Technologies
Quantifying the Impact of CRS on Student Course Achievment.
Kastro M. Hamed
The objective of this study was to isolate and to quantify the impact of using Class Response System (CRS) on the course achievement of students enrolled in a large introductory astronomy class. To achieve our objective we implemented a quasi-experimental arrangement. Two sections of introductory Astronomy—about 300 students each—were taught by the same instructor (Olgin). Both sections used the same textbook, same syllabus, same assignments, and were taught in the same room. Peer instruction was implemented in both sections. However, in one section the students used the CRS along with Peer Instruction, but no CRS was used in the other section. In this presentation we aim to share the results of our investigation and potential implications for instruction.

Session: Assessment of Educational Technologies
Student attitudes Towards Andes, an Intelligent Tutor Homework System
Brett D. van de Sande
We know that students benefit from solving problems in the presence of an expert tutor. A tutor can encourage good problem solving techniques, provide timely feedback and provide hints when the student gets stuck. Andes, an intelligent tutor homework system designed for two semesters of introductory physics, can fill this need by encouraging students to use sound problem solving techniques and providing immediate feedback on each step of a solution. On

request, Andes provides principles-based hints based on previous student actions. (See http://www.andes.pitt.edu for more information.) A multi-year study at the U.S. Naval Academy demonstrates that students using Andes perform better than students working the same problems as graded pencil and paper homework. In addition, student attitude surveys show that students prefer Andes over other homework systems. In this poster, we investigate the connection between student attitudes towards Andes and their actual use of Andes during the class.

Session: Assessment of Educational Technologies
Using personal response systems in conceptual and algebra-based classes
Paul G. Ashcraft
Student interaction within lectures in both conceptual and algebra-based introductory classes increased by the use of a personal response systems [PRS]. Students were queried by survey on benefits or disadvantages of using a PRS in the classroom. These results are compared to the instructor?s understanding of benefits and disadvantages of using a PRS. Additionally, three populations of students were surveyed: conceptual (n = 100), first semester algebra-based (n = 70) and second semester algebra-based (n = 50). The differences between the classes' attitudes about learning are discussed.

Session: Assessment of Educational Technologies
Virtual Environment with a Remote Control System of Physics Experiments.
Marcelo O. Souza
A virtual system was developed for physics teaching that includes an Internet portal (http://www.uenf.br/avief) that centralizes the functions, which are available for students and the general public. The virtual system can simulate the operation of real physics experiments and also has a remote control system of physics experiments with the use of a control software that uses the USB port of the computer. The interface used, based in the converter USB/Serial FT232BM, allows the reading of data through the USB port. This form of the data collection is innovative, with the possibility of high-speed data traffic.

Session: Astronomy on the Road
Taking Astronomy to the People
William Luzader
Many astronomy clubs sponsor "evenings in the park" for the public to view various celestial objects with telescopes. Depending on the location and weather of these events, attendance varies. Musea with planetarium offer programs to complement other museum programs. These days with the varying price of gasoline and environmental concerns and increased pressure on classroom "time-on-task," fewer groups leave their primary building for field trips. Having been a member of astronomy clubs and directing school planetaria looking for audiences, this presenter has experienced taking a telescope to the public and taking a portable planetarium to schools and libraries. These experiences will be shared and contributions from the audience will be encouraged.

Session: Award Winning Research at Small Colleges
Flow and Heating Dynamics of Merging Spheromaks in SSX
Michael R. Brown
Several new experimental results are reported from plasma merging studies at the Swarthmore Spheromak Experiment (SSX) with relevance to collisionless three-dimensional magnetic reconnection in laboratory and space plasmas. First, recent high-resolution velocity measurements of impurity ions using ion Doppler spectroscopy (IDS) show bi-directional

outflow jets at 40 km/s (nearly the Alfven speed). Second, ion heating to nearly 10^6 K is observed after reconnection events in a low-density kinetic regime. Transient electron heating is inferred from bursts on a 4-channel soft x-ray array. Third, the out-of-plane magnetic field in a reconnection volume shows a quadrupolar structure at the ion inertial scale. Time resolved vector magnetic field measurements on a 3D lattice (B(r,t)) enables this measurement. Each of these measurements will be related to and compared with similar observations in a solar or space context.

Session: Award Winning Research at Small Colleges
Imaging Transport: Monitoring Motion of Charge Through Detection of Light
Nancy M. Haegel
Transport imaging is a flexible technique to charge transport in luminescent materials. An optical microscope, inside a scanning electron microscope, collects and reimages the spatial information from the recombination luminescence. This allows direct imaging of drift and diffusion behavior from charge generated at a point. The technique is an optical Haynes-Shockley experiment, but with high spatial resolution and flexibility provided by e-beam generation. It also provides a contact-free approach to the direct determination of minority carrier diffusion length, a parameter of special interest for characterization of solar cell materials. Results will be presented for drift behavior in heavily doped heterostructures, anisotropic diffusion in ordered materials for solar cells and determination of local electric field profiles. For spatial imaging beyond the diffraction limit, a near field scanning optical microscope (NSOM) has also been introduced for transport imaging of nanostructures. This work was initiated with undergraduate students at Fairfield University.

Session: Award Winning Research at Small Colleges
Mentoring Undergraduates in Molecular Beam Spectroscopy
James Cederberg
The gift of a molecular beam electric resonance spectrometer in 1981 launched a project that has given 74 undergraduate students at St. Olaf College an opportunity to experience research first-hand. They learn about vacuum technology, machine shop construction of components, computer interfacing, software programming, and statistical methods of data analysis, as well as the quantum mechanics and thermodynamics of the molecules, and present their results at conferences and in journal publications. I will describe some of the lessons I have learned from my own mentors and the challenges encountered in our own project.

Session: Award Winning Research at Small Colleges
Quantum Entanglement as a Quantifiable Resource
William K. Wootters
Entanglement, a remarkable kind of correlation that can exist between quantum particles, was identified by Schrödinger as the crucial feature of quantum mechanics that forces a departure from the classical paradigm. Nowadays entanglement is viewed not only as a marvel of nature but also as a resource, specifically a resource for certain unusual forms of communication such as quantum teleportation. It has therefore become useful to quantify entanglement, just as one can quantify, for example, free energy or information. This talk reviews some of the applications of entanglement, and shows how the quantification of entanglement has been of value in quantum information theory and in other areas of physics.

Session: Best of ComPADRE
Ben Franklin on ComPADRE: Historical Materials and Experiments in Modern Media.

Robert A. Morse
Printer and philosopher, newspaperman and postmaster—Benjamin Franklin was a media giant of his time. During a sabbatical at the Wright Center for Science Education at Tufts University, I explored Franklin's work in electricity and prepared resource and teaching materials for distribution via the Internet. I am pleased that ComPADRE—an aspiring media giant of our time—has chosen them for dissemination. This talk will describe the package of materials, their development, considerations of format and copyright in preparing them, their intended audience and the role of ComPADRE in disseminating them. Look for "Ben Franklin as my Lab Partner" on ComPADRE.

Session: Best of ComPADRE
The Best of Compadre: Science Appreciation—Introduction to Science Literacy
John W. White
Science literacy is a serious and difficult pursuit. New ways to inform nontechnical citizens about political issues with technical components is crucial. The speaker will describe a new college-level textbook that tries to address the need of science literacy. It has turned out that Compadre has been an excellent vehicle for disseminating the text. It has received many downloads. Although feedback has been modest (but positive), a potential publisher has come forward.

Session: Best of ComPADRE
Using ComPADRE and BQ to Distribute and Improve Interactive Curricular Material
Mario Belloni
With the explosion of material on the web, digital libraries have increasingly become an important resource for teachers and curriculum developers alike. The value of digital libraries, such as ComPADRE, and other curricular-specific search engines, such as BQLearning, is their ability to cut through the digital "noise" to provide high-quality material to teachers by cataloging, organizing, and ranking their content. Similarly, ComPADRE and BQLearning allow curriculum authors an avenue to disseminate and receive feedback on their materials. Recently we have begun to write Open Source Physics (OSP) materials specifically for dissemination by ComPADRE and BQLearning by using HTML- and XML-based materials that can be easily integrated and better searched for easier dissemination Examples from classical mechanics, general relativity, and quantum mechanics will be presented with the focus on how ComPADRE and BQLearning have helped us improve and distribute OSP material.

Session: Best Practices for Teaching with Technology
Does an Intelligent Tutor Homework System Encourage Beneficial Collaboration?
Brett van de Sande
All physics instructors agree that homework assignments are an integral part of physics instruction. When students complete their assignments, they choose to work individually or in small groups. Unfortunately, most computer-based homework systems are structured for individual learners. In particular, these systems only evaluate the final answer, putting pressure on any students working in groups to engage in copying. In contrast, Andes is an intelligent tutor homework helper that requires students to show intermediate steps when solving a problem and gives hints on demand. Andes has been used successfully by several college and high schools. In order to further investigate collaborative versus individual problem solving, we recorded verbal self-explanations and logged solution steps as individuals and student pairs use Andes to solve a set of problems. We found that students working in pairs rely less on the tutor's hints and engage in collaborative sense-making. Implications for instructional practices are discussed.

Session: Best Practices for Teaching with Technology
Enhancing Inquiry Science Teaching in St. Joseph, MO, Middle Schools
Michael B. Ottinger
During the summer of 2007 two workshops were held at Missouri Western State University to initiate a collaborative effort between the university and St. Joseph School District to enhance the inquiry method of teaching science in the middle schools. In the first workshop, lead teachers from each of the district's middle schools learned how to develop inquiry/ technology-based lesson plans. In the second workshop, the lead teachers guided the rest of the district's middle school science teachers, as well as pre-service teachers from the university in designing inquiry lessons for their classrooms. During the school year these lesson plans will be implemented on the middle school classrooms and copies of the lesson plans will be posted for all teachers to access. A detailed description of the workshops will be presented in the poster.

Session: Best Practices for Teaching with Technology
Francis Marion University's Summer Science Camp for Middle School Students
R. Seth Smith
As part of an Improving Teacher Quality Grant administered by the South Carolina Commission on Higher Education, Francis Marion University conducted a Summer Science Camp in physics and biology for 65 middle school students from 13 schools in the southeastern section of South Carolina. This presentation focuses on the physics portion of the camp. 34 of the middle school students participated in the physics camp. Under the guidance of a physics professor, an education professor, and five specially trained middle school teachers, these students spent two weeks performing inquiry-based physics experiments on topics related to energy, machines, and motion. The purposes of the camp were to teach students to think as scientists and to generate additional interest in physics. The physics experiments, student data, teacher feedback, and camp implementation will be presented.

Session: Best Practices for Teaching with Technology
Interactive Flash Movies
Fredrick P. Gram
Adobe Flash (formerly Macromedia Flash) enables one to make interactive movies and put them on the Internet. It has drawing tools and ways to move them around without code, or with ActionScript, a language similar to Java Script, and allows the author to tell the drawings how to behave. The movies are user friendly: Over 95% of computers have the Flash Player, a free download, and they tend to load and begin playing in a flash.

Session: Best Practices for Teaching with Technology
Physics Jeopardy and Other Engaging Ways to Teach with Technology.
Brendan P. Noon
Whether you moodle, google, or doodle, technology is an essential part of developing engaging lessons. This presentation demonstrates a variety of innovative methods that are being developed in conjunction with an online science curriculum (www.sciencewithmrnoon.com). Some of the lessons that will be highlighted include implementing online learning modules, Flash animated lectures, video podcasting, interactive quizzes, live web conferencing, virtual simulations, online discussions, webquests, game show review, classroom response systems (clickers) and tapping into next generation mobile technology. Be sure to pick up your free cd-rom before they're gone.

Session: Best Practices for Teaching with Technology
Results of Computer-Based Modifications to Astronomy Curriculum for Special-Needs Students
Julia K. Olsen
In early 2006, the Lawrence Hall of Science (LHS) conducted a national field-test of a new GEMS space science curriculum package developed for use with middle school students. During this field-test we modified a sub-set of the curriculum materials for use by special needs students, to be delivered via computer-mediated instruction. These materials were implemented in a subset of the field-test classrooms and LHS collected pre- and post-test data for each unit. These data were analyzed to determine if students in the classrooms using the modified materials scored differently than students in the larger assessment database. Data was disaggregated to measure the impact on students with special needs, as evidenced by individualized education plans (IEPs). Results suggest that many students, not just those with special needs, demonstrate greater achievement gains using materials modified using the principles of best practice for special needs students.

Session: Best Practices for Teaching with Technology
Teaching with Technologies: Lessons Learned from My Life Sciences Students
William Mc Nairy
Teaching with technologies in the classroom presents many challenges. In my introductory physics courses for Life Sciences majors I have employed several online homework, classroom polling, web-based resources, computer delivered content systems during the past eight years. I've even used whiteboards, live lecture demonstrations, and collaborative student groups. Each semester I am faced with choices from many attractive alternates that are affected by the evolution of the use of technology by students at Duke University, the support I receive from the Center for Instructional Technology and the Department, the infrastructure provided in the classroom, and, most importantly, feedback from students in recent courses. In my talk I will summarize my experiences and the challenges I've worked to overcome, and review the current version of teaching technology used for the fall semester.

Session: Best Practices for Teaching with Technology
The Development and Use of Physics Monothematics Micro Videos in Brazilian High Schools
Marcelo O. Souza
This work will present the results obtained of an analysis of the efficiency of the use of physics educational micro videos for high schools students of two Brazilian public schools. The micro videos of physics were developed with the students active participation. The micro videos include topics of Mechanics, Thermodynamics and Electromagnetism.

Session: Best Practices for Teaching with Technology
The Visual Glossary for Physics
Natalia A. Semushkin
The dominant feature of globalization is the power and ubiquity of new global technologies. Internet resources provide diverse perspectives on ways in which education is being shaped by global processes. We are introducing an alternative to the standard Internet search engine Google that was developed in SPIRAS*, Russia. This search engine is referred as a Visual Glossary or “VisGloss.” The VisGloss is designed to improve the search for different areas of professional and educational information. The most important advantage of this search engine is that it provides access to information in interactive visual mode showing every term linked to the given topic. The VisGloss allows users to find information quickly by following semantic connections that surround every term linked to the topic. It provides quicker searches and faster and more

intuitive understanding of the topic. We put efforts in developing the version of VisGloss for physics as the first part in a group of semiotic information system resources for science education.

Session: Best Practices for Teaching with Technology
Video Analysis in the U.S. Military Academy Core Physics Program
Chad C. Schools
The study of physics should not be limited to the physics building. Video analysis using Vernier Logger Pro® 3.4.6 was introduced in the 1,000-cadet, calculus-based, introductory mechanics course, with the goal of providing a link between the physical life of U.S. Military Academy cadets and physics. Video analysis was introduced in the laboratory, "in the barracks," and in the classroom. All cadets determined an objective quantity using video analysis in a capstone laboratory where they were provided an ill-defined scenario on video that related to "cadet life." Approximately 130 cadets in the advanced sections of the course were assigned out-of-class ("in the barracks"), small-group, video analysis projects with minimal guidance. Twenty instructors demonstrated video analysis through in-class demonstrations. We found our initial introduction of video analysis provided relevance, context-rich problems, cadet engagement, and a unique opportunity for synthesis and analysis.

Session: Best Practices for Teaching with Technology
YouToo'b Can Extend Class Time with Technology.
Brendan P. Noon
Every educator knows that classes are too short to cover the amount of material we're expected to teach. Brendan Noon has been successfully using the world wide web to motivate his students to learn physics outside the classroom environment. This poster presentation discusses a variety of innovative methods that are being used in conjunction with an online science curriculum (www.sciencewithmrnoon.com). Some of the lessons that will be highlighted include implementing online learning modules, Flash animated lectures, video podcasting, interactive quizzes, live web conferencing, virtual simulations, online discussions, webquests, and tapping into next generation mobile technology.

Session: Beyond Correctness: Conceptualizing and Coding High-Quality Scientific Reasoning
Recognizing Mechanistic Reasoning in Student Scientific Inquiry
Rosemary S. Russ
Education research is rightly focused on developing tools for assessing scientific inquiry, and there has been progress in that regard with respect to student performances in experimentation and argumentation. However, assessments of the substance of student thinking during inquiry are often reduced to assessments of correctness—does student thinking after inquiry agree with the knowledge presented in the textbook? Yet the history and philosophy of science suggest other aspects of inquiry that may be more appropriate measures of the quality of student thinking. In particular, this work describes the activity of reasoning about the causal mechanisms that underlie natural phenomena. Using philosophy literature, I develop a framework for reliably recognizing mechanistic reasoning in student discourse. I apply the framework to a student science discussion to show that while sophisticated mechanistic reasoning is abundantly present in students, it may be overlooked and thus discouraged by more traditional assessments of correctness.

Session: Beyond Correctness: Conceptualizing and Coding High-Quality Scientific Reasoning

Redefining the Word

Anna Karelina

The Rutgers PAER group has been developing tasks and rubrics* to help students develop scientific reasoning abilities. In this talk I will focus on the abilities to test a hypothesis, to develop and justify a mathematical model, and to identify, evaluate and validate assumptions. The tasks that we use to help students develop such abilities usually do not have one correct solution and require choosing between the alternatives and justifying the choice.

Our study involves 180 students in an introductory physics course for science majors, which is taught via the Investigative Science Learning Environment approach. Students have a set of tasks to acquire scientific reasoning abilities. Developed rubrics used in labs help them self-assess their performance and help TAs evaluate their work. Free response exam questions also assess how students acquire these abilities during the semester and how they apply them for solving problems. The project was supported by NSF grant DRL 0241078.

*E. Etkina, A. Van Heuvelen, S. White-Brahmia, D. T. Brookes, M. Gentile, S. Murthy, D. Rosengrant, and A. Warren. (2006) Phys Rev. ST Phys, Ed. Res. 2, 020103.

Session: Beyond Correctness: Conceptualizing and Coding High-Quality Scientific Reasoning

Student Behavior and Epistemological Framing: Examples from Tutorials

Rachel E. Scherr

In a tutorial setting, we want students to engage in a particular kind of activity (collaborative investigation of physics ideas) more than we want them to produce a particular outcome (correct answers recorded on the tutorial worksheet). How might we assess the kind of activity students see themselves as engaged in in tutorial? In particular, how might we observe the extent to which students frame a tutorial as an opportunity for making sense of the physics, rather than an assignment to fill in the blanks? Previous analyses have found evidence of framing primarily in linguistic markers associated with speech acts. We show that there is useful evidence of framing in easily observed features of students' behavior. More broadly, we describe a dynamic among behavior, framing, and the conceptual substance of student reasoning in the context of tutorials in introductory physics.

Session: Beyond Correctness: Conceptualizing and Coding High-Quality Scientific Reasoning

Symbolic Calculators Are Not Inert Tools

Thomas J. Bing

Powerful symbolic calculators are not passive tools for physics students. They do not merely offer students a convenient way to perform the computations they would have done by hand anyway. These calculators can play an active role in sustaining students' thought around computational schemes. This poster presents a detailed example from the work of undergraduate physics majors where Mathematica helps keep their search for a dilemma's answer in the computational realm. The students employ powerful mathematical reasoning and do not treat Mathematica as a black box. Their difficulties arise, rather, from their focus on calculation instead of mapping their mathematics to the physical situation at hand. We model Mathematica's influence as an integral part of the constant feedback that occurs in how students frame, and hence focus, their work. This work is supported by NSF grants DUE 05-24987 and REC 04-40113 and a Graduate Research Fellowship.

Session: The Case for Specialized Physical Science Courses for Pre-Service K-8 Teachers
Facilitating Inquiry by Using Powerful Ideas in Physical Science (PIPS)
Patsy Ann Johnson
In the National Science Education Standards, scientific inquiry abilities and understandings are included in content standards for kindergarten through high school. Students preparing to teach grades K-8 need substantial experiences engaging in inquiry if they are to be ready to guide others in inquiry. An efficient and effective way to provide these experiences is to design a college or university course using Powerful Ideas in Physical Science (PIPS) published by the AAPT. PIPS was developed and field tested by faculty, usually in small sections of physics courses. The four original modules are Light and Color, Electricity, Nature of Matter, and Heat and the Conservation of Energy. Two additional modules are Force and Motion. Most of the PIPS activities use inexpensive and readily available materials. Students record their prior knowledge, consider what their classmates think, observe discrepant events, take measurements, record data, make inferences, and reconstruct their understandings about natural phenomena.

Session: The Case for Specialized Physical Science Courses for Pre-Service K-8 Teachers
Physics and Everyday Thinking and Physical Science and Everyday Thinking [1]
Fred Goldberg
Physics and Everyday Thinking (PET) and Physical Science and Everyday Thinking (PSET) are curricula for one-semester college courses designed for prospective and practicing elementary teachers and non-science majors.[2] PET focuses on the themes of interactions, conservation of energy and Newton's laws. PSET also focuses on conservation of mass and atomic molecular theory. Both curricula include a substantive Learning about Learning component, focusing on the learning of scientists (NOS), young children and the students themselves. Both curricula were designed around principles based on research on learning: learning builds on prior knowledge; knowledge construction is a gradual process; interaction with tools facilitates learning; social interactions aid in learning; and norms (evidence, responsibility, respect) can structure student interactions, discourse and learning. Pre/post conceptual tests and the Colorado Learning Attitudes about Science Survey [3] administered at many sites show growth in students' understanding of content and the nature of science and learning.

Session: The Case for Specialized Physical Science Courses for Pre-Service K-8 Teachers
Physics by Inquiry: A Research-based Approach to Preparing K-12 Teachers to Teach Science as a Process of Inquiry
Paula Heron
The Physics Education Group at the University of Washington (UW) has been helping prepare pre-service and in-service teachers to teach physics and physical science for more than 30 years. Based on this experience, and on systematic research, *Physics by Inquiry* (Wiley, 1996) has been developed to help college and university faculty conduct courses, workshops and Institutes for K-12 teachers. This talk will address the development and use of PbI at the UW and elsewhere. Evidence of its effectiveness at helping teachers master important concepts and scientific reasoning skills will be presented.

Session: The Case for Specialized Physical Science Courses for Pre-Service K-8 Teachers
Role of the Physics Department in Program Accreditation
Carl J. Wenning
Program accreditation by states and national organizations represents

Session: Celebrating Women in Physics in the Baltimore Area
A Woman's Perspective on Inspiration and Science in Today's NASA
Kimberly A.Weaver
I was a child of the space age, with my eyes drawn toward the stars and my heart drawn toward America's Space Program. I always imagined a career at NASA. Having now served as a NASA scientist for nine years, I have had amazing opportunities to study exotic objects like black holes and exploding stars with observatories such as the Hubble, Chandra and Spitzer Space Telescopes. These telescopes provide new eyes on our universe covering the entire electromagnetic spectrum and our views of the universe have changed dramatically in the past 40 years. NASA has also changed. More women are pursuing careers in physics and astronomy, while at the same time, they bring new personal styles to the process of science, which can have tremendous benefit. I will talk about my journey as a scientist within NASA and the joys and challenges I have faced along the way.

Session: Celebrating Women in Physics in the Baltimore Area
Galaxies, Telescopes, and Women: A Life in Astronomy
Vera C. Rubin
I became an astronomer because the majesty and mystery of the night sky captivated me as a child, and I could not imagine living on earth and not trying to understand what I saw. A series of almost unrelated incidents permitted me to have one husband, two children, and a PhD degree in astronomy at the age of 25. My nontraditional background led to unconventional questions, such as "what happens at the outer edge of a galaxy?" I will describe the observations that led to the interpretation that most of the matter in the universe is not radiating at any wavelength, that is, it is dark. In addition to my research work, I will describe my continuing efforts to eliminate the roadblocks that face young women who wish to become astronomers. I still protest a system that makes it harder for a woman than a man to succeed in science.

Session: Celebrating Women in Physics in the Baltimore Area
Seeing Atoms: the beginnings of NanoTechnology
Ellen D. Williams
Exciting opportunities in science often arise from a new discovery or capability. I was fortunate that the invention of the scanning tunneling microscope occurred just at the beginning of my academic career. As a result, I was an active participant in the transformation of how we think about doing low energy science, from indirect observation of average quantities, to direct observation and manipulation of the properties of individual atoms. I was also fortunate to enter science at a time of change of attitudes towards women's participation. When I began graduate school at Caltech, formal admission of women had only been allowed there for a few years. My generation, in some sense, became the guinea pigs for an experiment in allowing women access to science. In addition to discussing my research in seeing atoms, I will discuss the challenges and opportunities that I have experienced in making things happen in science.
Acknowledgment
*Major support for my work has been provided by the NSF-MRSEC and the Laboratory for Physical Science, with additional support over the years from the DCI post-doctoral fellows program, NSF, ONR, NIST, the ACS-Petroleum Research Fund and Research Corporation.

Session: Challenges and Successes of CASTLE Teaching
Modeling Modified CASTLE: A More Open Ended Approach
Richard J. McNamara

As a guided discovery curriculum, the CASTLE Curriculum provides a series of hands-on and minds-on activities that cover the major concepts related to simple DC circuits. Because the level of guidance in the original CASTLE materials was intended to make the curriculum successful independent of teachers' content knowledge, the developers were interested in providing a more open-ended approach to the curriculum. The Modeling Workshop in High School Physics has worked to create a set of curricular materials that maintains the spirit of the original CASTLE curriculum while requiring students to be more involved in the experimental design of the original CASTLE activities. This talk will address the development process, the current status of the materials and workshops that have provided training for teachers in the use of the revised materials.

Session: Challenges and Successes of CASTLE Teaching
Something IS Moving
Karen J. Matsler
What has CASTLE done to get things moving in physics education? Curriculum is often perceived as a short-term fad that will soon be replaced with something bigger and better. Instead of being replaced, CASTLE has been a “charge” to the educational community. How the curriculum has impacted classroom teaching, pedagogy, student learning, and professional development will be highlighted. Session will include summary of data collected during the AAPT/PTRA summer institutes.

Session: Challenges and Successes of CASTLE Teaching
Studies of Two CASTLE Teachers Fostering Modeling of Electric Circuits
Grant Williams
This study examines the teaching strategies of two high school teachers using the CASTLE curriculum for circuit electricity. From classroom transcripts and interviews with the teachers, diagrammatic tools were developed for analyzing whole-class conversational interactions and suggesting hypotheses about co-construction of explanatory models. Student and teacher contributions to the model-building process were tracked in an attempt to identify differences in the ways teachers can foster students' model construction processes. Two levels of teaching strategy are identified: (1) supporting dialogical elements of classroom interaction, and (2) supporting students' cognitive model-construction processes. While the teachers used different strategies at both levels, both appeared guided by intentions of promoting dissonance, concept differentiation and integration, evidential and predictive reasoning, and the challenging of misconceptions. In both cases, the teacher moves appeared to contribute to what we call OGEM cycles: (O) utilizing observations, (G) generating model elements, (E) evaluating model elements and (M) modifying model elements.

Session: Closing the Gap Between Understanding and Action II: Institutional Policies That Promote Change
A Faculty Perspective
Mariajose Castellanos
UMBC provides professors with the opportunity to teach in a diverse community. Preparing to make a difference involves more than just figuring out what you are going to do in class next week. As a teacher we should set goals for both students (as a population and individuals) and ourselves. The way we think about teaching and who we are teaching, influences the way we teach. Teaching should be more than telling; teaching is sharing meaning, engaging students so they can construct the implications and apply them. Multicultural education should take priority, where all students should have an equal opportunity to learn. However, in the real world, due to

differences in some cultural characteristics, some students have a better chance to learn than others. Promoting dialogue with the students and recognizing our students as individuals who are independent and capable of original thoughts should lead to success.

Session: Closing the Gap Between Understanding and Action II: Institutional Policies That Promote Change

Preparing Environments for Successful Underrepresented Graduate Student Recruitment and Retention

Renetta G. Tull

Attracting and retaining talented underrepresented students in STEM fields is crucial if America is going to add to its scientific workforce and compete with other nations in innovation. This talk will highlight methods that UMBC, an Honors University in Maryland, has used in the past five years to increase the university's underrepresented graduate student population, retain the students, and facilitate successful MS and PhD graduation. Much of the success is attributed to progressive leadership in The Graduate School, connection with the vision of the university, building programs based on the successful undergraduate Meyerhoff Scholars program, involvement of faculty and staff, and leveraging awards such as the NIH-NIGMS funding of the Graduate Meyerhoff Biomedical Fellows program (which includes research in biophysics), NSF's Alliances for Graduate Education and the Professoriate or AGEP (PROMISE: Maryland's AGEP), NSF Bridge to the Doctorate program, and the Council of Graduate School's PhD Completion Project.

Session: Closing the Gap Between Understanding and Action II: Institutional Policies That Promote Change

The Meyerhoff Scholars Program at UMBC

Anthony M. Johnson

The Meyerhoff Scholars Program at UMBC was developed in 1988. At that time, UMBC was graduating fewer than 18 African-American STEM majors per year. In 1996 the program was opened to all students with an interest in the advancement of minorities in STEM fields. The program enjoys an overall 18-year retention rate of greater than 95% and has more than 500 graduates since 1993. The program challenges notions about minority achievement. Meyerhoff Scholars have changed the perceptions of those around them—the expectations of faculty who instruct them, the attitudes of students who learn beside them, and the perspectives of scientists who engage them in research. Having been a strong proponent of the recruitment and retention of women and underrepresented minorities into the scientific enterprise since my days at Bell Labs in the early 1980s, I will attempt to present an overview of this remarkable Meyerhoff Scholars Program.

Session: Common Student Misconceptions of High School Physics Students

Conceptions and Misconceptions of High School Physics Students

Vincent Bonina

What knowledge and misconceptions do beginning high school physics students bring to the classroom? During the past 15 years, over 2000 students have taken the Fast-Paced High School Physics course through Johns Hopkins University’s Center for Talented Youth (CTY). The course covers the complete content of an introductory series in physics, preparing them for an honors or AP physics course. These students were all given AAPT-developed pre- and post-tests to gauge their initial and final knowledge, providing a rich and unique source of data. In this session, we present an analysis of the results of the pre-tests in order to determine what beginning high school physics students already know and what they have misconceptions about.

We also examine the results of the post-test to see which misconceptions were dispelled and which persisted. Parallels will be drawn between the Force Concept Inventory and the mechanics portion of the AAPT-developed examinations.

Session: Computational Physics in Undergraduate Curricula
Enhancing the Study of Waves in Metals Using Computational Analysis
Michael B. Ottinger
When a compression transducer sends a sound pulse through a one-inch thick piece of aluminum with the reflected pulse observed on an oscilloscope, a faint secondary reflected pulse is also observed at the transducer. This second pulse travels through the material in a time consistent with that of a transverse wave generated at the metal's reflecting surface. To determine if the secondary pulse was a transverse wave, a simple computer simulation was created using a modified Euler technique with basic equations of motion found in introductory physics texts. The results confirmed that the secondary pulse was indeed a transverse wave generated when the compression wave reflected off the metal's free surface. In addition to showing the origin of the secondary pulse, the computer simulation also provides students with an alternate, enhanced view of the wave motion within the metal.

Session: Cutting-Edge Research in Simple English
Cutting-Edge Research in Simple English
Michael Thoennessen
Communicating fundamental research results to the general public is a difficult task. In the following presentations students will present their research in simple English. Their task is to imagine that they are riding in a taxi from the airport to a scientific conference and the taxi driver asks them about the purpose of the trip. They have less than 10 minutes to convince him that they are doing something meaningful.

Session: Cutting-Edge Research in Simple English
Useful Techniques for Spin You Didn't Learn in Graduate School
Gregory D. Mahlon
Most quantum field theory textbooks focus on the calculation of spin-averaged or spin-summed stattering amplitudes, leaving the question of how to obtain spin-polarized amplitudes as ”an exercise for the reader.” We describe a method for calculating polarized scattering amplitudes for an arbitrary choice of spin quantization axis.
This is particularly interesting in situations where the traditional helicity spin-basis does not provide the most transparent description of the underlying physics (such as for processes involving massive fermions). In fact, our method explicitly illustrates the role of the non-zero fermion mass in the decomposition of the spin eigenstates into a superposition of the two chirality eigenstates."

Session: Data Mining
Astroinformatics: The New eScience Paradigm for Astronomy Research and Education
Kirk D. Borne
The growth of data volumes in science is reaching epidemic proportions. Consequently, data-driven science is becoming comparable to theory and experimentation. Many scientific disciplines are developing subdisciplines that are information-rich and data-based, to such an extent that these are recognized as stand-alone research and academic programs on their own merits. These disciplines include bioinformatics and geoinformatics, but will soon include astroinformatics and data science. Informatics is the discipline of organizing, accessing, mining,

and analyzing data for scientific discovery. We will describe Astroinformatics, the new paradigm for astronomy research and education, focusing on new eScience education initiatives. The latter includes “Forensic Astronomy” (or “CSI Astronomy”) and the new undergraduate program in Data Sciences at George Mason University, through which students are trained in Discovery Informatics tools to access large distributed data repositories, to conduct meaningful scientific inquiries into the data, to mine and analyze the data, and to make data-driven scientific discoveries.

Session: Data Mining
CSI Astronomy: Evidence-Based Learning for the 21st Century
Julia K. Olsen
Current projects such as Sloan Digital Sky Survey, Google Earth with Sky, Galaxy Zoo and many others are moving large datasets from research science to the educational arena. Current institutional pressures to improve student achievement make it critical to develop, test, and evaluate data-based educational strategies. The impending avalanche of astronomical data will provide a wealth of material for students to experience real science in the classroom. Data Mining makes it possible to immerse students in physics, astronomy, and mathematics (as well as other content areas) while teaching and reinforcing 21st century skills. The Large Synoptic Survey Telescope (LSST) is a developing program for integrating research and education with large astronomy datasets. http://www.lsst.org/

Session: Data Mining
Data Mining in Astronomy
Alexander S. Szalay
Astronomy is now entering a golden age, with new telescopes generating enormous volumes of data. Astronomers need new ways to store, analyze, and understand all these data. At the same time, the Internet allows scientists to easily combine datasets—for example, to look at an image of the same galaxy in visible light, infrared light, and x-rays.
Given these developments, “data mining” techniques from computer science will play an increasingly important role in helping astronomers understand the data they collect. Data mining refers to searching for patterns in large datasets. Such techniques can help in two ways: finding “needle in the haystack” objects like brown dwarfs, and “understanding the haystack” to solve problems such as finding the average spacing between galaxies in the universe.
In this talk, I will share some major trends in modern astronomy research, and discuss how data mining can help increase our understanding of the universe.

Session: Data Mining
Data Mining in Physics Research
Petar Maksimovic
In this talk I discuss the role of Data Mining in physics research. This role is examined through a contrast of two important but different examples—the use of large quantities of data in Astronomy and High Energy Physics. The latter is especially interesting since, with the advent of the Large Hadron Collider, it will soon face data samples sizes that dwarf those of the past.

Session: Data Mining
Integrating Algorithm Research with Measurement Data Analysis in Exploratory Science
Norman H. Fontaine
In first-stage research, many scientists must switch frequently between four modes of working: measurement systems development, algorithm exploration, data analysis and reporting. And, it is

a fact of life that all software platforms are specifically optimized for one of these four working modes. How can research scientists and students, with very limited budgets, personnel and time, find the right combination of software platforms and develop the most time-efficient methods for using them together? We present our solution for enabling interactive algorithm exploration and rapid analysis of data from evolving measurement systems.

Session: Directions of the New NSF Division of Research in Learning
Education Activities in the NSF Physics Division
Kathleen V. McCloud
The Physics Division strongly supports workforce development, education, and broadening participation at all levels, from outreach efforts in large facilities and centers, to supporting efforts through groups such as the National Society of Black Physicists and National Society of Hispanic Physicists, to large-scale projects such as QuarkNet, CHEPREO, CROP, and ASPIRE, to individual PI awards. Students and teachers involved in these projects gain skills and knowledge to become members of the nationally critical high tech workforce, and the results of physics education and curriculum development projects are improving classroom activities throughout the physics curriculum. Many of these efforts within the Physics Division are funded through the Education and Interdisciplinary Research (EIR) program. The EIR program also supports Physics Related Research Experience for Undergraduate (REU) and Research Experience for Teachers (RET) sites across the nation and internationally.

Session: Directions of the New NSF Division of Research in Learning
Educational Activities in the NSF Division of Materials Research
Uma D. Venkateswaran
The interdisciplinary nature of materials research uniquely positions the Division of Materials Research (DMR) to invest in research and education activities that cut across disciplinary barriers. Current education and outreach activities within DMR, are embedded in Centers (Materials Research Science and Engineering Centers—MRSEC), Facilities (National High Field Magnet Laboratory, synchrotron facilities), Research Experience for Undergraduate (REU) Sites and Supplements, and individual investigator or group efforts. A number of these activities include K-12 students, pre- and in-service teachers as well as the general public. This presentation will highlight some of these activities. Furthermore, it will outline some areas where materials researchers and educators can join hands in evaluating and strengthening educational impacts and disseminating best practices in pursuit of a globally competitive materials workforce that is broadly inclusive of groups that are traditionally underrepresented in the field.

Session: Directions of the New NSF Division of Research in Learning
Interactions in Physical Science: A Middle School Curriculum for Students and Teachers [1]
Fred Goldberg
The Interactions in Physical Science [2] curriculum was developed to provide middle school students the opportunity to develop a deep understanding of national and state science content standards. The yearlong curriculum is hierarchical, designed around the major themes of interactions, Newton’s laws, Conservation of Matter and Energy, and Atomic Molecular Theory. An accompanying online teacher resource and specially developed workshop materials provide substantive professional development for teachers who implement the curriculum. Both the student and teacher materials were designed around principles based on research on learning: learning builds on prior knowledge; knowledge construction is a gradual process; interaction with tools facilitates learning; social interactions aid in learning; and norms (evidence, responsibility, respect) can structure student interactions, discourse and learning.

Session: Directions of the New NSF Division of Research in Learning
Learning What Students Are Thinking
Robert Tinker
With collaborators, we have developed software for authoring and delivering sophisticated computer-based learning activities that use models, tools, and probeware. The technology permits us to monitor performance in solving problems and undertaking investigations of participating students wherever they are. We can generate electronic reports on student performance and infer from these their thinking patterns. One study involving 12,000 high school students revealed patterns in the students' use of models that correlate with other aspects of their learning, such as their scores on traditional question-and-answer assessments. Students who were systematic in their use of models learned the content better and were able to apply their knowledge more broadly. We also saw a longitudinal effect: students exposed to our materials in one year performed significantly better than their peers when they encountered another set of model-based activities in a subsequent year, even though the scientific domains of the two units were different.

Session: Directions of the New NSF Division of Research in Learning
Physics in Informal Settings
Roy R. Gould
Recent research on how visitors learn in informal settings, combined with marvelous new exhibit technologies, now make it possible to engage diverse audiences in the frontiers of physics.

Session: Directions of the New NSF Division of Research in Learning
Promoting Learning in Formal and Informal Settings Through NSF Programs
Joan Ferrini-Mundy
The Division of Research on Learning in Formal and Informal Settings (DRL) invests in improving the effectiveness of STEM learning for people of all ages. DRL promotes innovative research, development, and evaluation of learning and teaching by advancing innovative knowledge and practices. The Research and Evaluation in Education in Science and Engineering program funds research at the frontiers and provides foundational knowledge for understanding and improving STEM teaching and learning at all educational levels. Discovery Research K-12 enables significant advances in K-12 student and teacher learning through research, development, and evaluation of innovative resources, models, and technologies. Informal Science Education increases engagement with STEM by individuals of all ages through self-directed learning experiences. Information Technology Experiences for Students and Teachers motivates student and teacher interest and engagement in STEM using information technology in school and after-school settings. We discuss the challenges and opportunities for improving STEM education through DRL-based programs.

Session: Directions of the New NSF Division of Research in Learning
The CHEPREO Project: Building from a Learning Community
Laird Kramer
CHEPREO brings together high school students and their teachers, undergraduate and graduate students, and university faculty to form a rich learning, teaching, and research community. CHEPREO, the Center for High-Energy Physics Research and Education Outreach, is located at Florida International University, a MSI serving more than 38,000 students in Miami. Our goal is to generate excitement about science, improve learning in the classroom, and increase enrollment in both high school and college physics courses by using high-energy physics as a foundation.

Our team of particle physicists, educational researchers, teacher leaders, and lead students has combined inquiry-based instructional methods with particle physics outreach and community-building models to meet these goals. Our project also provides a unique research opportunity to study the evolution of a learning community in a diverse South Florida. Results from teacher and student assessments will be presented as evidence of the community's success and challenges.

Session: Ethics in Research
The APS and Ethics: 1952-2005
Michael Paesler
In collaboration with the NC State Philosophy and Ethic Program, the Physics Department has instituted a graduate course in research ethics required of all physics graduate students. The course is part of a research collaboration sponsored by a major grant from the NSF and titled LANGURE (Land Grant University Research Ethics). I will describe the course and other aspects of the academic program in research ethics at NC State and in the nationwide LANGURE effort. The course emphasizes case studies and includes computer modules that are available online at www.chass.ncsu.edu/langure/index.html.

Session: Ethics in Research
The APS/AAPT Joint Task Force on Graduate Education Study of Ethics
Michael Paesler
In 2005 the APS/AAAPT Joint Task Force on Graduate Education was charged with undertaking a study of graduate physics education in the United States. Among the specific items was a charge to determine the status of and make recommendations concerning ethics education. In this talk, I will discuss the backdrop to the Task Force's work, report on the results of their investigations, relate their deliberations, and present their recommendations.

Session: Exploring the Energy Frontier at the CERN Large Hadron Collider
An Introduction to the Large Hadron Collider
Peter J. Limon
The Large Hadron Collider is on the verge of turning on to do physics, pushing the energy frontier higher by a factor of seven. The combination of its cutting-edge technology, its complexity and its vast size make the LHC the most challenging scientific instrument ever built. I will present an introduction to the LHC as an accelerator and storage ring, including discussions of some of the specific technological and management challenges that had to be overcome to bring it to fruition.

Session: Exploring the Energy Frontier at the CERN Large Hadron Collider
Exploring Nature's Fundamental Forces and Particles with the Large Hadron Collider
Beate Heinemann
The "Large Hadron Collider" (LHC) is a new particle accelerator currently being constructed in Geneva in Switzerland. It is among the most powerful and largest scientific instruments ever built and will probe the fundamental forces and particles in nature with unprecedented precision. Starting in summer 2008 proton-proton collisions will take place inside two huge detectors (called ATLAS and CMS) which record the particles produced in those collisions. More than 2000 scientists from all over the world are working on the construction of each of these detectors and will analyze the large data volumes they produce. Nobody knows what new particles will be found at the LHC but it is very likely that some revolutionary discoveries will be made: among the most likely discoveries are the "Higgs boson" (that will explain the origin of mass), "super symmetric" particles or extra spatial dimensions as predicted by theoretical models. I will

explain the LHC detectors and outline the experimental methods used to detect such new particles.

Session: Exploring the Energy Frontier at the CERN Large Hadron Collider
The Large Hadron Collider and the Future of Particle Physics at High Energies
Lawrence Hall
The Large Hadron Collider will reorient particle physics toward a new realm—what will the coming era look like? New elementary particles without spin, unlike anything ever seen, would solve the mystery of how a new force can spoil symmetries and create mass. Could the 20th century discovery of anti-matter be followed by a 21st century discovery of super-matter, leading to a whole new regime of particles and hinting at an ultimate unification of the forces? Alternatively, replications of heavier versions of electrons, quarks and photons would imply that the four-dimensional space-time of Einstein is but a fragment of a higher dimensional world. Perhaps the LHC will discover new stable particles that comprise the dark matter of distant galaxies. We may find evidence for a microscopic world of strong gravity and black holes or for a large scale multiverse of universes, each with different laws of physics. The LHC will test these and other speculations of the last 30 years, defining the direction of particle physics for the coming decades.

Session: Exploring the Energy Frontier at the CERN Large Hadron Collider
The LHC Accelerator and Its Challenges
Rudiger Schmidt
The motivation to construct the LHC at CERN comes from fundamental questions in Particle Physics. A deeper knowledge in Particle Physics today is linked to the understanding of particle mass scales: Is there an elementary Higgs boson? The primary task of the LHC is to make an exploration in the TeV energy range. To reach the 1 TeV scale in the centre-of-mass of proton constituent collisions, a proton collider with two beams of 7 TeV/c moments has been constructed in the 27 km long LEP tunnel. The machine is also designed for collisions of heavy ions (for example lead) at very high centre-of-mass energies. A magnetic field of 8.33 tesla is necessary to achieve the required deflection of 7 TeV/c protons, which can only be generated with superconducting magnets. Beams will be accelerated in the complex chain of CERN accelerators, injected into LHC, accelerated and stored for many hours to collide at four interaction points. The collision rate is expected to be one to two orders of magnitude higher than for any other hadron collider. The nominal performance requires the operation with large stored energy in the beams in the presence of superconducting magnets with a very low quench margin. The presentation will present the layout of the accelerator and its planned performance and discuss the implications on the used technologies. Due to the unprecedented complexity of the technical systems, the thorough commissioning of LHC technical system (“Hardware Commissioning”) started already in 2005. The commissioning will be discussed and an outlook to operation with beam will be given.

Session: Exploring the Energy Frontier at the CERN Large Hadron Collider
The ATLAS Experiment at the LHC
Ayana T. Holloway Arce
Experiments at the Large Hadron Collider (LHC) will make detailed measurements of the most energetic particle collisions ever engineered, because we expect that some of these collisions will involve new interactions that can only be explained by correcting our theoretical picture of fundamental particles and forces. ATLAS is one of two general-purpose instruments designed to record proton-proton collisions at the LHC. I will describe the ATLAS detector and how we are

preparing it to accurately measure the particles created in collision events, and preparing ourselves to interpret these measurements and to recognize the unexpected.

Session: Frontiers in Space Science and Astronomy
Hubble Now and Again: Recent Results and Future Efforts
Carol A. Christian
The Hubble Space Telescope, now in its 17th year, continues to provide marvelous images and insights to the Universe. The faintest, smallest galaxies yet discovered; the detailed structure of planetary nebulae; Uranus's thin ring—these are just some of the objects about which astronomers have expanded our knowledge using Hubble images. This fall, some of the best images were incorporated into Sky in Google Earth. In the same way users can explore the far reaches of the planet, they can now also explore the far reaches of the Universe. With so many great discoveries behind it, what's next for Hubble?

Session: Frontiers in Space Science and Astronomy
The James Webb Space Telescope: Ahead to the Past
Kathryn A. Flanagan
The James Webb Space Telescope is one of NASA's Great Observatories, a worthy successor of the Hubble Space Telescope. This space observatory will detect star clusters formed from of the universe's first stars, giving it the nickname "the first light machine." It will explore how galaxies and black holes grow, form, and evolve, and how stars and protoplanetary systems are born. It will determine the properties of planetary systems, investigating their potential for life. In order to look back to the earliest stars, JWST is optimized to detect infrared light, using a mirror more than 20 feet in diameter and operated cold (< 50K) at L2, an orbit 1.5 million kilometers from Earth, well beyond the moon. Launch is scheduled for 2013.

Session: Future Technologies
Beyond Clickers: Web-Based Wireless Interactivity for the Physics Classroom*
Dean Zollman
Wireless technology, which is rapidly becoming available in classrooms, offers the capability of engaging students in a wide variety of interactive and even collaborative learning. A web-enabled personal data assistant (PDA) or notebook computer can collect data in a variety of formats from students in any size class, even from students who are not all in the same location simultaneously. These data can be submitted as text, graphics, or a simple click of the mouse. All types can be analyzed and help an instructor learn how well the students are understanding information that is being presented. Perhaps a more important development is the number of collaborative tools which offer new ways of having peers interact in any size class. These tools allow instructors to create collaborations among students who may have not met each other but can work together through software. Results of collaborations from different groups on the same project or related projects can then form the foundation for a lesson. At present many of the collaborative tools would be cumbersome to use in large physics classes. However, they are pointing the way to what we should find readily available in the not too distance future. Some examples of our present efforts and speculations about future interactive physics classrooms will be presented.

Session: Future Technologies
Offline, Online and Beyond Communities as We Know Them
Jennifer Preece

There has been much talk about the steady decline of physical communities since the end of the first-world war. In contrast the buzz about online communities has reached a crescendo during the last five years. Supported by a variety of synchronous and asynchronous software, people have come together to chat, vote, protest, share tales of woe, exchange jokes, checkout each others movements, do homework, look for, edit or contribute new information, play games and much more. Cell phones, Blackberries and other handheld devices, special input devices, digital kiosks, digital cones, lap and desktops all provide ways of sending, searching and retrieving information, and communicating with others. With the help of artists and creative technologists have developed digital clothes, and tiny, tiny, processors monitor our health and our movements, or check our behavior.
So much is happening in our digital worlds, but how do these devices and communication trends impact education and vice-versa. What do we mean by community? What is a learning community? Does it matter if it is face-to-face or online? What kinds of trends have there been and what might happen next? These are some of the questions that I will address in this brief talk.

Session Gender in Science: What Recent Data Tell Us
Gender and Science: What the Data Tells Us
James H. Stith
There is much discussion about the low numbers of women and other underrepresented groups in the sciences. The Statistical Research Center, an arm of the American Institute of Physics (AIP), has a long history of collecting and reporting ethnic and gender diversity data. While the numbers reflecting the representation of women in physics has made steady progress and are now sizable at many levels, the numbers for other underrepresented minorities have not experienced similar growth. This talk will look at some of the stories behind the AIP numbers. Are we for example, asking the right questions? Why is it that efforts that seem to improve the gender diversity are apparently ineffective in addressing ethnic diversity?

Session Gender in Science: What Recent Data Tell Us
Key Transition Points in Scientific and Engineering Careers
Catherine Didion
The National Academies has issued several recent reports that address women's participation in the scientific and engineering workforce. These include Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering (2007) and the forthcoming Gender Differences in the Careers of Science, Engineering, and Mathematics Faculty. This session will share some of the findings and recommendations from these reports and explore the critical points of transition in the career pathways for women in the scientific and engineering disciplines as well as what institutions can do to encourage greater participation of women at all levels.

Session Gender in Science: What Recent Data Tell Us
Leaks in the Pipeline for Academic Scientists Are Discipline-Specific
Phoebe S. Leboy
Years ago it was appropriate to discuss generic problems of women in science and draft possible solutions. Most of these focused on making science careers more attractive to girls. However, the increasing numbers of women earning doctoral degrees in many scientific fields has led to a situation in which generic approaches must yield to discipline-specific approaches. Most of the areas in life sciences now have roughly equal numbers of women and men, the pipeline of qualified women is full, and the focus is on ensuring that these qualified women are recruited and retained in faculty positions. Graduate enrollments in chemistry and mathematics suggest

that these disciplines are rapidly approaching the situation in life sciences. However, bringing adequate numbers of women role models into physics, computer sciences and engineering education still requires concentrated efforts to fill the pipeline by recruiting and retain undergraduate and graduate women in these fields.

Session: Gender Issues in High Schools
A Qualitative Examination of Mixed and Single-Sex Cooperative Groups
Jacob Clark Blickenstaff
Though group work is widely used in high school physics courses, few studies have examined laboratory exercises for how male and female students interact in the setting. As part of a larger examination of students' experiences of introductory physics, observations, interviews and document analysis in a high school physics classroom revealed interesting patterns in the behavior of single-sex and mixed laboratory groups. Though most attempted to get just “enough” work done in the laboratory period, the strategies used varied with the mix of males and females in the group. Implications for design and implementation of
cooperative work in physics will also be discussed."

Session: Gender Issues in High Schools
Are Single-Gender Physics Classes Still Useful for a High-Achieving Population of Secondary Students?
Olga Livanis
The purpose of this study was to investigate the efficacy of single-gender physics classes. Literature abounds with studies of single-sex science classrooms that show positive or null results when students are separated by gender when studying science. The investigations primarily cite differences in learning styles, gender sensitivity by the teacher, and gender equity in the science classroom. Our brief study, however, looked at general attitude patterns and their correlation to academic achievement as determined by students’ scores on department-wide assessment by an already high-achieving population. Our question was whether single-gender physics classes still make sense at Stuyvesant High School.

Session: Gender Issues in High Schools
Gender Differences in College Physics Performance: The Influence of High School Physics Preparation and Affect
Zahra S. Hazari
The attrition of females studying physics after high school has been a continuing concern for the physics education community. If females are well prepared, feel confident, and do well in introductory college physics, they may be inclined to study physics further. This talk presents a quantitative study that focuses on factors from high school physics preparation (content, pedagogy, and assessment) and the affective domain that predict success in introductory college physics. The study includes controls for student demographic and academic background characteristics and employs 1973 subjects from 54 randomly chosen introductory college physics classes across the country. The results highlight high school physics and affective experiences that differentially predict female and male performance. The results paint a dynamic picture of the role of coverage, assessment, homework, and encouragement from parents.

Session: Gender Issues in High Schools
VIBES: Gender Equitable Physics Curriculum
Stacy S. Klein

The National Science Foundation-funded Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) Engineering Research Center in Bioengineering Educational Technologies at Vanderbilt University has worked over the last eight years to develop a high school level, biomedical-engineering based, interdisciplinary curriculum. The Vanderbilt Instruction in Biomedical Engineering for Secondary Science (VIBES) curriculum (http://www.vanth.org/vibes) is now ready to be disseminated throughout the country. It uses a challenge-based approach anchored in biomedical engineering to motivate student interest and achievement in science, especially physics. These curriculum units meet numerous national science standards. In 2005, the National Science Teachers Association Press published a book, edited by Robert Yager, entitled *Exemplary Science in Grades 9-12: Standards Based Success Stories*. The VIBES program is featured as a chapter in this book, having been recognized as one of the 15 best science curricula in the country. New statistical analyses are proving this program to be appropriate for both male and female students.

Session: Gender Issues in High Schools
When Do Girls Lose Interest in Math and Science?
Jennifer Blue
Girls enter elementary school interested in math and science, but lose confidence by middle school (1). Women get a smaller percentage of bachelor's degrees in science than men do (2). When do girls lose interest in math and science? I worked with an experienced elementary school teacher to survey 2000 girls in grades 4-8 in southwest Ohio, asking them at each grade to rate science, math, and other school subjects. Some of our results were quite surprising. This talk will ground our survey and its results in the literature.

Session: How to Get a Math-Science Grant: Some Real Experiences
PD ToPPS—Teaching Physics Teachers in North Carolina
Stephen Danford
PD ToPPS (Professional Development for Teachers of Physics and Physical Science) is a new partnership between two public universities in North Carolina (UNC Greensboro and University of North Carolina at Pembroke), AAPT, and three North Carolina public school systems (Winston-Salem/Forsyth County School Schools, Guilford County Schools, and Robeson County Schools). PD ToPPS will provide a means for high school and middle school physics and physical science teachers to hone their physics teaching skills through hands-on workshops based on AAPT's PTRA model.

Session: How to Get a Math-Science Grant: Some Real Experiences
Strike While the Iron Is Hot—Grants from Private Foundations
Mark E. Mattson
In an effort to enhance the training and retention of physics teachers, the Department of Physics and Astronomy at James Madison University applied for and received a grant from the Toyota USA Foundation in the amount of $255,365. The success of this effort was contingent upon a well documented need for STEM teachers which was addressed using two proven programs, Teacher-in-Residence for pre-service teachers and a summer institute paralleling the Physics Teaching Resource Agent program for in-service teachers. This talk will focus on the details of the justification for the grant as well as the system for determining likely funding agents.

Session: How to Get a Math-Science Grant: Some Real Experiences
Texas Trails and Trials
Karen J. Matsler

Uncharted territory is often daunting and challenging, but the trials of others can be your triumphs. This talk will highlight the groundwork that was done to obtain the first Texas AAPT/PTRA MSP grant and what has been done to maintain those funds and visibility as a professional development provider. The grant is a cooperative effort between AAPT/PTRA, the University of Dallas, Lee College, and the Texas Regional Collaborative to prepare teachers for the upcoming Texas state mandated change in curriculum requiring all students to take physics to graduate by 2011. By using PTRA and C3P materials and the 5E learning cycles we have trained both teachers and professional development providers. Trails (evidence) of successes will be shared as well as areas that are still being modified and improved.

Session: How to Get a Math-Science Grant: Some Real Experiences
The AAPT/PTRA Project (Grant Ideas)
Jim Nelson
The AAPT/PTRA Project, http://www.aapt.org/PTRA/index.cfm, designed to provide Professional Development for Teachers of Physical Science and Physics has existed for more than 20 years. During that time the project has garnered over $10M in federal, state, and foundation grant support. The Project is presently seeking additional funding and has developed grant templates that highlight the infrastructure, curriculum, assessment, and leadership development components of the PTRA Project. The purpose of this session is to describe some of the recent successful grants and to explore ways you can work with the project to host a PTRA Professional Development project for teachers in your area.

Session: How to Get a Math-Science Grant: Some Real Experiences
TIPPS: The Georgia MSP Grant
Bob Powell
The University of West Georgia received a two-year grant from the Math Science Partnership Program (MSP) in the State of Georgia in March 2007. The proposal was funded because of a demonstrated need for improved physics instruction in area schools and the proven track record of the Physics Teaching Resource Agents (PTRA) workshops nationally. Other factors included the proposed assessments of the instruction incorporated into the project and letters of support from members of the partnership. The funded project is Training Institutes for Physics and Physical Science (TIPPS). Two PTRAs from Georgia taught 24 participants the AAPT/PTRA units on “Kinematics and Dynamics” (first year) in a summer workshop with two follow-up sessions and will teach “Momentum and Energy” (second year). Problems of putting the format for the PTRA workshops from the funded rural initiative program into the MSP requirements will be discussed.

Session: How to Get a Math-Science Grant: Some Real Experiences
TOPPS: A Win-Win Situation in Maryland
Francis M. Tam
TOPPS is an Improving Teacher Quality (ITQ) Project, through Training Opportunities in Physics and Physical Science (TOPPS). Under the “No Child Left Behind” federal legislation, $300,000 has been awarded to Frostburg State University (FSU) from the Maryland Higher Education Commission (MHEC) for three years. The Project is providing high school and middle school teachers in the “high-need” LEAs across the state with training in Physics content, research-based teaching strategies, integration of technology, and assistance to reach the “Highly Qualified” status. The ultimate goal is to improve student approaches and achievements in Physics and Physical Science. The Project is modeled after the highly successful AAPT/PTRA

program. This paper will discuss some of the challenges, lessons learned, as well as success stories that have made TOPPS a Win-Win situation in Maryland.

Session: Information Fluency and Physics Curriculum
Information Fluency and Physic Graduate Students
Pat Viele
To avoid reinventing the wheel, it is essential that physics graduate students be able to conduct a thorough literature search. In this information age, a literature search can be quite challenging. This talk will describe techniques I have used in working with physics graduate students on the topic of information fluency.

Session: Information Fluency and Physics Curriculum
Information Fluency for Graduate Students
Pat Viele
During this session, I will discuss ways to integrate information fluency instruction into the physics graduate student experience.

Session: Information Fluency and Physics Curriculum
Information Literacy and Informative Literature in Physics
Jean-Francois S. Van Huele
To become productive physicists, students need to be fluent in two-way communication. They need to be able to retrieve (existing) information and they need to be able to produce and disseminate (new) information. Neither is easy. Both skills have to be learned. The undergraduate physics curriculum needs to make room for the teaching of communication skills to a receptive audience. In our department, we believe that doing original research as an undergraduate is the best way to guarantee physics learning and communication. An accompanying writing-in-physics course gives seniors hands-on skills to communicate their results and write their thesis. By learning how to connect their work to the existing physics literature, by writing up their research for an audience of peers and instructors, and by reflecting on the process of scientific communication and publication, our students become more effective contributors to the scientific literature.
In this talk, I will give examples, share tools, discuss challenges, and review progress of our approach.

Session: Information Fluency and Physics Curriculum
Seizing Opportunities for Library Instruction Beyond the Physics Classroom
Adriana Popescu
Librarians can be very creative when it comes to implementing information fluency activities to enhance the academic curriculum. In recent years, academic librarians have made significant progress in promoting the importance of developing solid information evaluation skills in addition to educating students to become successful in their physics related careers, and the success in part is due to the various means and ways that they have worked and collaborated with faculty members to incorporate these skills in the academic curriculum.
At Princeton University there are several significant points in the academic path of undergraduate and graduate students when information fluency skills can be taught. The presentation will highlight several instructional opportunities, some of them taking place outside the physics classroom setting, which were used by science and engineering librarians to build information fluency skills and enhance the lifelong learning skills of physics and engineering students.

Session: Information Fluency and Physics Curriculum
Integrating Active Learning and Information Literacy in the College Classroom
Bonnie A. Osif
Time is always a scarce commodity in college science and engineering classes. Most professors find it is difficult to include all of the lectures and laboratories needed to accomplish the basic requirements of the class. “Losing” a class session to provide librarians a chance to promote information literacy is difficult. Yet, the benefits of early and appropriate library instruction can provide a high yield on the time invested. Research papers, laboratory exercises, and exams all can be improved with knowledge of appropriate databases, search techniques, and evaluation criteria. Several successful strategies to incorporate information literacy in engineering classes at Penn State will be reviewed.

Session: Innovations in Teacher Preparation: Recruitment of Prospective Physics Teachers
A Modest Proposal: Addressing the Physics Teacher Shortage by Master's Level Cross and Alternative Certification into Physics Teaching
Dan MacIsaac
Since 2002, SUNY-Buffalo State Physics has established and grown two M.S.Ed. (Physics) programs leading to NYSED 7-12 Physics Certification from two to more than 45 candidates, with another 25 graduates. An attendant Summer Physics Academy serves 60-90 physics teachers annually, awarding graduate credit to both program and non-program graduate students. These programs will be described in some detail, together with their impact on the candidates and our department. Funding opportunities for candidates of these programs leading to physics teacher certification will also be described.

Session: Innovations in Teacher Preparation: Recruitment of Prospective Physics Teachers
Improving Learning and Recruiting Teachers: The SPU Learning Assistant Program
Stamatis Vokos
Seattle Pacific University is a Primary Program Institution of PhysTEC, a national program of AAPT, APS, and AIP that seeks to increase the number and improve the professional preparation of teachers of physics and physical science. One of the national challenges is the effective recruitment of undergraduate students who are willing to consider science teaching as a career. The Learning Assistant program is one strategy to address this challenge. In this talk, a description of the elements of the program and its implementation at Seattle Pacific University will be presented. Far-reaching benefits to our overall undergraduate physics program will be discussed, as will stubborn difficulties.

Session: Innovations in Teacher Preparation: Recruitment of Prospective Physics Teachers
Recruiting the Next Generation of Physics Teachers: The Illinois Model
Carl J. Wenning
In 2004, the Illinois Section of the AAPT established the Ad Hoc Committee for the Recruitment, Preparation, and Retention of High School Physics Teachers using a $500 grant from the national office. Since that time the Committee has conducted research, held a workshop, conducted cracker barrel discussions, and presented findings and recommendations in a 9-page report published in the Journal of Physics Teacher Education Online (Vol. 2, No. 2, November 2004). The Committee has recently produced an 8-page recruitment booklet for teachers, a tri-fold brochure for students, and two follow-up web pages.* This has been done in cooperation with three other Illinois science teacher associations. The presenter will provide

access to these materials, and explain their use in recruiting the next generation of high school physics teachers.

Session: Labs & Wikis
"Adopt a Physicist": Connecting High School Physics Classes with Physicists via Online Forums
Jennifer L. Fischer
The Adopt-a-Physicist program (www.adoptaphysicist.org) is designed to connect high school physics students to people with bachelor's degrees or higher in physics via online discussion forums. Through their interactions, students can find out about the careers, educational backgrounds, and lives of current physicists.
Physicists and students interact through discussion forums for a three-week period. Before the three week period begins, the physicists and classes each create a brief introduction page. After registration closes, teachers choose some physicists for their classes to interact with, usually from different career categories.
The physicists each host a discussion forum where students dialogue with them about careers, educational level, current projects, and issues.
The Adopt-A-Physicist project is a great opportunity for high school physics teachers to create excitement and inspiration amongst students. It is also a great way to incorporate new technology into the classroom. There are several different ways to implement the program into high school physics classes and throughout the briefing I will highlight specific implementation ideas.
I will mainly talk about the logistics of the program including how it works, how it is set up, how to register, etc. I will also share from personal experience how the program played out with my physics classes and especially how students reacted to it.
Adopt-a-Physicist is a service provided by the American Physical Society (APS) in collaboration with the physics honor society Sigma Pi Sigma (SPS), the American Association of Physics Teachers (AAPT) and ComPADRE.

Session: Labs & Wikis
Biological Application Oriented Physics Labs for Life Sciences Students
Fang Liu
No data is more interesting to a student than data about his or her own body. In our efforts to promote more engaged learning in physics for life sciences students, we have introduced several biological application-oriented physics labs into our Physics for Life Sciences Laboratory. These new labs take advantage of the advanced lab apparatus including EKG system, stress-strain apparatus, and human arm model. Physics for Life Sciences students use these advanced lab apparatus and DataStudio software to obtain and analyze data in each section, enabling them to see the electrical signals generated by their hearts, to see the stress and strain during the entire process of stretching and breaking material such as bone and tissue, and to evaluate the work done by the arm in many types of motion such as extending and lifting an object, curling, or throwing a ball overhand.

Session: Labs & Wikis
Celestial Navigation: Using a Simple Quadrant to Find Latitude and Longitude
Philip M. Sadler
With the simplest of instruments, a protractor and a watch, students can easily determine their latitude and longitude within 30 miles. Measuring and recording the altitude of the Sun is a straightforward daytime activity, possible on any sunny day. By graphing such data, the time of Local Apparent Noon can be determined, along with the Sun's peak altitude. The special case of midday reduces the spherical trigonometry to the drawing of plane triangles and calculation

requiring only addition and subtraction. The lab can be repeated on different dates and locations (e.g., during student vacations) demonstrating a practical use for positional astronomy still in use today as a backup to electronic navigation.

Session: Labs & Wikis
Does Sugar Cause Dental Decay?
Jayeong Lee
We developed a guided inquiry program for secondary school students to conduct a quantitative and microscopic experiment to find the cause and progress of dental decay. High school and middle school students were invited to observe a chemical and morphological change on the surface of teeth treated in various media such as pure sugar, sugar+saliva, acid and soda solutions. The quantitative analysis of the amount of decay, i.e., the amount of the melted enamel was estimated using an absorption spectroscopy, i.e., calorimeter and the corresponding morphology was examined using an atomic force microscopy. Many people believe that dental decay is caused by sugar. Students found, however, that sugar solution alone did not cause damage to the teeth but the dental decay was caused when the tooth was treated in a sugar+saliva solution. Our guided inquiry program proved to be effective to help students get a correct idea that an acid produced by bacteria feeding on sugar is the real reason of dental decay.

Session: Labs & Wikis
Experimenting with the Introductory Physics Lab Sequence
Toni D. Sauncy
The introductory calculus-based physics lab sequence at Angelo State has been reinvented in an effort to fully address the AAPT Goals of Introductory Physics Labs as outlined by AAPT some years ago.[1] Since its initial publication, there has been much research on the exact manner in which these goals are best attained. The changes to the two-semester lab sequence are derived from such published research [2], and include an emphasis on conceptual understanding utilizing Internet-based simulations, digital recording technology, and increased interaction between instructor and student. Experiments focus on experimental technique, data acquisition skills, and detailed error analysis. Students transition from prompted lab recording to independent experimentation over the year. Students have responded favorably as have subsequent advanced lab instructors.
[1] AJP, V66(6), pp. 483-485 (1998)
[2] J. Profl. Issues in Engrg. Educ. and Pract., V133(3), pp. 192-198 (2007); AJP V74(11), pp. 979-986 (2006); AJP, V73(8), pp. 771-777 (2005).

Session: Labs & Wikis
IBEAM: Integrative Biology Experimental Activity Modules
Tatiana A. Krivosheev
The objective of the IBEAM project is to develop modular interdisciplinary educational materials for use in both introductory physics and upper-division biology courses. These activities increase student understanding of both disciplines—content and the interplay between them. The modular nature of these materials allows them to be easily integrated into existing courses with little to no modification necessary. In the introductory physics courses, the biology content is introduced via the laboratory component. Biology-oriented capstone activities apply the physical principles students learn in hands-on experiments to show the interdisciplinary nature of the subject. The physical concepts learned in these physics courses are reinforced in later biology courses with activities that refer back to the original modular activities, but expand

and broaden their application. Pre- and post-course self-assessment survey is developed and administered to estimate the learning gains.

Session: Labs & Wikis
Long-Range Wiki Interactions
Kenneth Cecire
Since the spring of 2007 the author has been using wikis and wiki pages to support teacher and student involvement in the Particle Physics Masterclass, the QuarkNet Virtual LHC Center, and interactions of the European Particle Physics Outreach Group. In each case the wiki has proven to be a useful tool for long-distance interaction of widely distributed groups. It has also proven very useful for creating less formal web pages that can be updated instantly from anywhere. Examples of the use of wikis and what can be done with them will be discussed.

Session: Labs & Wikis
Organizing an Undergraduate Research Group: Graduate Mentoring, Scaffolding, and Wikis
Ramon E. Lopez
In this talk I will describe how my group manages a large number of undergraduates engaged in meaningful research projects. The interaction is very structured and includes considerable scaffolding to ensure student success. The undergraduates are organized into groups with specified research foci, and a graduate student assigned to each group as a mentor. Groups meet regularly on several levels, leading to a weekly whole group meeting. The structure fosters positive interdependence as well as individual responsibility as students are assigned individual projects with the research focus of the group. The use of a wiki is critical to facilitating the interaction, maintaining a record of progress, centralizing shared resources, and it allows for significant asynchronous interaction. This structure leads to student success, professional growth for graduate students, and a manageable time budget for the group leader.

Session: Labs & Wikis
Physics Labs on a Shoestring Budget
Takeyah Young
Many valuable physics labs can be conducted with minimal funding. Even when budgets are generous, often these are the most successful labs, because they creatively convey the excitement that physics is all around us. Over the last few decades, the many instructors of physics and physics-related courses for the Johns Hopkins University's Center for Talented Youth (CTY) have used a variety of engaging physics labs and activities that can be done on a shoestring budget. In this presentation, we review examples collected from CTY instructors and share some resources and techniques for designing labs to support your curricular goals.

Session: Labs & Wikis
Pictures in Quantum Mechanics.
Dereje Seifu
In undergraduate and first-year graduate quantum mechanics courses a major conceptual difficulty students face is neither the orthodox viewpoint of measurement in quantum mechanics nor the exclusively quantum effects that have no classical analog, rather the major difficulty is the conceptual difficulty in Schrodinger's picture where dynamical variables such as momentum and energy become operators that were once functions that evolve in time. This conceptual difficulty can be surmounted by introducing early on Heisenberg's picture of quantum mechanics which unfortunately is omitted by most introductory quantum mechanics text books.

Session: Labs & Wikis
The RC Circuit with LEDs
Feng Zhou
By measuring the discharge voltage in an RC circuit with an LED, we can accurately determine the time constant and voltage to turn on the LED by fitting the exponential decay curve. This method is reliable, generating an interesting way to determine an important physical constant such as Planck's constant h, the speed of light c or the basic charge on an electron e. The low-cost computer-integrated lab experiment combined with simple math modeling exhibits desirable characteristics for an entry-level physics course or an interactive lecture demonstration.

Session: Labs & Wikis
Spreadsheet Analysis of X-ray Powder Diffraction Patterns for Advanced Lab
Eugene J. Hoffman
Students in our Advanced Lab course analyze diffractometry results with the commercial software Jade, useful for professional training, but too automatic for a clear view of peak-matching logic. We therefore have them also work up the same data on a spreadsheet template that requires user decisions. The analysis is preceded by a complete process: pre-quizzes on Miller indices and on interference and diffraction, grinding and sieving the sample to 45 μm, filling a sample holder and running it in a Rigaku Miniflex powder diffractometer. We thus cover both the technique and the underlying theory of the method.

Session: Labs & Wikis
Student Blogs and the LHC
Michael J. Wadness
This poster presents a pilot program involving students utilizing Internet technologies to learn about particle physics. Students from Massachusetts and Virginia collaborate to create an online blog and wiki page about the Large Hadron Collider under development at CERN outside Geneva, Switzerland. The goal of this program is to increase students' awareness of contemporary physics research and to develop a more comprehensive understanding of the nature of science. To aid the students in the creation of the blog and wiki, students are able to attend virtual office hours held by a particle physicist at CERN who has volunteered his time. This pilot program is in association with QuarkNet, an organization established by NSF and DOE to increase physics teachers' participation in particle physics research.

Session: Labs & Wikis
Student-Created Wikis in Introductory Physics.
Eric J. Page
Many students are aware of, and some even contribute to online wikis, the most well known of which is the Wikimedia Corporation's Wikipedia. In this report, we describe how the creation of online secure wikis by introductory physics students working in small groups can benefit both the student and the instructor: the students gain understanding through an online collaborative creation of a "study guide," and the instructors gain insight into how the students are processing the information by overseeing the creation of these pages. We also describe how this method could be used to help evaluate student gains in introductory physics.

Session: Labs & Wikis
TeachSpin, Inc., Instruments Designed for Teaching
Barbara Wolff-Reichert

TeachSpin's hands-on instructional apparatus sets the standard for advanced and intermediate teaching labs worldwide. And now, many of our optical components, including mirror mounts, lasers and detectors, are available individually. Each year we try to introduce two new instruments. This year, the first one is called Quantum Analogs—acoustic experiments modeling quantum phenomena. It's ready for your inspection. But you may also try your hands on Modern Interferometry, Muon Physics, Two-Slit Interference, One Photon at a Time, and the other units we brought with us.

Session: Labs & Wikis
The Ultimate High School (2000+) Astronomy Teachers Resource List
Larry E. Krumenaker
A pair of dissertation surveys to more than 2,000 high school astronomy teachers has netted the ultimate resource list, what is really used by teachers. Books, textbooks, websites, and other curricular materials will be discussed for content, for pedagogy and for networking. Which are the most popular and which should be given more attention than they have had?

Session: Labs & Wikis
Using Mobile Technology to Transform Physics Laboratory Learning for Women.
Joseph Di Rienzi
Using mobile technology the General Physics labs at the College of Notre Dame of Maryland have been redesigned to provide a more integrated and cohesive learning environment that better meets the aspirations and needs of the unique student population served (100% female, 33% from underrepresented groups, 91% supported by financial aid, 50% first-generation college attendees). The General Physics course sequence attracts highly able science and engineering majors. With wireless technology and HP tablets, the two physics laboratories have been redesigned to support PASCO Science Workshop@ Physics equipment. With a more interactive laboratory environment more teaching time is now spent on directing Notre Dame's women students to work collaboratively on using computer-aided technology to run the experiment, analyze the data, and write up the results during the lab period instead of working individually outside of lab. As a result, there is a measurable increase of enthusiasm and interest in learning physics.

Session: Labs & Wikis
Working With Wikipedia, Not Against It
David L. Morgan
This talk describes a project in which college physics students spend a semester editing incomplete "stub" entries in physics and astronomy on Wikipedia.org.

Session: Lobbying for Physics
Science Policy in Congress: A View from the Inside
Dahlia Sokolov
There are two intertwined aspects of science policy that I will address: policy for science and science for policy. Policy governing the scientific enterprise includes how much money the federal government spends on science, how that money is allocated, what role we play in technology transfer, and how we help ensure a diverse and well-prepared pipeline of students going into scientific fields. The process by which we seek answers to these questions is influenced by a number of competing factors: lobbying by the various stakeholders, priorities of those in power at that moment (in both Congress and the Administration), and ongoing issues of national concern, including competitiveness, energy, health and national security. With regard to

issues of national concern, science is just one seat at the table during the policy-making process. But it is an increasingly important seat, and I believe that more scientists need to come down from their ivory towers, get educated about the process, and get involved.

Session: Lobbying for Physics
What to Say to Congress and Why?
Don Engel
Congress is built to respond to the desires of its constituents. Representatives and their staffs are awash in information. If scientists do not communicate regularly and effectively with Congress, the interests best represented by educators and scientists will not be met by the government. This talk will cover why we must communicate with Congress, and how to do so effectively. Effective collaboration with Congress requires an understanding of its structure and practices, as well as knowledge of recent and current happenings. Therefore, these will be addressed at the beginning of the talk.

Session: Medical/Health Physics Research and Education
Medical Physics and Physics Education
Rod Milbrandt
The fields of medical physics and health physics have grown tremendously in recent years. Physicists have played key roles in the development of many imaging modalities, including ultrasound, MRI, and CT, as well as radiotherapy and radiation protection. These topics are interesting to students, and bringing some medical physics into the physics classroom can build interest and real-world relevance in our classes as well as making students aware of other career possibilities—yes, some physicists work in medical centers! Medical physics can be brought into the classroom in many ways. Instructors can choose examples and problems drawn from medical topics, show and discuss medical images and their production, create labs and activities related to medical physics, and set up visits to medical centers and corporations. This talk will include ideas and resources to bring medical physics into your classroom.

Session: Medical/Health Physics Research and Education
MRI as a Physics-Based Technology Driven by Applications in Medicine
Richard G. Spencer
Magnetic resonance imaging (MRI) is a prime example of an applications-driven physics-based technology. Because the basic goal of acquiring high-quality diagnostic images of most internal organs has largely been achieved, much of MRI physics research centers on further improving available information content. Exploratory studies using tissues and animals play a central role in these developments. Examples include study of dynamic processes such as blood flow and cardiac motion, assessment of tissue properties such as hydration, vascularization, and macromolecular orientation, and, using MR spectroscopy, defining the metabolic state of tissue. In parallel with important extensions such as these, there remains the ongoing engineering challenge of working at higher magnetic fields in order to improve spatial and temporal resolution for all types of studies. An overview of the technology and applications will be presented from the perspective of the physicist.

Session: Meeting the Needs of NCLB Requirements for Highly Qualified Teachers
ASU Math and Science Teaching Fellows: Models of Teacher-Researcher Interactions
Robert J. Culbertson
Forty-two 8th to 12th grade science and mathematics teachers participated in a four-week summer program where they were placed in one of 14 research groups in the areas of

biosciences, computer science and information technology, or sustainable systems. Several effective models of teachers working in scientific research laboratories emerged to accompany our original model of teachers as 'embedded reporters.' In one model the researchers hosted the teachers and discussed their research every third meeting day. A second model was the use of a graduate student to host a team of three to four teachers on a series of experiments; the teachers attended larger group meetings and heard about research projects throughout their research experience. A third model was the orchestration of teachers' activities by research faculty directly. The key to success in all three models was coordination of activities throughout the four weeks rather than relying on teachers to fit into the group on the fly.

Session: Meeting the Needs of NCLB Requirements for Highly Qualified Teachers
Inquiry Physics for Elementary Science Teachers: The RIPE Program
Stephen J. Van Hook
This paper describes the refinement of K-3 teachers' physics concepts (specifically, air & sound, light, motion, energy, and magnetism) from a professional development program employing the Research-based Inquiry Physics Experiences (RIPE) model. This model has evolved from a seven-year collaboration between a university physics professor, science education professor and a collaborative field elementary school to develop and test lessons in physics concepts for early childhood students. We describe the instructional model used with elementary science teachers and changes in their ideas about physics concepts from the professional development experience.

Session: Meeting the Needs of NCLB Requirements for Highly Qualified Teachers
Problem-Based Learning in the Science Preparation of Elementary Education Majors
Keith Sturgess
Preparation in the sciences has long been seen as a weakness for many elementary school teachers. Students majoring in elementary education tend to be a self-selected group that fears science and math. To address this, The College of Saint Rose School of Math and Science, together with the School of Education, have created a new two-course sequence required for Elementary Education majors. In Science 100, students are team-taught by a physicist and chemist, while in Science 200 they are team-taught by a biologist and earth scientist. The courses are designed to teach the science an elementary school teacher needs, be highly interactive, and show the interconnections of science through the interactions of the team of scientists teaching the course. We also use peer leaders to emphasize class content during problem-based workshops held each week. These two courses are tied directly to the Science Methods course in the School of Education.

Session: The Minority Science and Engineering Improvement Program
Virtual Community for Physics and Mathematics Teaching in Engineering Education
Roman Ya. Kezerashvili
Engineering is the application of mathematics and physics to develop useful products or technologies and then turning ideas into reality. Physics is the study of the physical world based on observations and mathematical description, and physics and mathematics are an indispensable component in engineering curricula because technology is based on our knowledge of physical laws. We have two primary and complementary objectives that facilitate students' ability to transfer knowledge from physics and mathematics to engineering and technology: i) to establish the laboratory as a primary learning tool in STEM; ii) to demonstrate the efficacy of using e-learning and e-teaching through Blackboard and web-based communication systems. All these provide more avenues of STEM learning and support the retention, persistence, and graduation of the underrepresented groups in STEM. To achieve the objectives, we are creating a virtual

community of students and faculty as a vehicle for promoting the transfer of knowledge from physics and mathematics to computer science and engineering applications using e-learning and e-teaching mechanisms as well as laboratory exercises and demonstrations.

Session: The Minority Science and Engineering Improvement Program
Study Groups, Whiteboarding, and Community at a Minority Serving Institution
Leanne M. Wells
Florida International University's Student Equity and Achievement in Mathematics and Science (FIU-SEAMS) project recruits and supports undergraduate students from groups underrepresented in mathematics and physics with the goal of increasing the number of these students graduating with mathematics and physics degrees. Housed in the College of Education at FIU, Miami's public research university of 38,000 students of which more than 70% are Hispanic or African-American, FIU-SEAMS has built a system of study groups and peer mentoring that makes the academic environment hospitable and supportive. Project successes include a strong social and academic support network for math and physics majors, improved persistence in pursuing physics and math degrees, and increased academic achievement. An overview of project design and activities as well as effective practices will be presented along with results from analysis of participants' academic successes. Efforts to effect long-range improvements in FIU's physics and mathematics programs will also be addressed.

Session: National Aquarium as a Physics Resource
Physics at the National Aquarium in Baltimore
Joe Harber
Non-formal science institutions can provide opportunities for learning outside the traditional classroom. Learn about the exhibits, habitats, and unique animals found at the National Aquarium in Baltimore. In addition an overview of the Aquarium's programs will be provided.

Session: National Aquarium as a Physics Resource
Physics at the National Aquarium: Brainstorming
Thomas Foster
The Pre-High School teacher frequently needs to be an expert in all the sciences, but it does not mean that they do not favor Biology over Physics. The National Aquarium in Baltimore is an excellent example of this bias. Teachers and students visit to learn about marine biology, but why shouldn't they learn about physics? Come to this session and help the national aquarium create programs highlighting physics for its visitors.

Session: Physicists in the Medical Profession
A "Beam's-Eye-View" on Therapeutic Medical Physics
Erik J. Tryggestad
Therapeutic medical physics, or the physics of radiotherapy, has a rich history that evolved from the discovery of natural radioactivity near the turn of the 20th century. Driven by both basic and industrial research, over time the field of radiotherapy physics has broadened in scope and now employs an increasingly multi-disciplinary group of scientists. Worldwide, the broader field of medical physics now employs perhaps 5,000 physicists. It is in spite of these facts, however, that radiotherapy physics remains a relatively unfamiliar niche in the vast world of applied physics. Against the backdrop of a pop culture that increasingly associates the word *radioactive* with *bad*, modern radiotherapy provides the basis for effective, life-sustaining treatments for otherwise terminally ill patients. In 30 minutes or less, I hope to convince the audience that not only is

radiation in radiotherapy not “bad”, but that it also provides for an interesting and highly rewarding career.

Session: Physicists in the Medical Profession
From Cascade Hyperons to Cartilage: a Physicist’s Career in Medicine
Jeffrey Duryea
Research medicine is a field that increasingly relies on innovative technology to make advances and new discoveries. Much of the new biomedical science is based on physics and methodologies used for physics and engineering research. Individuals with degrees in physics are a valuable resource for the medical community, and are in a position to have a major impact on the field.
In this presentation, the speaker will discuss his transition from the field of high-energy physics to a faculty position in the radiology department of a major teaching hospital, and to a specialization in arthritis imaging research. The speaker found that his physics background provided a strong foundation for success, but unanticipated obstacles and the need to acquire new skills were among the challenges faced along the way.
Medical imaging is an exciting field and an excellent career for individuals interested in an applied field with real-world impact.

Session: Physicists in the Medical Profession
Physics Thinking in Biomedical Research
Alison J. Lin
Discoveries in physics and subsequent development of cutting-edge technologies have been at the forefront of medical diagnosis and treatment since the discovery of x-rays in 1895. More than the techniques and technologies, a physicist can bring a new perspective to problem solving in biology and medicine. Education and training in physics provide an analytical and quantitative approach for studying complex biological systems. During the 1999 American Physical Society meeting, Dr. Harold Varmus, Nobel Prize laureate and then director of NIH, identified three areas of opportunities for physicists in contemporary biomedical research. These include single molecule manipulation, computational analysis of gene expression, and elucidation of cellular signaling pathways. All three areas are urgently active today, and have indeed become hot beds of multidisciplinary research. Here, based on my own experience working between the two disciplines in two of these areas, I will explore the power of physics thinking in biomedical research.

Session: Physics and Art
A Systematic Approach in Correlating the Sound Characteristics of Cello Strings with Materials and Price
Courtney .L Kaita
Every year, string instrumentalists buy thousands of dollars worth of strings. There are numerous different brands, with a wide range of prices from $10 strings to $100 strings. Is the extra money really worth the better sound, or will the $10 strings adequately suffice? This experiment closely examines this problem by examining the wave forms of 14 different strings. Their resulting overtones and amplitudes were correlated with their respective weights and prices. Results will show whether there is a distinctive relationship between these variables, proving that there may just be a way to quantitatively determine which strings are “better.”

Session: Physics and Art
Homemade Animated Physics Cartoons
Jeffrey M. Wetherhold
I make animated cartoons to entertain as well as teach certain physics topics. A video camera capable of doing stop motion animation is used to film the original art work. Editing and some of the special effects are done with Apple's iMovie. The cartoons are full of science and whimsy and each one lasts approximately 2 minutes long. Each cartoon takes many hours to create. A 3-D look is created using layers of glass.
So far I have created 26 cartoons on the topics of 1-D kinematics, 2-D kinematics, dynamics, energy, gravitation, waves, and electricity.

Session: Physics and Art
Symmetry and Aesthetics in Introductory Physics
Jatila van der Veen
In 2007, we piloted a new interdisciplinary physics and fine arts course entitled Symmetry and Aesthetics in Introductory Physics with a group of physics and arts majors at the College of Creative Studies at U.C. Santa Barbara. Our model curriculum begins with Symmetry and Relativity, uses interdisciplinary strategies and interactive methods, and is underlain by the ideology of aesthetic education. Instead of a textbook, students read articles by theoretical physicists, and Lawrence Krauss' book, *Fear of Physics.* We used art and music as visualization strategies along with more traditional assignments. The final project was to create a physics work of art. The course received outstanding ratings, and we plan to offer it again and develop the sequel. We will describe the curriculum, methodology, assessments, and potential applications for physics majors, liberal arts majors, teacher education, and implications of this model for addressing issues of diversity in physics through curriculum reform.

Session: Physics and Art
Teaching Physics with Art and Photography
Tetyana Antimirova
Although the community of physics educators has come a long way in developing and implementing effective strategies for teaching physics, physics still stands out among other sciences as the subject particularly difficult to learn and to teach effectively. Part of it is because the students still do not see physics as related to our everyday life and lack motivation. Visual arts such as photography, paintings, movies and cartoons seem to be totally unrelated to physics, and yet they all can become powerful tools for bringing excitement while teaching physics. I will present a series of professional and amateurs' visual arts samples containing manifestations (intentionally or not) of various physical phenomena we encounter in everyday life.

Session: Physics and Society Contributed Paper
Novel Ways of Bringing Science to Students of All Ages
Brian Schwartz
A major challenge is to bring science to students of all ages and adults. For the past seven years the Science & the Arts program at The Graduate Center has made use of the performing arts to bring science to new audiences. See http://web.gc.cuny.edu/sciart. In this paper we focus on four examples of our innovative approaches: 1). A city-wide science festival in venues throughout the city including a legitimate theater. 2.) The display and performance of hands-on science experiences in association with a typical New York City weekend street fair, offering science amidst the kielbasa and tube socks. 3.) A multidimensional performance of an event entitled "String Theory for Dummies." 4.) A comprehensive program being planned with the

Metropolitan Opera for October 2008 associated with the opera Dr. Atomic, (Oppenheimer and the Manhattan project).
*Supported in part by the National Science Foundation NSF PHY-0431660

Session: Physics and Society Contributed Paper
Radiative Equilibrium and Climate Change as an Application of Radiation
Mark Seefeldt
Climate change and radiative equilibrium can be used as an application of the characteristics of EM radiation. Wien's displacement law indicates that the radiation from the sun is emitted in the shortwave and that terrestrial radiation is emitted in the longwave. This difference leads to the greenhouse effect as the radiative absorption of atmospheric chemical species is dependent on the wavelength. Stefan-Bolzmann law provides the ability to understand the amount of incoming solar radiation to the Earth as well as the outgoing terrestrial radiation. An imbalance in the equilibrium between the incoming solar radiation and the outgoing terrestrial radiation results in a climate change with the Earth's atmosphere and ecosystem. By combining the principles of EM radiation with climate change the physics material can be connected to real-world events as well as providing a more educated understanding of one of the primary current environmental concerns.

Session: Physics and Society Contributed Paper
Recapturing Household Heat from Waste Water
Thomas F. Haff
Five to fifteen seconds. That's the approximate length of time it takes water to travel from a showerhead to the drain. The water then travels out of the house. In the greater Seattle area, water is recycled, but the heat stored in the water is not. In order to recapture that heat, Issaquah High School's Student Energy Conservation Group constructed a prototype apparatus that holds used hot waste water inside a wall until the heat energy has dissipated throughout the house. The heat is recycled. This lowers energy consumption, which in turn lowers greenhouse gas emissions and heating bills. We invite you to learn more about our project.

Session: Physics and Society Contributed Paper
What Physics Is Needed on the Web?
Göran Grimvall
The Internet plays an increasing role as a source of information on which we may act, depending on how it is interpreted. Consider reliable web pages, which the general public may consult, dealing for instance with medicine or consumer reports. Is today's school physics relevant for their interpretation? Knowledge of physics may lead to a deeper understanding of an issue, but does it also lead to a different decision. If one seeks a low-noise product, the numerical value of the noise level is in itself sufficient for most people as the basis for a decision, without further knowledge of acoustics. The physical definition of mmHg is of little importance in a discussion of blood pressure. Medical information is arguably the most important example of how web pages with technical content can be used as a source of information for the general public. What does this mean for physics education?

Session: Physics and Society Education—Crackerbarrel
Project WISE: Working in Informal Science Education
Gregory A. DiLisi
We piloted educational programs at Cleveland's International Women's Air and Space Museum (IWASM) while simultaneously conducting a research project to see if high school students

could be hooked into STEM-based careers through an initial, positive exposure to teaching. Our goal was to develop materials for early-level children that focus on STEM and women's contributions to aeronautics and aviation via the creation of the "Working in Informal Science Education" (WISE) teaching academy for high school students. In this academy, diverse cohorts of secondary-level students performed preparation activities to give them specialized knowledge in content and pedagogy. Volunteers collaborated with university faculty, student teachers, and education specialists to develop, test, and evaluate permanent displays, classroom activities, and biographical portrayals of famous aviators. The project is remarkable in that our academy supports the social and scientific development of children, emphasizes cooperative learning, and directly benefits Cleveland-area youth who will utilize project deliverables.

Session: Physics Education Research
Case Studies in Learners' Ontologies in Physics
Ayush Gupta
Some difficulties in learning science ideas can be analyzed in terms of students trying to understand the "ontology" of a concept, or in other words "what kind of thing" it is. In our previous work [1,2] we presented the perspective that experts as well as novices are not committed to a single ontology of a concept and showed instances of ontological category hopping in everyday, professional and classroom settings. Detailed case studies of students interacting with science concepts in vivo can provide valuable insights for modeling learners' ontologies in physics. We will present case study data from our physics classroom. Preliminary analysis suggests variability in students' ontological view of a concept and that students at times struggle with questions about the ontological nature of a concept. We then discuss theoretical and instructional implications and directions for research.
[1] Edward F. Redish, Ayush Gupta, and David Hammer, AAPT Greensoro, 2007,
[2] Ayush Gupta, Edward F. Redish, and David Hammer, AAPT Greensboro, 2007.
This work supported in part by NSF grants REC 0440113 and DUE 0524595.

Session: Physics Education Research
The Dynamic Assessment of Student Acquisition of Scientific Abilities
Eugenia Etkina
In the past five years our group has been working on helping students develop such scientific abilities as the ability to design an experiment to investigate a phenomenon, to test a hypothesis or to solve a problem, the ability to collect and analyze data, to evaluate and validate assumptions, etc. while learning physics content. We found that with proper guidance and scaffolding, students develop such abilities during one semester of an introductory physics course without compromising the learning of traditional content. Our new study focused on the dynamics of the development of a particular ability. Using scientific abilities rubrics developed and validated earlier, we took weekly measurements of student progress and found the average time interval that students needed to understand the meaning of the ability and be able to demonstrate proficiency.
The project was supported by NSF grant DRL 0241078.

Session: Physics Education Research
Gestures as Evidence of Student Meaning
Rachel E. Scherr
Students' spoken language and written records provide primary evidence of their understanding. However, students (and experts) use language differently in different activities, and words that people say or write may not mean the same thing in another context. In particular, terms with

specific technical meanings in science contexts often have other meanings in informal discussions. Student discussions in tutorials are often both informal and scientific, complicating the task of understanding what they mean by what they say. One source of evidence of students' meaning is the gestures they use as they speak. We analyze a number of gestures that one student makes in conjunction with verbalizations about “surface area” as part of her reasoning about a third law question. Our analysis suggests that for this student, the term “surface area” in this episode does not necessarily reference what she would call surface area, volume, mass, or any other specific quantity in another conversation, but instead is an ambiguous term that could refer to a variety of size-related properties of the object.

Session: Physics Education Research
Investigating and Addressing Student Difficulties with Periodic Waves*
Mila Kryjevskaia
The Physics Education Group at the University of Washington has been developing and modifying research-based instructional materials on waves and physical optics for Tutorials in Introductory Physics1. In a typical introductory course, students develop a basic understanding of the quantities describing periodic waves (such as wavelength, frequency, and propagation speed). They then establish a relationship between these quantities that they later apply in a variety of more advanced contexts, including refraction of periodic waves, interference, diffraction, and thin-film interference. Our findings suggest that difficulties with these basic concepts persist even after extensive practice in more advanced contexts. Illustrative examples of such difficulties will be discussed.

Session: Physics Education Research
Learning Goals and Epistemological Beliefs: Case Studies from Physics Graduate Core Courses
Yuhfen Lin
What are we trying to teach students in graduate level physics courses? Physics graduate core courses often teach the base-line physics knowledge through traditional problem solving and lengthy derivations. However, to learn to do research, graduate students need to learn more than derivations, or a sophisticated form of plug and chug problem solving. In order to help students become physics researchers, I will propose that students need to be exposed to the culture of physics research inside the core courses. I will consider the cases of a traditionally taught core course, and a course taught by a physics professor who tried to implement a graduate physics course that focused on preparing the students for future research. Using case studies from two graduate students, I will examine how their different epistemological beliefs and learning goals led these two students to perceive the same courses in very different ways.

Session: Physics Education Research
The Relationship Among Mathematics Anxiety and Conceptual Knowledge of Electromagnetics
Johanna Leppävirta
Students in engineering schools and universities generally have the ability and skills to perform mathematical tasks. However, prior research has indicated that even students with aptitude for mathematics suffer anxiety that affects their academic performance. The Electromagnetics Math Anxiety Rating Scale (EMARS) was developed to assess engineering students’ perceived mathematics anxiety when learning electromagnetics. The mathematics anxiety is defined as a feeling of tension and anxiety that interferes with the manipulation of numbers and solving of mathematical problems. The EMARS instrument consists of five qualitatively different factors: usefulness, mathematics confidence, interpretation anxiety, fear of asking help and persistency. Traditionally math anxiety tests have been used as diagnostic instruments. Only recently, math

anxiety research has considered the underlying cognitive processes involved when performing mathematical tasks. This study examined the relation between mathematics anxiety and engineering students' online performance in Conceptual Survey in Electricity and Magnetism (CSEM).

Session: Physics Education Research
Research to Improve Student Understanding of Time-Dependence in Quantum Mechanics
Andrew D. Crouse
The Physics Education Group at the University of Washington is engaged in a long-term effort to investigate student understanding of quantum mechanics. One component of this investigation is to examine student ideas about time dependence. We have identified some specific difficulties, developed curriculum to address those difficulties, and implemented the curriculum in junior level physics courses at the University of Washington. An iterative process of assessing and refining that curriculum is under way. Elements drawn from this body of research will be discussed.

Session: Physics Education Research
Should We Use Ill-structured Physics Problems in Introductory Physics Courses?
Vazgen Shekoyan
Most of real-life and professional problems are ill structured. Ill-structured problems do not have one right answer and require the solver to examine different possibilities, assumptions, and evaluate the outcomes. However, in traditional educational settings we polish problems and make them well-structured problems (most of traditional end-of-chapter book problems are well-structured). Introductory physics courses are usually short and packed with new content. Should we engage introductory physics students in solving ill-structured problems at the expense of traditional problems? In our study we substituted some of the traditional problems with ill-structured physics problems in cooperative group problem solving activities in recitations in an algebra-based introductory physics course. We provided scaffolding with a particular emphasis on epistemic questioning. In this talk we will discuss the implications of this intervention on the enhancement of students' cognitive abilities and physics content knowledge.

Session: Physics Education Research
Student Understanding of Energy: Difficulties Related to Systems*
Beth A. Lindsey
An understanding of the relationship between work and changes in energy is important in many areas of physics from introductory mechanics onward. In order to apply this relationship, students must identify a system of interest and then be consistent in identifying which external objects do work on the system. We will describe a sequence of questions that have been administered to students on pre-tests and post-tests and during individual demonstration interviews in order to identify student difficulties with analyzing systems in the context of energy in introductory mechanics. A set of instructional materials (1) designed to address these difficulties is under development by the Physics Education Group at the University of Washington.

Session: Physics Education Research
Student Use of Mechanics Knowledge in Electrostatics*
Maria Dolores Gonzalez
Instructors of introductory courses often try to use students' mechanics knowledge as a basis for the development of related concepts that are central to the subsequent electricity and magnetism

course. This approach is most successful if students enter the second-semester course with an adequate mechanics background, and if they recognize the underlying features that are common to the two contexts. We are developing a pre- and post-test that is intended to measure the extent to which (1) students enter the electricity and magnetism course with a sufficient mechanics foundation; (2) there is a correlation between student responses to similar questions in mechanics and electrostatics contexts; and (3) mechanics understanding is strengthened through reintroduction of physics principles in a second context. We will give examples of "paired" questions and give data from administrations of the pre- and post-tests.

Session: Physics First Book Review: Criteria for a 9th Grade Physics Textbook
Active Physics
Arthur Eisenkraft
Active Physics guides students and helps them learn and apply physics. The program is built on research results from studies in cognitive sciences, student assessment, student engagement, and problem-based learning. It supports inquiry in the classroom and meets the expectations of the National Science Education Standards, the AAAS Benchmarks and State Frameworks. Active Physics was developed by hundreds of physicists and physics teachers with support from NSF. There is a sharp contrast between the traditional physics textbook and its approach to learning and the Active Physics text with its attempt to bridge research in learning with practice in the classroom. In both traditional texts and Active Physics, there is content, equations and homework. In Active Physics, students also have a challenge to frame the content, an opportunity for teachers to elicit prior understanding, and a need for students to transfer their knowledge at the activity level and the chapter level.

Session: Physics First Book Review: Criteria for a 9th Grade Physics Textbook
Conceptual Physics, the New edition.
Paul G. Hewitt
I will describe some of the new features in the new edition of *Conceptual Physics.*

Session: Physics First Book Review: Criteria for a 9th Grade Physics Textbook
Engaging All Students in Real Physics
Thomas C. Hsu
For students to learn physics, they need to experience it, first hand. That means getting real physics into classrooms on a large scale, training teachers to create engaging lessons, and competing in a market dominated by science textbooks. CPO Science was founded by a small team of teachers to create quantitative, hands-on, physics education programs that would teach students to think and problem solve, not just memorize. By incorporating textbooks and lab equipment into a seamless learning system we have been able to achieve this goal for more than 500,000 middle and high school students in nearly all 50 states. The success is due to the melding of good teaching, deep knowledge of physics, and also comprehensive attention to the business of how schools select and purchase curriculum. I suspect my strongest personal contribution to science education will have been a workable, sustainable strategy for making this happen and extending that strategy to chemistry (this year) in a way that builds on physics.

Session: Physics First Book Review: Criteria for a 9th Grade Physics Textbook
Experiences and Motivation Leading to the Development of an Introductory Physics Text
Tom Hsu
I intend to describe my early teaching experiences that led me to decide to write a textbook for introductory students.

Session: Physics First Book Review: Criteria for a 9th Grade Physics Textbook
Survey Results of Texts Suitable for Physics First
John L. Hubisz
In the past few years a number of books suitable for a Physics First course at the 8th or 9th grade level have risen to the surface. We have recruited a cross-section of more than 30 reviewers to look at many of these books for accuracy, readability, age appropriateness, and adherence to an accurate portrayal of the scientific approach.

Session: Physics in America and Russia
A Brief History of the Inclined Plane in America
Steven Turner
The inclined plane has been called the "Alpha" experiment, dating all the way back to Galileo and studied by nearly every physics student since the 18th century. In America, the evolution of this simple demonstration mirrored the changes in science teaching and the growth of technology. This history can be traced in the historic instruments, catalogs, textbooks and student lab manuals found in the Smithsonian collections.

Session: Physics in America and Russia
Politically Nonconforming Scientists Met Behind the Iron Curtain
Mikhail M. Agrest
Contemporary inventions in science and in physics particularly are often more exciting then science fiction fantasies of the most sophisticated writers. The life and work of scientists in the contemporary world is of great interest to the public and politicians partially because of mass destruction opportunities hidden in these inventions. The gravitation to free communication and the exchange of ideas with colleagues in the world independently of their political affiliation sometimes takes over the sense of personal security. This paper uncovers just one page in the relationships of former USSR and U.S. scientists during the Cold War. A meeting of renowned American particle physicist Thomas Stix with one of the invisible Russian scientists, a participant of the Russian Nuclear project, a generator of extraordinary ideas, and a dissident Mates Agrest was documented by the KGB agent. The photographs of that meeting became available.

Session: Physics in America and Russia
The "Modern" American Physics Textbook
Thomas B. Greenslade, Jr.
Reading the forwards to American physics textbooks, as the authors explain the necessity for still another physics book, can be a sport in itself. Despite noteworthy attempts to break the mold over the last century and more, our textbooks tend to revert to the plan of the first truly American physics textbook, written by Denison Olmsted in 1831 "for the use of the students in Yale College." The modern American calculus-level book probably stems from the series of textbooks written for the cadets at the U.S. Military Academy by W.H.C. Bartlett in the 1850s. The natural philosophy book originally written in French by Ganot at the same time was widely used in a series of English translations until the first decade of the 20th century. The talk will conclude with the many permutations of the basic text written by Robert A. Millikan in the beginning of the 20th century.

Session: Physics Teacher Preparation Program Accreditation
Achieving Accreditation Through the Integration of Professional Association, State and National Teacher Education Standards for Preparing Physics Teachers
Ken Witmer
Identifying common language to create performance assessments is an effective tool used by Maryland colleges and universities to address accreditation requirements. A model for aligning and integrating common elements of the National Physics Standards, Maryland Program Approval Standards and National Teacher Education Standards will be shared to achieve program accreditation. A matrix visually displaying the integration of all three standards will be a frame of reference for the presentation.

Session: Physics Teacher Preparation Program Accreditation
Physics Teacher Preparation Program Accreditation—National Perspective
Erica M. Brownstein
Accreditation for teacher preparation can seem to be a daunting task. This presentation will describe how to keep continuous improvement a priority in your physics teacher preparation program while using accreditation requirements as a constructive component. Historically, the physics community has been highly involved in education and made significant contributions not only to the learning of physics but also to the generalizable audience of teaching and learning in science. This session will invite members of the physics education community to become more involved in the science teacher preparation accreditation process.

Session: Placing Computational Physics in Undergraduate Curricula
Changing the Status Quo: Live to Tell the Tale
Andrew S. Hirsch
Instituting a significant curricular change requires buy-in from many different constituencies in addition to effort expended by supporters. I will share our experience at Purdue in adopting Matter & Interactions for our Physics majors and, more recently, for approximately 2,000 engineering students.

Session: Placing Computational Physics in Undergraduate Curricula
Computation as a Learning Tool in an Undergraduate Nanoscience Course
Ronald M. Cosby
Modeling and simulation exercises are used as learning tools in an undergraduate nanoscience course at Ball State University. Web-based computational resources are conveniently used by students to study the basics of quantum tunneling, compute electronic structure and density of states for long carbon nanotubes, and predict molecular conductance using a toy model. More sophisticated exercises on the electronic properties of nanostructures are completed using the commercial software packages Gaussian-03 and Atomistix's Virtual NanoLab. Local resources for the computations include a 128-processor Linux cluster and workstations. The historical context for computational activities in nanoscience is briefly established and a course description is given. The objectives, procedures, and outcomes are described for selected computational exercises completed by undergraduates in the nanoscience course.

Session: Placing Computational Physics in Undergraduate Curricula
Computational Physics and Departmental Change
Robert C. Hilborn
Instituting a computational component of an undergraduate physics program can be carried out in many ways, either through specialized courses or through a distributed model or through a

combination of the two. In any case, such developments require a department to articulate goals and objectives for its undergraduate curriculum and to coordinate the content and pedagogy in a variety of courses. I will analyze several computational physics efforts in light of the recommendations contained in the report Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP) of the National Task Force on Undergraduate Physics. Computational physics can serve as a catalyst for significant enhancement of all aspects of an undergraduate physics program.

Session: Placing Computational Physics in Undergraduate Curricula
Integrating Computational Activities into the Upper-division Paradigms Curriculum
Corinne A. Manogue
Paradigms in Physics is a novel upper-division physics curriculum developed at Oregon State University. The junior year comprises 10 modular courses, each focused on a specific paradigm or class of physics problems that serves as the centerpiece of the course and on which different tools and skills are built. As an integral part of the curriculum, we use multiple software packages including Maple, Mathematica, Java, and special purpose code to help students do calculations, visualize graphics, and perform simulations. We will discuss the criteria we use to decide what computational tools will be fruitful in different classroom situations and how we sequence a variety of activities to have added pedagogical impact.

Session: Placing Computational Physics in Undergraduate Curricula
Lessons for Integrating Computation into Undergraduate Curricula: Changing Minds & Hearts
Norman Chonacky
There is evidence that the traditional undergraduate physics curriculum does not serve the computational needs of many of its graduates.(1) There is also evidence that, where computation has made inroads in the curriculum, it is the result of sustained effort of individual faculty without the support of a majority of their departmental colleagues.(2) A case can be made for integrating computation in the full undergraduate physics curriculum, but these data suggest this will never be possible without a greater degree of faculty and administrative support. I will describe some conceptual challenges presented by the objective of installing numerical modeling and simulation across the physics curriculum. The succeeding speakers will describe a variety of perspectives on making and managing significant curricular changes of any type, for consideration by those who would dare to contemplate the comprehensive integration of such computation in their own departmental curricula.

Session: Placing Computational Physics in Undergraduate Curricula
More Fun with Wavelet Analysis
Joseph J. Trout
Fourier Analysis and Wavelet Analysis are used to analyze experimental data. Fourier Analysis is used to analyze the time (or space) independent features of the signal or data. Wavelet Analysis is used to analyze the time or space) localized features of the data.

Session: Placing Computational Physics in Undergraduate Curricula
Using Wavelet and Fourier Analsys on Surface Temperature Data
Joseph J. Trout
Fourier Analysis and Wavelet Analysis are used to analyze the surface temperature data. Fourier Analysis is used to analyze the time (or space) independent features of the temperature data. Wavelet Analysis is used to analyze the time (or space) localized features of the temperature data.

Session: Project Based Physics
Out of the Projects and into the Game?
David Weaver
I tossed the baby out with the bathwater (and the shampoo, and the rubber ducky) seven years ago when I discovered problem/project-based learning. That transformation took me from what was (I think) an active engagement environment to a more immersive one. Gone was the tyranny of the topics and I embraced the power of learning in context. I should've been relatively content, yes? Not yet! I am on sabbatical this year to explore the interface between video/computer gaming and physics. Contemporary video games have amazing physics engines that could be wonderful sources of learning in contexts that my students already understand and enjoy. Moreover, my initial research indicates that video game designers might have a lot to teach us about keeping students willingly engaged in complex problem-solving for hours on end. Come see where I'll be halfway through my sabbatical.

Session: Project Based Physics
The Solar Car Project: A Synthesis of Scientific Inquiry, Research, Experimentation, and Content Application
Kristen M. Guyser
The purpose of the solar car project is to create an end of the year synthesis activity that incorporates mechanics, electricity/magnetism, as well as the scientific method. In this project, students must research the physics behind a working solar panel, apply their content knowledge of mechanics and circuits, use the scientific method to independently create three experiments that would be used to enhance the building of their solar car, then race their car, not against each other, but against a predicted time value they submit based upon experimentation.
On the day of the race, students submit their final projects in binders which include pictures of the stages of design/redesign of the car, purpose/data/analysis/conclusion for three experiments they independently ran on their car, a journal with entries outlining the day/time/people present and what was accomplished, a synthesis of how their results from their experiments were used to design the car, and a time they predict it will take their car to cross the finish line.

Session: Relating Undergraduate Mathematics and Physics Education
Comparing Student Performance on Mathematical and Physical Isomorphic Vector Tasks
Joel Van Deventer
Using past research into student difficulties with vectors in introductory and high school physics courses [1,2,3], we have developed isomorphic mathematics and physics vector tests to evaluate student understanding of vectors in both contexts. Questions are identical, with only the context of the question changing in each case. To validate our test, we carried out task-based interviews with introductory physics students completing a semester's instruction. We used results to develop multiple-choice versions of each vector test. These were administered to introductory physics students at the start of a semester, giving us insight into what knowledge students bring to understanding vectors in mathematics and physics contexts. Supported in part by NSF grant REC-0633951.
1 N.-L. Nguyen and D. E. Meltzer, Am. J. Phys., 71 (6), 630-638 (2003).
2 R. D. Knight, Phys. Teach. 33 (2), 74-78 (1995).
3 P. S. Shaffer and L. C. McDermott, Am. J. Phys. 73 (10), 921-931 (2005).

Session: Relating Undergraduate Mathematics and Physics Education
Integrating Mathematical and Physical Reasoning: The Role of Mechanistic Explanation
Brian W. Frank
Students often fail to relate mathematical representations to the physical situations that they represent. We observe this disconnect in a tutorial about one-dimensional motion, in which students' qualitative conclusions based on a ticker tape representation of motion contradict their quantitative results. Some students notice the contradiction and some don't. We have made preliminary observations that those students who explicitly reason about the mechanisms by which the ticker tape equipment works are more successful in integrating their intuitive resources for thinking about motion with their mathematical resources for thinking about scaling and proportionality. We support this hypothesis with video case studies of students at the University of Maryland.

Session: Relating Undergraduate Mathematics and Physics Education
Teachers' Mathematical Modeling of Motion
Jill Marshall
I will report results of a study of pre-service and experienced teachers in a university physical science class. These teachers developed mathematical models of motion based on data acquired while observing actual motions. In general, even the teachers with the most experience in formal physics struggled to develop fully Newtonian models as characterized by Hestenes (1992). Clearly, the Newtonian mathematical framework that would be developed in a calculus class had not transferred to this modeling endeavor. However, some teachers with less formal experience developed their own approaches by invoking high school mathematics, the distance construct in particular. These teachers independently developed successful frameworks to describe and predict motion based on the concept of average velocity, i.e., the distance covered in a given time, and regular changes in the average velocity, analogous to the acceleration.

Session: Relating Undergraduate Mathematics and Physics Education
Transfer of Learning from Calculus to Physics
Lili Cui
Many introductory calculus-based physics students have difficulties when solving physics problems involving calculus. This study investigated students' retention and transfer of learning from calculus to physics. We proposed a theoretical framework to assess students' transfer of learning in the context of problem solving. A total of 28 students who enrolled in a second-semester introductory physics course were interviewed. The video-taped interviews were transcribed and analyzed. A major finding from this study is that a majority of students possess the requisite calculus skills, yet have several difficulties in applying them in the context of physics. A detailed understanding of students' difficulties in terms of the proposed theoretical framework will be discussed. Instructional strategies are also suggested at the end to facilitate the transfer from calculus to physics.

Session: Research Experience for Teachers and Students
MARIACHI—Forefront Science Research by Teachers, Students and Scientists
Helio Takai
MARIACHI is a unique experiment that is being carried out by a team of high school teachers, students and scientists. This highly motivated group's goal is the development of an innovative technique to detect cosmic ray showers either produced by ultra high energy cosmic rays or neutrinos using radar technology. This unique mix of professionals leads to a natural integration of research and education. Real science makes it into the classroom environment while scientists

have a front row opportunity to contribute to the development of experiments and demonstrations for the classroom. During the presentation we will introduce you to the experiment and discuss the lessons learned from the few years of its existence. We will describe what we have achieved so far and present our future plans.

Session: Research Experience for Teachers and Students
Teacher and Student Research in Particle Physics at COSM
Kenneth McFarlane
The author has experience working with high school teachers and students in particle physics research at the Hampton University Center for the study of the Origin and Structure of Matter (COSM). The research projects will be described and the author will discuss the impact on research as well as the ramifications for the participants.

Session: REU (Poster)
Dipole Lattice Shells as Optical Metamaterials
Jared Maxson
We consider the response of low-dimensional lattice shells of coupled dipoles to an applied electric field. We assume that the lattice constant is much smaller than the wavelength of the field, to provide a coherent excitation. We consider four lattice types: a linear chain, a ring, a plane, and a cylindrical shell of dipoles.
We apply a Fourier transform to the interaction matrix (Hamiltonian) to diagonalize it in reciprocal space. From the eigenvectors of polarization and the dispersion data, we then calculate the response of each lattice type to an electric field. The response function was analyzed in terms of the partial response functions as they come from individual polarization modes. We determine resonance conditions for the eigenmode coupling by varying the shell geometry. We propose that dipole lattice shells may be considered as optical metamaterials given proper tuning of the optical properties by changing the geometrical system parameters."

Session: The Role of Student Evaluations in Faculty Assessment
Multiple Evaluation Behind Quality Improvements in the Cadet course
Antti Rissanen
This study was made at the National Defence College to the first year cadets. The quantitative survey on a Likert-scale questionnaire studied students' attitude toward teaching methods and tactics, content and amount of exercises, group work, learning material and motivational aspects. Open questions gave qualitative data. Main shortages in education were lack of a specific course material, feeling of unclear course structure, too theoretical teaching, and shortage of exercise. The content of the common course book in physics was too extensive for the most compact refresher course in physics. The results were joined to the evaluation data produced by the department's evaluation and analyzed with the SWOT-method. The study inspired to a course material project. The developed course book set was specified and synchronized with the lectures. Student feedback can give valuable information.

Session: RTOP Implementation to Improve Teaching & Learning
Results of Mentoring New Science Teachers Using RTOP
Julia K. Olsen
Research suggests that new and early career teachers benefit greatly from systematic and frequent feedback on their classroom lessons. In the absence of useful feedback, even the best trained teachers will move away from reformed teaching approaches for more didactic, teacher-centered approaches. In an effort to mitigate this natural tendency to backslide, repeated

observations of 10 first-year science teachers were conducted using RTOP as a discussion and feedback tool for the new teachers. Evaluations of new teachers' RTOP scores throughout the year demonstrate their progress as educators, both in their classroom teaching practice and in their attitudes toward teaching. Significant progress was made by these new teachers when RTOP was used as a device for initiating discussion in a mentoring relationship.

Session: RTOP Implementation to Improve Teaching & Learning
Use of the RTOP to Reform a Science Education Program for Elementary Education Students
Gail R. Luera
All elementary education students at the University of Michigan-Dearborn are required to complete 18 credits in science content and methods. This unique program was driven in part by the definition of "reformed pedagogy" described in the RTOP. As a group of physics, chemistry, biology, and science education faculty jointly constructed and taught three new science content courses using a guided inquiry approach, they were trained in the use of RTOP. RTOP training gave faculty a common language and tool to use when evaluating their curriculum and pedagogy. Methods faculty use RTOP with their students to analyze science teachers and to evaluate the impact of the reformed science education program on our students' instructional practices once they are in their own classrooms. This work would not have been possible without the continuing close collaboration between natural sciences and science education faculty.

Session: RTOP Implementation to Improve Teaching & Learning
Using RTOP to Assess Interactive Engagement in Two Widely Disparate Classroom Environments
Cathy M. Ezrailson
In this study, the RTOP was used to assess instructor attitudes about interactive engagement pre and post their teaching. Participants were drawn from two disciplines with widely different classroom environments. These included: 1) pre-service elementary teachers in an elementary instructional setting and 2) physics graduate teaching assistants teaching freshman physics. The instructors were trained on the RTOP instrument before stepping into their teaching assignments and given subsequent weekly instruction in Socratic questioning, cognitive apprenticeship techniques, cooperative group dynamics and context-rich activity design. Differences between the two populations were examined as well as synthesis of common issues. Changing attitudes toward teaching and adherence to method were among factors examined. An ongoing study of a new population of graduate students teaching a common interdisciplinary course from across many disciplines will supply new data to be compared with the results of this study in order to test the validity of the conclusions further.

Session: Scientific Reasoning/Discourse in the Laboratory
Habits of Mind: Learning to Reason Like a Scientist
Maria R. Ruibal-Villasenor
The Rutgers PAER group has designed and implemented a sequence of laboratory investigations for introductory physics. These laboratories are neither exercises nor illustrations or confirmations of lecture teachings, but their goal is to help students become acquainted with the processes of science by mirroring physicists' work: students make observations of phenomena, record data, find patterns, hypothesize mechanistic explanations to account for those patterns, test their hypotheses, and apply the newly acquired knowledge to solve experimental problems. The writes-ups provide scaffolding for completing the tasks but they do not outline experimental procedures; students need to design their own investigations. In this talk we will describe a qualitative video study that investigates the patterns in students' reasoning in these labs. We will

also describe the different approaches adopted by these students and students in traditional laboratories when they face an experimental problem in an area of physics that they have not studied.

Session: Scientific Reasoning/Discourse in the Laboratory
Inquiry-Based Versus Traditional
Patricia E. Palko
How much does the mode of laboratory instruction matter for undergraduate non-major physics students? The results of a recent study comparing student performance on classroom materials, questions about the nature of science, and standardized tests after completing one or two quarters of inquiry-based or traditional "cookbook" laboratory exercises will be presented.

Session: Scientific Reasoning/Discourse in the Laboratory
Proportional Reasoning Test: An Instrument to Assess Instructional Strategies
Cheryl P. Schaefer
The Proportional Reasoning Test was developed to have a way to evaluate student reasoning prior to instruction and to evaluate the efficacy of instructional strategies in improving student ability to reason with rates and ratios. This session will share the test in final form and will promote distribution of the test for general use.

Session: Scientific Reasoning/Discourse in the Laboratory
Simple Experiments to Help Students Understand Magnetic Phenomena
David P. Jackson

Session: Statistical and Thermal Physics in the Undergraduate Curriculum
Energy and Entropy: A Paradigms-in-Physics Approach to Thermodynamics
Michael Rogers
Oregon State University's Paradigms in Physics is a revisioning of the junior-level curriculum where nine, 3-week-long courses offered in series focus on unifying themes. The Energy and Entropy paradigm approaches thermodynamics using a quantum mechanical perspective. With its internally consistent unification of statistics with microscopic mechanics, quantum mechanics offers thermodynamics based on quantum averages and quantum probabilities. But thermodynamic systems are not the isolated quantum systems found in QM courses. Interactions of thermodynamic systems with the "outside" has enormous consequences with thermal variables now understood as macroscopic quantum averages and thermal probabilities as macroscopic quantum probabilities with an entropy postulate playing the crucial role of matchmaker in this marriage. This approach gives rise to an overarching philosophy and a clear pedagogical path that allows thermodynamic methods to resemble the epigrammatic laws of "real physics." Adapting this approach to a traditional, semester-long thermodynamics course at Ithaca College will be discussed.

Session: Statistical and Thermal Physics in the Undergraduate Curriculum
Research on Learning and Teaching of Thermal and Statistical Physics
John R. Thompson
Over the past several years, physics education researchers have begun to investigate student learning at the upper division, including the topics of statistical and thermal physics. A small but growing body of research presents clear evidence that university students, at both the introductory and advanced levels, display a number of difficulties in learning many thermal physics concepts. Work to date has largely focused on the First and Second Laws and the

associated concepts (work, heat, entropy, etc.). Some investigations further probe connections between physics and relevant mathematics concepts in these areas (integrals of state functions and process variables, partial derivatives, probability). Results point to difficulties among advanced students incorporating mathematics and physics into a coherent framework.

Session: Statistical and Thermal Physics in the Undergraduate Curriculum
Teaching Statistical Physics by Thinking about Algorithms
Jan Tobochnik
A discussion of algorithms and models can provide concrete examples of abstract ideas in physics. We illustrate some ways of illustrating important concepts in statistical and thermal physics by considering various algorithms and models. In many cases it is sufficient to discuss only the results of an algorithm or the behavior of a model rather than actually coding or even running a program.

Session: Teaching Physics Around the World
Average Learning Gains: The Effect of Instructor Implementation
Genaro Zavala
Our department has more than 2,000 students in four introductory physics courses each semester. Since our sections have a maximum of 36 students, there are a large number of sections each semester and a large number of instructors are needed. Instructors are either faculty members or part-time instructors. We started implementing Tutorials in Introductory Physics from the University of Washington in a large scale in the fall of 2004. It has been three years after our initial implementation and still the variability of average learning gains of sections is very large. A characterization of the way instructors implement tutorials in their own classrooms was done in one of the courses, Physics 3. Results show that a great deal of the variability is due to instructor implementation.

Session: Teaching Physics Around the World
Helping Students Think Critically During Problem Solving
Josip Slisko
Problem solving is commonly used in physics teaching both as an appropriate context for learning physical concepts and laws and as an instrument for easy evaluation of the learning results. Improvement in problem-solving skills is usually sought by making students practice explicitly expert-like steps: problem comprehension, conceptual and mathematical modeling of the problem situation, solution plan and its execution and evaluation of solution.
Although the last step should be an excellent opportunity for critical thinking, traditional problem design, codified in many physics textbooks, doesn't promote it adequately. In this talk, I show by a few examples how some slight changes in problem design might help students think more deeply about what they should calculate and evaluate more critically the results of their calculations."

Session: Teaching Physics Around the World
Impact of Student Major on their Achievement in Introductory Physics
Tetyana Antimirova
Most of the Canadian universities teach introductory physics to three different program streams: physical science, life science and engineers. However, at Ryerson University, in order to allow students to switch between programs after the first year, all of the science students are required to take common introductory science courses. Therefore students in all science programs have a common first-year physics course. Moreover, as a sizeable part of the class are students who did

not declare their intentions upon entering the university, the impact of an introductory physics course on them can be even more significant. The current study investigates whether student achievement and attitudes toward physics correlate with their major and with their decision to switch programs or to stick with their original choice. We will also discuss how the results of the study can be used to improve future introductory physics curriculum design and implementation.

Session: Teaching Physics Around the World
Physics for All: A Chinese Model
Ling L .Liang
Each year, the science, technology, and engineering fields in higher education institutions in China successfully attract a large number of high school students who excel in the disciplines of mathematics and sciences. The *physics education for all* requirement in Chinese schools may partially account for such success. In this presentation, I will explain what and how physics education is provided to all secondary school students in a multi-year, spiral curriculum model.

Session: Teaching Physics Around the World
Tasks That Inspire Learners in Physics
Eunsun Kim
We cannot be inspired by this solving, "3×5=3+3+3+3+3." But when we were young, we might feel satisfaction and inspiration because we can solve this problem without memorizing. When I was a middle school student, I was confused because sometimes Electric power(P) is proportional to Resistance(r) but sometimes inversely proportional to Resistance(r). I moved deeply when I solve this problem by myself—fixed value in the proportional expression. I think tasks for inspiration, whether it is easy or not, are important to students to be interested in physics. All we might have had these experiences but it is not easy to recall them. In this poster, I want to share learners' experiences. Teachers can offer tasks in these experiences to students for inspiration

Session: Teaching Physics Around the World
The Design and Effect of Laboratory Instruction Emphasized Uncertainty Analysis
Young Chang Kang
In this study, laboratory instruction emphasized uncertainty analysis for teaching uncertainty is designed and the effect of this instruction is analyzed by responses of students after laboratory instruction. Uncertainty concepts and calculation methods were previously executed, and experiments that need to consider uncertainty during quantitative analyzing was selected. After instruction, analysis of reports, online discussion, and a questionnaire were executed to analyze the effect of this instruction. And an effective instruction program for uncertainty was presented.

Session: Teaching Physics Around the World
The Regularities of Physics Development
Genrikh Golin
One of the most important objectives of teaching physics is to demonstrate to the students that physics as science is not a rigid code of absolute laws, but a vivid organism liable to renewal, expansion, and corrections. This can be achieved through making the students familiar with the basic regularities of the development of physics. The regular character of the development of physics is determined by a number of factors, both external and internal with respect to physics. Among the external factors are social phenomena, the general level of culture, and the demands of technology. Among the most important internal laws in the history of physics is the alternation of "quiet" periods and revolutionary jumps. Albert Einstein named this law "a drama of ideas."

Another important law in the development of physics is the existence of applicability of scientific concepts and laws at each stage of the development. There is still another feature to be mentioned—the continuity in the development of scientific knowledge (the correspondence principle).

Session: The Use of Labs in Physics First Class
Goals for Physics First Labs
Barry H. Feierman
What makes a good Physics First (9th grade) lab? Remember that 9th graders are more likely to be concrete thinkers and have less mathematical experience compared to juniors and seniors. I will show a few examples of simple, inexpensive, creative labs that challenge 9th graders to think conceptually without overwhelming them with complex math. Apparatus will include home-made instruments to measure mass made from springs, straws, and aluminum meter sticks. This leads to a wonderful discussion contrasting mass and weight.

Session: The Use of Labs in Physics First Class
Labs in "Active Physics"
John L. Roeder
As a physics course for all high school students, but especially for ninth graders, "Active Physics" is heavily lab-based, leading students to discover fundamental relationships experimentally rather than derive them theoretically.
I shall present several examples of how this process works in my classroom.

Session: Undergraduate Student Research
Addressing Students' Difficulties in Explaining Current Conservation Experiment
Kwangmoon Shin
In this research, we address student difficulties in explaining current conservation experiment. Students carry out an experiment to find out whether current in both of two light bulbs is conserved with a simple electric circuit consisting of DC battery, galvanometer, leading wire, light bulb, and switch. Then they explain the result. However, they find that current is not equal at both sides of the light bulb and can't explain that result. In this process, we recognize many students have difficulties about error and uncertainty in measurement. We investigate students' difficulties by analyzing questionnaires and their experiment reports. Inevitability of error, finding source of error, analyzing results with considering uncertainty frequently appeared. We make a class supporter sheet and provide it to them. After that, we find out which part is helpful and which part must be added or modified.

Session: Undergraduate Student Research
An Investigation of Mn-Ni Double Perovskites
Robert J. Booth
The discovery of materials that exhibit both ferroelectric and ferromagnetic behavior at room temperature would have a tremendous impact on technology, particularly in the area of spintronics. To this end, we have investigated double perovskites of the form R2NiMnO6 [R=Y, Pr, Nd, Sm, Gd, Tb, Dy, Ho]. We studied the magnetization and electron paramagnetic resonance of these materials. The magnetic ordering temperature, effective magnetic moment, spin relaxation time, and the Lande g-factor were investigated. All materials were ferromagnetic. It appears that the Mn-Ni network is effectively independent of the rare earth moment: the magnetic ordering temperature appeared to be dependent only on the ionic radius of the rare earth and the effective moment remained essentially constant with ferromagnetic alignment of

the Mn and Ni moments. However, both the spin relaxation time and the g value did depend upon the rare earth, indicating that one cannot neglect the effect of spin-orbit coupling on the Mn-Ni network. This work was supported in part by NSF grant DMR0520471.

Session: Undergraduate Student Research
Analysis of Students' Difficulties in Solving Problems Related to Magnetism
Jungho Choi
The achievement in electromagnetism in college physics course is not good. Especially students seem to think that magnetism is the most difficult topic. Thus in this study we tried to find the students' difficulties about the magnetism in college physics and the reason for the difficulties. We used paper-pencil tests and the semi-constructed interview. The students' difficulties and reasons were classified using the framework of knowledge and belief. These difficulties and reasons were substituted by the steps of the Wessels problem-solving model, which is a basic model in psychology. Our study showed that the main source of students' difficulties were concept understanding and thinking power.

Session: Undergraduate Student Research
CDMS Veto Stability Study and Calibration
Gabriel A. Caceres
Most experiments searching for dark matter particles have been led deep underground to minimize the background produced by cosmic rays. The Cryogenic Dark Matter Search (CDMS) lies ½ mile underground in the Soudan Mine in Minnesota. Even though the muon rate is lowered by a factor of ~10^5, the rate is still high enough to produce background signals. To solve this problem, scintillator panels have been placed around the detector to veto cosmic induced events. This work studies the behavior over time of the scintillator veto panels. By analyzing and tracking the response to a LED pulser system, the stability was determined to be within 3%. The absolute energy scale of the spectrum was then calibrated using radioactive sources, as well as the muon distribution. Knowing the absolute energy scale and where the veto trigger threshold lies provides useful information for calculating the amount of background that can be rejected.

Session: Undergraduate Student Research
Detection of One-Bead-One-Compound (OBOC) Combinatorial Library Using Oblique-Incidence Reflectivity Difference (OI-RD) Microscopy
Jamy B. Moreno
The utilization of an Oblique-Incidence Reflectivity Difference (OI-RD) microscope to investigate a One-Bead-One-Compound (OBOC) combinatorial chemical library is described. A 6,000 random sample molecule library was previously prepared for proof-of-principle experiments. This paper describes the initial results of these experiments.

Session: Undergraduate Student Research
Properties of LINERs
Diana M. Marcu
With the recent discovery that virtually all local galaxies harbor massive nuclear black holes, there is now convincing evidence that active galactic nuclei (AGN)—galaxies containing accreting supermassive black holes—and normal galaxies in our local universe are fundamentally connected. However, the nature of this connection and the detailed evolutionary history connecting these objects is unknown. Low Ionization Nuclear Emission Line Regions (LINERs), defined by their narrow optical emission lines of low ionization uncharacteristic of

photoionization by normal stars, may constitute a vital piece of this puzzle, possibly representing the “missing link” between the powerful quintessential AGN in the universe and galaxies such as our own.
Despite several decades of intense research, there are still open questions, including: what fraction of LINERs are truly AGN, what are their accretion properties, and how do these quantities relate to the properties of the host galaxy? In this talk, I will summarize recent results from our ongoing infrared spectroscopic investigation of LINERs using data from the Spitzer Space Telescope."

Session: Undergraduate Student Research
Synthesis of V2AlC for Fundamental Electronic Transport Measurements
Patrick E. Hann
We present a technique for synthesis of vanadium carbide (VC) and vanadium aluminum carbide (V2AlC) films using multi-target sputter co-deposition. V2AlC belongs to a class of materials that may be described as nanolaminates and are given the name MAX-phases because of their general chemical formula Mn+1AXn, where M is an early transition metal, A is an A-group element and X is either C or N. In spite of their anisotropic structure, the electrical properties of these materials have been found to be surprisingly isotropic. It is of interest to synthesize single crystals, epitaxial or highly textured films of several MAX-phase materials to study the anisotropy to determine if these properties are universal. We have found that V2AlC can be synthesized with VC seed layers or directly on Al203 substrates. We will also report comparisons between electrical transport measurements made on the oriented films and bulk polycrystalline samples.

Session: Undergraduate Student Research
The Double Cone Project of SPS@UCF
Kevin H. Thomas
The double cone ascending an inclined v-rail is a common exhibit used for demonstrating concepts related to center of mass in introductory physics courses. One student of SPS@UCF recently delved into the physics behind this demonstration, and made unexpected predictions for its motion. A group of SPS students have been constructing double-cone/v-rail systems at different scales as well as variations of the system to explore its physics (and have some fun).This talk will briefly review the physics of the system and summarize the efforts of the students at UCF. Hopefully, this will inspire other SPS chapters to initiate similar projects.
References:
1. PIRA demonstration 1J11.50. See http://www.physics.ncsu.edu/pira/.
2. S. Gandhi and C. Efthimiou, The Ascending Double Cone: A Closer Look at a Familiar Demonstration, European Journal of Physics 26 (2005) 681."

Session: Undergraduate Student Research
The Society of Physics Students Summer Internship Program
Meagan A. Saldua
The Society of Physics Students (SPS) National Office provides internships to undergraduate physics students from around the nation. The focus of these internships ranges from advanced research to outreach programs, including positions with the SPS National Office, the APS, the AAPT, NASA or NIST. I will present my “D.C.” experience as a first-time intern and my work at the American Center for Physics in College Park, MD. My position with the APS was in the PhysicsQuest program, where I focused on developing educational kits for middle school

classrooms. These kits are made available to teachers at no charge to provide resources and positive experiences in physics for students. The impact of the internship program as well as the theme and experiments of this year's PhysicsQuest kits will be detailed.

Session: Undergraduate Student Research
Toward the Investigation of Magnetic Vortex Dynamics in Layered Superconductors
Juan C. Roche
The dynamics of two-dimensional (2D) vortices in superconductors has been investigated over the past two decades. These investigations have focused on the extreme cases of weak pinning resulting from dilute native defects and very strong pinning resulting from extended columnar defects. The potentially large-scale applicable situation of strongly pinned superconducting layers with defects uncorrelated between layers has not been investigated. The work currently presented has the long-term goal of investigating this physical situation. Niobium nitride (NbN) is a superconducting material with strong native pinning. Adjacent layers of superconducting NbN will be coupled through varying thicknesses of aluminum nitride (AlN). We will adjust the AlN thickness from strongly coupled (~10Å), through Josephson coupled (10-40 Å) and decoupled (>40 Å). We have synthesized NbN and AlN films that are highly textured. Using this process, we will synthesize multilayers of NbN/AlN with varying AlN thicknesses. Initial electrical transport results will be presented.

Session: Undergraduate Student Research
Ultrasonic Technique for Measuring the Viscoelastic Properties of Magnetorheological Fluids
Jenna Smith
Magnetorheological fluids are composed of a suspension of very fine magnetic domains suspended in a carrier fluid. The domains in a magnetorheological fluid align themselves along the magnetic field, which affects the viscoelastic properties of the fluid. The goal of this project was to develop an ultrasonic measurement system that could measure the viscosity and shear stiffness of magnetorheological fluid in varying magnetic fields. To do this, we placed a 5 MHz AT-cut quartz crystal transducer in contact with the fluid and measured the change in the ultrasonic reflection coefficient at the transducer-fluid interface. Preliminary results show that the viscosity and shear stiffness change significantly when the magnetic field is parallel to the direction of propagation of a shear wave.

Session: Undergraduate Student Research
Using Microwaves to Determine Properties of Skin
Elizabeth Dowdell
We have investigated the use of microwaves to study properties of skin tissue. Samples of tissue were probed using a coaxial microwave resonator cavity with an exposed center conductor that operated at frequencies between 0.9 and 4 GHz. Measurements on several different materials indicate that the instrument is sensitive to a thickness of approximately 0.5 mm. This concentration of the microwaves ensures that the resonance frequencies indicate properties of the skin itself and are not significantly affected by underlying tissues. Subsequently, we have studied the change in resonant frequency with applied force on the tissue samples. In general there is a large change in the resonant frequency which shows hysteretic behavior once the force reaches above a particular threshold. We discuss these results in terms of water content and elastic membranes.

Session: Undergraduate Student Research (Poster)
An Undergraduate Experiment to Investigate Cantilever Beam Resonant Frequencies

Michael G. Hvasta
Physical applications of cantilever beams are observed in diving boards, airplane wings, tennis rackets and atomic force microscopes. In a new experiment designed to be suitable for a wide range of undergraduate students, we analyze the motion of cantilever beams at resonant frequencies for a variety of beam lengths. The experiment includes investigations of the “free-end” cantilever beam in addition to the case in which a mass is added to the free-end. This experiment uniquely demonstrates harmonic vibrational motion with a nonsinusoidal spatial profile. Excellent agreement between theoretical predictions and measured values is found and resonance curves (amplitude versus frequency) for both systems are presented.

Session: Undergraduate Student Research (Poster)
Applications of the Fourier Transform to Modern Physics
Brian Knorr
The purpose of this work was to investigate the use and properties of the Fourier Transform (FT) for several modern physics applications such as wave packets in Quantum Mechanics (QM), signal processing in nuclear magnetic resonance (NMR), and image reconstruction in magnetic resonance imaging (MRI). We created an undergraduate research/laboratory manual that includes an explanation of the fundamental principles, programming applications in IDL logic software, and visual examples of simulated image artifacts in MRI. This manual should serve as a starting point for the undergraduate student who decides to undertake research projects in the field of MRI. We focused in particular on the “mysterious” k-space in MRI and its applications. All programs are available online at http://physics.ramapo.edu/~nmrprograms. A sample set of data which represents an MRI of a brain slice is also given on this directory and is called ksp340_390.

Session: Undergraduate Student Research (Poster)
High Temperature Resistivity Changes in the Thin Films of Manganese Oxide
Khim B. Karki
Doped rare-earth perovskite-type manganese oxides R(
SUBSCRIPT 1-x)A(SUBSCIPT x)MnO(SUBSCRIPT 3)(R being a trivalent rare earth and A being a divalent alkaline-earth ion) exhibit wide variety of physical phenomena. External stimuli can induce magnetic, structural, and electronic transitions in these materials, which makes them attractive in the device applications. Behavior of these materials in thin film form often differs from bulk. Oxygen content is very robust in the bulk materials, but this is not always the case in the thin films. We report on electrical resistivity at high temperatures (from 290 K to 900 K) of Bi(SUBSCIPT 1-x)(Ca,Sr)(SUBSCIPT x)MnO(SUBSCIPT 3) thin films grown by Pulse Laser Deposition on different substrates. We have found a considerable increase of resistance at higher temperatures, presumably associated with the loss of oxygen. Influence of different substrates, annealing gases, and material of the electrical contacts on the temperature dependence of resistivity will be discussed. This research may lead to potential device applications of these materials.

Session: Undergraduate Student Research (Poster)
Learning Science Through Modeling and Simulation: A TELS Case Study
Katherine M. Linton
The Technology Enhanced Learning of Science (TELS) Center has designed a number of inquiry based online curriculum modules for secondary science classrooms. These modules emphasize making students' thinking visible, promote autonomous learning, foster peer interactions around content, and have built-in supports for teacher assessment of student work. In this poster we

present the pathway designed at CNU for future teachers to become involved in this kind of research—working closely with middle and high school teachers and students to investigate how their learning expands within the TELS environment. One of us (Buzan) is also completing an undergraduate capstone research project based around TELS. Data on project runs in a middle school physical science class and a high school physics class will be presented.

Session: Undergraduate Student Research (Poster)
Low Temperature Study of Mechanically Alloyed EuFeO3
Suman Khatiwada
Rare-earth (R) and transition metal (T) perovskite Oxides RTO3 are of interest since they have shown promise for application in a variety of probes, devices, and exhibit interesting Physics. In this work EuFeO3 synthesized by mechanical alloying is investigated using Mössbauer measurements. EuFeO3 is one of the rare cases where both the R and the T sites can be probed in the same compound using Mössbauer spectroscopy. Mössbauer measurements indicate that the hyperfine magnetic field increased with decreasing temperature. The 57Fe Mössbauer spectra depicts that there is only a magnetic sextet at 20K implying pure ferromagnetic state. The 151Eu Mössbauer measurements show that the line width at half maxima has a peak between 50K and 100K. The increase in line width at low temperature is not enough to suggest magnetic splitting in the spectrum at low temperature.

Session: Undergraduate Student Research (Poster)
Synthesis of Porous Silicon by a Noncontact Method
Kristin E. Peterson
The goal of this work was to produce porous silicon (p-Si) thin films on n-type and p-type crystalline Si substrates with various dopant types by using a light-induced hydrofluoric acid (HF) synthesis technique. The expanded beam of a He-Ne laser was used to produce a localized electric field on bulk crystalline silicon while the sample was immersed in hydro-fluoric acid for varying amounts of time. Samples were analyzed by photoluminescence spectroscopy to check for visible emission which is characteristic of p-Si. In addition, pore size was estimated by examining SEM micrographs, which indicate pore wall thicknesses on the order of one micron, with a typical pore size of two microns or less. The physical structure and size of the porous regions were found to vary with the concentration and dopant type of the crystalline Si wafer. In contrast to previous published reports, only the side of the sample illuminated with the He-Ne beam during HF synthesis was found to produce the porous thin film.

Session: Undergraduate Student Research (Poster)
The Angelo State University Peer Pressure Team: West Texas Road Trip 2007
Toni D. Sauncy
The Angelo State University Society of Physics Students (SPS) local chapter has a strong history of science outreach activities, driven by the ideal that service is an important part of life for responsible scientists. Since the first road show in 2003, SPS students have continued visiting middle and high school students in local schools and throughout the region. A 2005 World Year of Physics grant and subsequent local funding allows for longer trips to school districts where geographic isolation has a major impact on resources for science classrooms. This year's annual week-long trip took the team of eight undergraduate students and one faculty member to five school districts, where they performed 12 shows and interacted with more than 1,500 middle school students. SPS outreach programs are a critical part of our undergraduate program, but are equally important in bringing the excitement of discovery-based science to budding young scientists.

Session: Undergraduate Student Research (Poster)
The investigation of blast mitigating materials for aircraft hardening
Jennifer E. Thompson
The purpose of this study is to investigate blast mitigating materials to protect an aircraft during an onboard explosion.
Several protective materials were tested. The protective layers were mounted to the vertical frames of a test panel replicating the internal structure of an aircraft. The completed panels were then clamped to a vacuum tank and a charge of C-4 was detonated at a pre-determined standoff distance.
Two combinations were successful: a sheet of aluminum 2024-T3 coated on one side with a thermoplastic elastomer, and a fiber-metal laminate backed with a Kevlar reinforced elastomer. The aluminum and the fiber-metal laminate were by themselves ineffective in preventing panel rupture, indicating that a stiff layer coupled with an elastic backing allows the protective panel to fracture while preventing rupture of the fuselage skin.

Session: Undergraduate Student Research (Poster)
Undergraduate Research and Outreach Activities in Physics at Hampton University
Claudia M. Rankins
The Department of Physics at Hampton University offers a number of exciting and unique research opportunities for undergraduate students, as well as outreach programs for students ranging from K-12 age. This poster will showcase the research of our undergraduates, all of whom are required to participate in research, culminating in a senior thesis. Additionally it will feature research conducted by undergraduate students participating in the Undergraduate Institute for Physics—Research Experiences for Undergraduates (UnIPhy—REU) and the CUSP—COSM (Center for the Study of the Origin and Structure of Matter) Undergraduate Summer Program. We will discuss our numerous K-12 outreach programs, which have established a pipeline for the next generation of physics undergraduate students.

Session: Upper Level Labs for the Biosciences
Optical Trapping for Biological Instrumentation Teaching Laboratories
David C. Appleyard
Optical trapping has become a powerful tool for probing the biomechanics of single molecules and cellular structures as well as examining basic tenets of physics and statistical mechanics. Bringing optical trapping technology to the classroom offers exceptional hands-on exposure to advanced instrumentation and biological assays. The simple, inexpensive, and open layout maintains functionality for a wide variety of experiments while offering position detection, computer-controlled stage movement, and fluorescence imaging. Laboratory modules have been developed designed to expose students to a range of measurements from basic optical trapping operation to single molecule force spectroscopy. A calibration experiment serves to introduce trapping theory and examine characterization of stiffness through equipartition, Stokes drag, and roll off measurements. A second assay examines the rotation speed and stall torque of E.coli. The third assay measures the force-extension relationship of dsDNA to extract persistence and contour lengths.

Session: Upper Level Labs for the Biosciences
Photodynamic Therapy: Capping Off a Year of Integrated Laboratories
William Ryu

A new series of laboratories and introductory courses for science majors have been recently developed at Princeton University. The freshman course presents a broadly integrated, mathematically and computationally sophisticated introduction to physics and chemistry, drawing on examples from biological systems. I will present, in detail, a three-week laboratory on the synthesis and use of Erythrosin B as a photodynamic therapy agent applied to yeast and bacteria. This final laboratory makes many connections to previous laboratories in the series and I will highlight these connections. I will describe how the use of a "core" set of laboratory equipment, protocols, and computational tools, has made many of these connections possible and have given the students who use these techniques with increasing sophistication throughout the year, the independence and confidence necessary to tackle the final Photodynamic therapy laboratory.

Session: Using Remote Telescopes
A Life Changing Experience: Astronomy Remote Observing
Mimi Hang
Teachers have the ability to change students' lives and their future to a great extent. I know this for a fact when my 9th-grade biology teacher introduced me to the world of astronomy and telescopes. With the Faulkes Telescope, I was able to take images of the sky and learn so much about celestial bodies without ever having to visit them. After attending the 2005 Faulkes Telescope/Deep Impact Workshop in Maui, I completed and entered my Comet Tempel 1 project in the 2006 Hawaii State Science Fair. I will share what I did with you. Ever since then, astronomy has become my great passion. I want to convince teachers to give students opportunities to use robotic telescopes for astronomy projects because the experience my teacher gave me changed my life forever.

Session: Using Remote Telescopes
HI STAR: Hawaii Student Teacher Astronomy Research
Mary Ann Kadooka
Can middle and high school students learn astronomy research skills and a few basics about solar system bodies, stars and galaxies in a week? Yes, they can, as evidenced by the results of our 2007 HI STAR one-week summer program designed to encourage students to work on research projects after this experience. Armed with some background reading and a passion for astronomy, the 19 motivated students wanted more hours, lectures, and time to devote to learning. Students did image processing using astrometry and photometry software in preparation for working in groups on variable stars, asteroid, or galaxy projects. They found it exciting to do remote observing in real time with the 2-meter Faulkes and the 0.4-meter DeKalb Observatory telescopes. Highlights of the program and student selection process will be discussed, as well as pre-test and post-test results.

Session: Using Remote Telescopes
Remote Telescopes for Engaging Students in Real Research Experiences
Kirk D. Borne
We will describe plans for the LSST (Large Synoptic Sky Survey), an enormous project that will image the entire visible sky every three nights repeatedly for 10 years. This "cosmic cinematography" will enable the discovery and recovery of tens of thousands of astronomical events every night. These events include moving objects (e.g., asteroids) and optical transients (e.g., supernovae, quasars, variable stars of all kinds). The challenge will be for the world community to follow-up on these hundreds of millions of events (over the 10-year lifetime of LSST). A worldwide distributed network of robotic telescopes will enable classroom and citizen

scientist participation in the research and characterization of the LSST bonanza of astronomical events. We will describe some of the plans by the LSST education and outreach team for bridging the gap from the LSST database to the Robotic telescopes, to engage students in real research experiences.

Session: Using Remote Telescopes
Utilizing Current Windows(tm) Programs for Remote Telescope Observing and Control
Donn R. Starkey
With the explosive growth in the number of amateur-based CCD cameras attached to modest aperture telescopes, the potential exists for interfacing this equipment with elementary and HS students via the Internet. Because this equipment utilizes an Internet interface, the process is not hampered by geography. We detail the successful integration of CCD camera equipment in an amateur-owned observatory with the curriculum of high school students at a distance of 6 time zones. Students control the camera and view the results in real-time. The Internet interface between the equipment and the students is accomplished using off-the-shelf software that is typically bundled at no additional cost with current Microsoft Windows-based computers. The use of this technology allows receptive amateur astronomers to offer the use of their facilities to remote high school classrooms. This provides an additional tool to help instructors inspire students in the fields of math and physics.

Session: Women in Science Policy
Perspectives on Science and Federal Policy
Jane A. Alexander
This talk will focus on the changing role of science in federal public policy making. I will also discuss trends in federal policies concerning research and development funding. I will present examples for my over 19-year career serving in the federal government, from Congressional aide to senior manager in federal R&D funding agencies including DARPA, ONR, and the Department of Homeland Security.

Session: Women in Science Policy
Scary Things That Don't Exist: The Costs of Bad Science Policy to the Pentagon
Sharon Weinberger
Everything is possible, but not all things are equally possible. In recent years, U.S. national security institutions have been forced to change how they think about future threats to U.S. security—and how to counter those threats. Faced with the possibility that terrorist groups or rogue states could “surprise” the United States with new weapons or tactics, the U.S. government must ensure that it possesses the most advanced technology to counter future threats and stay ahead of its adversaries. Yet are judgments about possible threats being made on the basis of sound scientific and technical advice? And is the Pentagon making reasoned decisions about its investments in science and technology? After years of decline, there is again a resurgent interest in the need for sound scientific advice to the government. A recent proposal to revive the Office of Technology Assessment may have foundered, but Congress is again awakening to the need for scientific expertise. A host of scientific and technical dilemmas—from radiation detection to protect U.S. ports to the threat of new weapons of mass destruction—challenge our national security institutions. This talk will examine the costs and threats of bad science to the Pentagon and other national security agencies, spanning mainstream issues like technology for homeland security and WMD, to more bizarre concepts for weapons that violate the laws of physics.

Session: Women in Science Policy

What the Heck is Science Policy and Who Really Does It?
Amy K. Flatten
The objective of this discussion is to provide insights regarding careers in science policy—how a scientific graduate degree can lead to a opportunities beyond the laboratory, combining scientific expertise with diverse interests such as business, international affairs and national security. The topics covered will include: 1) an overview of the U.S. Government bodies and other stakeholders involved in science policy development; 2) case studies to exemplify the

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Unassigned Papers and Posters

2001 A Space Odyssey: Whose Gravity Is It Anyway?
Robert Schwartz
By observing and making measurement estimates from the space station scene in the movie *2001 A Space Odyssey*, a value for the simulated g value in the station can be determined. What value might be desired in such a space station? Also the simulated g value in the spaceship Discovery will be discussed.

An Experience Teaching and Assessing an Undergraduate Level Course in Biophysics
Mitra Feizabadi
The importance of including concepts, examples, and techniques from mathematics and the physical and information sciences in biology courses to fulfill the need of today's undergraduate biology students has been the principle motivation for developing interdisciplinary biology-focused courses. Although this movement started many years ago, developing and offering courses like biophysics is still new in many liberal arts colleges. Taking advantage of the experiences gained by introducing an interdisciplinary course, biophysics, this work was developed to present the adapted structure, course assessment, challenges met and factors which can be useful to further develop such a course in order to heighten students' retention of the material.

Analyzing Student Difficulties with Longitudinal Standing Wave Concepts
Jack A. Dostal
In prior work, I reported on student difficulties with longitudinal standing wave concepts, specifically with respect to sound waves in air columns. Instructors commonly teach transverse standing waves first, and then treat longitudinal standing waves as an extension. Consequently, students often have little conceptual understanding of the underlying physical processes present in longitudinal standing waves, relying largely on pattern-matching and analogy (both appropriate and inappropriate) to answer questions. This investigation led to the creation of the Standing Wave Diagnostic Test (SWDT) to identify some of those difficulties, and a Longitudinal Standing Waves tutorial (LSW) to address these concepts in the classroom. In this poster I will describe the two instruments mentioned above, report student performance on the SWDT in algebra-based introductory physics courses, and discuss the differences between classes using the LSW tutorial and those that did not.

Are Introductory Physics Students Better Prepared for Kinematics and Dynamics?
Jeff Marx
Every fall term since 2001, we have been administering Interactive Lecture Demonstrations (ILDs) to our first-semester, calculus-based General Physics class. As part of each ILD sequence,

students are asked to make a “prediction” regarding the outcome of a demonstration. Students then share their predictions with their classmates who are sitting near them, and, possibly, update their predictions as a result of their discussion. We collect these Prediction Sheets (on which the students have signed their names) at the end of the class, or if they are part of a bound volume, at the end of the term. In this presentation, we will put forward our results and analysis of shifts in students’ predictions related to the Kinematics and Dynamics ILDs over the last several years.

Assessing Conceptual Knowledge and Problem-Solving Skills in Basic Electromagnetics Course
Ari H. Sihvola
Basic electromagnetic field theory forms a part of the core of engineering education in the Electrical Engineering department of the Helsinki University of Technology, Finland. Particularly abstract concepts, heavy mathematics as well as difficulties of visualizing electric and magnetic fields, compel the teacher to constantly revise his/her education methods and strategies. In our Fall term (2007) courses (see http://www.tkk.fi/Yksikot/Sahkomagnetiikka/kurssit/S-96.1111/) the Conceptual Survey in Electricity and Magnetism (CSEM) was applied in addition to classical problem-solving based exams to assess student performance. In this talk, we will share the experiences and results of how the two learning outcomes (the understanding of physical concepts and the ability to solve problems) possible correlate.

ATE Program for Physics Faculty: Year Two
Thomas L. O'Kuma
This poster will report on all the various activities of the Project. A section of the poster will be devoted to the New Faculty Training Conference for Two-Year College Faculty to be held March 6-8, 2008 at Delta College, University Center, MI. Another section of the poster will be on the follow-up activities done by the participants as part of the Project. Results from year one of the multi-year project will be exhibited.

Bringing Inquiry to the Pre-College Classroom Through Research-Based Professional Development*
Donna L. Messina
The Physics Education Group at the University of Washington conducts an intensive six-week Summer Institute for K-12 teachers. Physics by Inquiry1, a research-based curriculum, is used in providing an opportunity for teachers to develop a deep understanding of topics relevant to the K-12 curriculum and to experience the impact of inquiry on their own learning. Additionally, the pedagogical approach used in the Summer Institute serves as a model teachers can use for their own teaching practice. During an Academic-year Continuation Course, these teachers continue to work collaboratively with other teachers and members of the Physics Education Group in trying to implement inquiry teaching and learning in K-12 classrooms. Pre- and post-test results and RTOP scores will be presented that illustrate the effects of the Summer Institute and Continuation Course on K-12 teachers’ content understanding and classroom practice and on student achievement.

Case Studies in Developing Activities with a Data-Rich Online Resource
Jordan Raddick
Over the past several years, the SkyServer website of the Sloan Digital Sky Survey has offered access to a complete scientific dataset of more than 200 million stars and galaxies. Students can browse through the data to view individual objects, and can search through the data for objects that meet their criteria. There are a number of projects available on the site that use the data to

teach concepts from astronomy and physics, but there are also many activities that were designed by teachers for their own courses. I will talk about, and provide copies of, both types of activities from the site. I will also show tools and guidelines for instructors to develop their own activities from the materials on the site.

Challenges Faced by First-Time Users of an Inquiry Science Curriculum
Cody Sandifer
The purpose of this study was to document the expected and actual challenges faced by three part-time instructors as they taught the Physical Science and Everyday Thinking curriculum for undergraduate elementary education majors for the first time. Data included interviews, email communications, classroom RTOP observations, and audiorecordings of instructor mentoring sessions. Pre-interviews indicated that the instructors expected challenges involving the use of technology and student participation. In addition, prior to the start of the course, instructor communications indicated that certain instructors had intended to apply traditional lecture-based teaching strategies to the PSET curriculum because they were unaware that such strategies were contrary to the curriculum's underlying purpose and philosophy. Classroom observations, mentoring sessions, and post-interviews revealed that the instructors faced teaching challenges in many different areas, including groupwork, discussions, and the role of the teacher in inquiry. Some of these challenges were expected, whereas others were not.

Challenges of Adopting Physics by Inquiry
Homeyra R. Sadaghiani
Teaching by inquiry, a pedagogical method in which students are guided through investigations to “discover” concepts, is among the most preferred instructional methods in teacher-prep programs. Implementations of such a method require a certain degree of alterations and adaptations. This talk describes issues related to adopting Physics by Inquiry in a course for pre-service teachers (at Cal Poly Pomona), the challenges that arose, and the difficulties that were encountered.

CLUSTER: A Museum-College Partnership for Teacher Preparation
Sébastien Cormier
CLUSTER (The Collaboration for Leadership in Urban Science Teaching, Evaluation, and Research) is a partnership of The City College of New York, the New York Hall of Science, and the City University of New York's Center for Advanced Study in Education. The goal of the partnership is to design a model to recruit and prepare science majors to become high school science teachers. The project integrates formal education, informal education, and education research. In this poster, we describe the model and give samples of how we are exploring participant approaches to the teaching and learning of science.

Cognitive Work Analysis: Whole-to-Part and Concrete-to-Abstract
Mark Rothmayer
We have developed a new conceptual research tool where we could potentially map the step-by-step flow of problem-solving strategies among experts and novices. This model is derived from the theory of cognitive work analysis, is grounded in ecological psychology, and as far as we know it has never been applied to a knowledge domain like physics. We have collected survey data from 140 undergraduates enrolled in an algebra-based introductory physics course at Miami University as part of a larger study aimed to test the validity of the model. The survey asks students to rank aspects of mechanics from whole to part and from most concrete to most abstract. These data will be presented and discussed.

Combating Bad Science—Ethical Considerations
John L. Hubisz
We simply cannot allow bad science to go unchallenged. As teachers we are obligated to respond to all media promoting pseudoscience as legitimate science. Some suggestions for accomplishing this will be presented including ideas for a resource library that can be accessed by teachers and journalists.

Cosmic Calibrations: Summer Research with the QuarkNet Muon Detector
Andrea J. Geyer
This paper will outline our work in the Teacher's Institute for Research in Physics (TIRP) program at Hampton University during the summer of 2007. The purpose of our work was to calibrate a cosmic ray detector to optimize its performance. Our research included the evaluation and comparison of several different calibration techniques. Our work focused on selecting an optimum threshold and operating voltage for the detector. Once the optimum settings were selected new performance studies were done with excellent results. The detector will be used in future cosmic ray studies by teachers in the quark net program.

Cosmic Rays and Aerogel Performance: Cherenkov Detector
Brian L. Meechan
This paper will discuss my work in the Teachers Institute for Research in Physics (TIRP) program at Jefferson Lab in the summer of 2007. The purpose of my work is to test the performance of a Cherenkov detector using cosmic rays. The detector was and will be again part of particle identification system. Basic work is to take various data and find the characteristics through the analysis over the collected data. The end result is to expose students to current practices of research physics.

Covariation Framework in Higher Dimensions: Proficiency in The Function Concept
Adam S. Thompson
Studies show that students' struggles with the concept of a mathematical function (the ability to coordinate changes in two functionally related variables) often prevents them from gaining a deep conceptual foundation in calculus and related sciences. Although several mathematics researchers collaborated to design a research framework (covariation framework) to allow more robust analysis, this framework was not extended beyond scalar functions of scalar variables. This talk will introduce a possible extension to the covariation framework that generalizes it to vector functions and vector variables (e.g., position, velocity, acceleration; gravitational and electric potentials; electric and magnetic fields; etc.). Questions will be addressed, such as "How can this framework be used to diagnose proficiency of physics students?," "What benefit will such a diagnostic bring to my classroom?," and "How can this framework be used to guide curriculum?" Results of a initial diagnosis will be given."

Crossed Products: Student Use and Difficulty with Right Hand Rules
Mary Bridget Kustusch
While there have been several studies in recent years that have looked at student understanding of vector mathematics, none have focused on cross products and the tools we teach to deal with them, such as the different *right hand rules*. We will present preliminary results of a pilot study focused on how students deal with cross product problems in the context of both mathematics and introductory physics. The focus will be on the choice and implementation of methods, as well as the correlation between spatial ability and performance on these types of problems.

Determining the Coefficient of Drag on Various 8 Man Rowing Shells by Means of Computerized Computational Fluid Dynamics
Joseph T. Manzo
In the sport of rowing, where races may be determined by seconds, the drag of the racing shell is of great importance. An increase or reduction in drag over the span of the typical 2-km race will significantly impact the performance of the crew. This topic has been studied theoretically in the 1960s, but has yet to be extensively researched by means of computerized computational fluid dynamics (CFD). Since the size and shape of a rowing shell is constrained by functionality and racing regulations, the general contour of all shells is similar. The following analyzes actual racing shells used by the ERAU crew team, with the CFD program STAR CD, to obtain accurate coefficients of drag. By looking at the results, along with the subtle differences in shell design, recommendations were formed to minimize drag while preserving constraints. Afterwards, a brief look into using riblets to further reduce drag is considered. To demonstrate the results, a model incorporating the design recommendations as well as the riblets is prepared and analyzed using the same program.

Developing Heat and Temperature Diagnostic Tools for K-12 Teachers
Hunter G. Close
The Department of Physics and the School of Education at Seattle Pacific University, together with FACET Innovations, LLC, are in the third year of a five-year NSF TPC project, Improving the Effectiveness of Teacher Diagnostic Skills and Tools. We are working with school districts to use formative assessment to help teachers and pre-college students deepen their understanding of foundational topics in physical science. Part of optimizing these diagnostic tools is ensuring that they are consistent with national and state science standards and research on student learning. A strong unifying theme for these standards is transformation of energy in all processes of nature in physical, earth/space, and living systems. This approach brings the concepts of heat, temperature, and energy into a broader context than is usually explored in traditional physics instruction. We discuss some challenges in developing formative assessment tools that synthesize and respect these different perspectives.

Does Configurational Energy Have Potential?
Daniel Crowe
The phrase “configurational energy” is proposed as a preferred synonym for “potential energy.” The proposed phrase has the advantages (1) that it implies that the energy is due to the interaction between two or more objects, and (2) it does not imply that the quantity is not really energy. The history of the two phrases will be reviewed, and the further advantages and disadvantages of the proposed phrase will be discussed.

Enabling Constraints: Making Physics Competitions Meaningful Learning Experiences
Rachel F. Moll
This presentation reports on a study that investigated students’ experiences of participating in a Physics Olympics and an amusement park competition. The study was guided by the question: what structures or features of the events and its activities promote meaningful learning experiences for senior high school physics students? Drawing heavily on complexity thinking in education (Davis & Sumara, 2006) student experiences during competitions will be contemplated and in doing so characteristics of complex systems such as positive feedback loops and self organization will be identified in these contexts. Conclusions will be drawn about the possibilities for similar activities and events to create meaningful learning experiences for

physics students by tinkering with the mechanics of complexity. This study will contribute to a body of work that seeks to understand the effects of science outreach efforts such as Physics Olympics competitions.

Evaluation of Physics by Inquiry Professional Development Programs for Teachers*
Robert J. Endorf
We report on a study of the effectiveness of the Physics by Inquiry professional development programs that we have been conducting at the University of Cincinnati for K-12 teachers in Southwest Ohio. Each summer since 1996, a four-week 120-hour graduate course in Physics by Inquiry has been held for teachers in grades 5-12 and a separate two-week 60-hour course has been held for teachers in grades K-5. More than four hundred teachers have successfully completed one of these summer courses, which use the Physics by Inquiry modules developed by Lillian McDermott and the Physics Education Group at the University of Washington. Pretest and posttest data will be presented demonstrating that the programs have produced large gains in the teachers' science content knowledge, science process skills, and their preparation and ability to teach inquiry-based science lessons.

Experimenting Along with Volta: From Electrostatics to Electric Current
Robert A. Morse
Beginning as a high school teacher, Volta's invention of the electrophorus helped to clarify and advance the study of electrostatics. His later discovery of the electrochemical cell changed the study of electricity completely. Versions of Volta's experiments can help students to understand different processes of electrostatic charging, and how electrical cells combine in series and parallel. In this short workshop, we will use inexpensive equipment to carry out entertaining Voltaic experiments suitable for use from middle school through high school.

Extensions of a Standard Physics Problem for a Curious Student
Jeff Weitz
The projectile launch angle for maximum range is independent of initial velocity only for level ground. When the projectile is launched above or below the landing point the launch angle for maximum range approaches 45 degrees as the initial velocity increases. We investigated this phenomenon using spreadsheets and by studying the properties of the parabolas that describe the motion. Our work illustrates how a standard problem in introductory physics can open several lines of questioning for a creative and interested student.

Facilitating Change in STEM Education: A Research-Based Perspective on Initiating and Sustaining Change
Noah D. Finkelstein
Over the past several decades, researchers, curriculum developers and practitioners in physics education have made significant strides in producing better educational experiences for our students. How is it that we might institutionalize these new approaches, and how can we promote the spread of these effective strategies elsewhere? We present a project [1] that seeks to integrate findings on institutional change from three different research fields into a coherent framework that allows us to propose answers to the questions of sustaining and scaling educational reforms. We draw from: Disciplinary-based STEM Education Researchers (SER), who focus on change in curricula and pedagogical materials; the Faculty Development Researchers (FDR), who focus on changing faculty, and the Higher Education Researchers (HER) who evaluate the policies and structures at various organizational levels that support or impede change. The outcomes of this synthesis project will be used to identify: 1) change activities, strategies, concepts, and theories

across communities 2) common themes among disparate literatures; 3) evidence to support each change activity and strategy; and 4) promising directions for future research, theory-building, and funding. We present our approach and theoretical framework, solicit input from attendees, and share information on an associated conference to be held June 2008 [2].

Formula Recollection Through a Never Before Seen Mnemonic Technique
Shannon Schunicht
While in the Army, Mr. Schunicht was involved in a mid-air collision rendering him unconscious for three weeks. Everything had to be re-learned, as nursing actions were reported as having been displayed upon awakening from the extended unconsciousness (19 days). Studies in recovery brought about some pragmatic discoveries to compensate for the residual memory deficits. The most valuable was having each vowel represent a mathematical sign.

Framing and Reasoning in Tutorials Over the Course of a Semester
Luke D. Conlin
In a previous study of student groups working during introductory physics tutorials, we found that the nature of explicit student reasoning changed according to how the group was framing the activity moment-to-moment within a tutorial [1]. That analysis showed a disproportionately high amount of evidence for mechanistic reasoning when the groups framed their immediate activity as a discussion, with their attention focused on each others' reasoning rather than on the worksheet. Comparison across groups, meanwhile, shows different patterns of moment-to-moment behavior, which may reflect differences in their epistemological framing of tutorials as a whole. In this study, we compare student work in tutorial sessions across groups that showed different patterns of behavior, following their work over the semester for evidence of framing, mechanistic reasoning, and correlations with course performance.

Future Ready Science for Middle School: Create a Data-Rich Environment
Lisa L. Grable
The Partnership for 21st Century Skills (http://www.21stcenturyskills.org/) has identified a set of competencies that can be used as a framework for science and math integration in the middle school curriculum.

Galaxy Zoo: a Citizen Science Site and its Classroom Potential
Jordan Raddick
The Galaxy Zoo website (www.galaxyzoo.org) is a new experiment in public science participation. Following the model of SETI@home and Stardust@home, it asks people to classify a million galaxies by shape (spiral or elliptical). This task is simple for humans but nearly impossible for computers; a database of human-classified galaxies would be a major step forward in astronomy research. A simple web interface presents volunteers with a single galaxy and a button for each classification. The response has been amazing—more than 100,000 volunteers in only two months. All galaxies have now been classified multiple times, and astronomers are now analyzing the results. Although the site was designed as a public outreach and research activity, many teachers have used Galaxy Zoo in their classrooms. I will talk about ways that teachers have used the site, and I will share some features of the site to help supervise and assess student classifications.

Graduate Programs at UMBC
Renetta G. Tull

Graviton Simulation
Daron A. Moore
This paper will discuss my work in the Teachers Institute for Research in Physics (TIRP) program at the Center for the study of the Origin and Structure of Matter (COSM) at Hampton University in the summer of 2007. The purpose of my work was to find the invariant mass of a graviton using events generated from Pythia, the high-energy physics event generator, using ATLAS fast simulation. Data analysis was completed using the ROOT analysis package. This study suggests that when the LHC comes online, there is a possibility for determining the existence of the graviton using the Randall Sundrum model.

Hanging Airplanes in a Museum: A Case Study in Statics
Debora M. Katz
As physicists we see the importance and relevance of physics, but our students often have trouble seeing that physics is anything more than a prerequisite to the next class. One way to help student connect their everyday experiences to the physics we teach in our classroom is through case studies. It is often difficult to make static problems interesting and relevant, and yet these problems are so important to our engineering majors. To make the topic exciting and fun, I have developed a case study based on an airplane hanging in a museum. This is a hands-on activity. Students measure the tensile strength of thread. Then they determine the number and location of threads required to hang a model airplane. This hands-on case study requires only modest equipment. You only need a few spools of inexpensive thread, and you can make the model airplane out of old meter sticks.

High School Astronomy Course—Sadler's 1983 Study Updated for NCLB
Larry E. Krumenaker
The status and makeup of high school astronomy courses hasn't been examined for 25 years. This multi-method study is the result of two surveys of hundreds of high school astronomy teachers. The results detail who is doing the teaching, their training and needs, how many and what schools off it and where they are, which students, what resources are used, and the effects of the No Child Left Behind Act on astronomy classes. Teachers' attitudes on the course's purpose, toward starting and defending their classes and concerns for the future of astronomy courses in their schools and the nation are reported. We can report that there are more female teachers than nationwide science averages but are not coming from physics or astronomy. They work in isolation and rarely teach more than two sections, often only one. The students are more representative of the U.S. than physics. Schools are more AYP Pass than the national average.

How Can We Determine What's Hard for Physics by Inquiry Students?
Gordon J. Aubrecht, II
Several techniques were developed to track what sections of physics by inquiry's electric circuits module were most difficult for students in their own view. These techniques and their analysis lead us to see that elements of the course related to voltage are the most difficult.

How Much Physics Is Too Much Physics
Stanley J. Sobolewski
It is hypothesized that high school physics teachers who have completed a traditional physics teaching degree may have been overburdened with upper-level physics coursework. Typical pre-service physics teachers are required to complete a two-semester sequence of introductory coursework. This sequence is normally completed during their first year. During upper-level coursework, a student is so concerned with success that they concentrate their focus on the

upper-level material and tend to forget the freshmen level material. In a September 2003 *Journal of Research in Science Teaching* (JRST) article, Joseph Taylor and Thomas Dana set out to develop a case study observation on the very ideas that I have aforementioned. I hope to expand on Taylor and Dana's 2003 JRST study and show that pre-service secondary education physics teacher may indeed have forgotten some of the upper- level material they have previously completed.

Improvising Inquiry: How Content and Pedagogical Structures Shape Inquiry-Based Instruction
Danielle B. Harlow
Providing elementary school students with the opportunity to engage in scientific model building challenges teachers to create situations in which children articulate, test, and revise their ideas. When teachers respond to students' initial and transitory models to provide opportunities for students to revise their models in light of new evidence, the teachers improvise within pedagogical and content structures derived from their understanding of content, pedagogy, and scientific inquiry. I discuss three teachers who adapted the same activity for their classrooms. Each teacher engaged her students in developing a model of magnetism but improvised within different structures when they encountered unexpected students' ideas. I report on how the structures they improvised within impacted their instruction and how explicitly discussing pedagogical and content structures in professional development and teacher education courses may help teachers implement inquiry-based activities in ways that are consistent with authentic scientific inquiry.

LCOGTN: Robotic Telescopes Keep Education in the Dark
Rachel J. Ross
Las Cumbres Observatory Global Telescope Network is building a completely robotic network of telescopes for education and science which will be longitudinally spaced so there will always be at least one in the dark with good weather. The telescopes will be accessible online allowing observations to be done either in a real-time or queue-based mode. Although the time on the current network is very limited, several research projects are currently being trialed with schools around the world. Some of this research includes supernova follow-up, searching for and classifying open star clusters, and NEO tracking. By using these telescopes and participating in real, cutting-edge astronomy research learners will be encouraged to pursue studies in science, technology, engineering, and math while developing skills that will be valuable to any subject studied.

Models and Assessment of Undergraduate Research
Michael R. Braunstein
Over the last decade, undergraduate research projects were required of physics majors at the author's institution (CWU) and considered an important component of meeting the learning objectives of the undergraduate programs delivered by CWU's Physics Department. Learning objectives for the research requirement include: demonstrate ability to use content/skills associated with CWU Basic/Breadth outcomes; demonstrate ability to apply content/skills associated with physics major curriculum outcomes; demonstrate ability to communicate scientific ideas; demonstrate ability to apply appropriate technologies; demonstrate ability to apply the process of science; demonstrate ability to work and learn independently; and, demonstrate ability to apply appropriate resources. We will discuss how we incorporated these learning objectives into an assessment instrument and point out how this process has been instrumental in establishing the model that we use for undergraduate research as well as an

extremely useful tool in identifying, developing and guiding research projects for the undergraduate research requirement.

Online Homework Self Reporting
Matthew L. Trawick
In an effort to encourage regular studying throughout the week, students in several undergraduate physics classes at the University of Richmond were assigned homework due at every class meeting rather than every week.The students were also required to complete online reports before every class meeting, reporting for each individual problem whether they had successfully completed it, needed additional help, or did not have time to complete the assignment. This strategy, which was implemented using existing Blackboard Learning System software, allows the instructor to see both aggregate and individual responses and respond accordingly in class or by email. Data collected from the reports indicate that students in these classes overwhelmingly worked on homework regularly throughout the week. Responses from later anonymous surveys demonstrate that the students do complete the reports honestly, and that the students strongly support the strategy of online homework self reporting.

OpenCourseWare—Highlights for High School
Daniel M. Carchidi
Would you like to use the world famous lectures and demonstrations from Professor Walter Lewin's intro physics course at MIT for your AP students? Now you easily can!
MIT OpenCourseWare (OCW) is a free and open collection of MIT curricular resources used by high school students and teachers all over the world to supplement their coursework, reinforce lessons, and prepare for AP exams. OCW launched "Highlights for High School"—a guide for teachers and students to make finding resources on OCW even easier.
This poster session is intended to introduce physics teachers to the Highlights for High School site. Teachers interested in adding real-world applications to their classes, viewing science demonstrations by MIT faculty, adding to their professional knowledge, or guiding students to exams, homework problems or resources to help them study for their AP science exams will find this poster session valuable."

Optical Phase Change Upon Reflection
Carl E. Mungan
The phase changes for reflection at normal incidence from an interface between nonmagnetic, nonconducting media are needed in introductory physics for thin-film interference. Many textbooks attempt to justify these phase changes using a flimsy analogy to the reflection of a string wave off an end. But in fact it only takes a simple diagram and a few lines of algebra to formally derive the phase changes. As a bonus, index matching naturally arises as a possibility when comparing the refractive indices of the two media. The reflectance and transmittance can also be easily introduced in this context.

Physics Lessons from A to Z; American and Zambian Collaboration
Joseph J. Fehr
This paper will discuss my work in the Research Experiences for Teachers (RET) program in Zambia. The program involved a series of workshops at Lusaka, Livingstone and Chivuna. The goal of the workshops was collaboration with Zambian teachers to develop student-oriented lesson plans using readily available local resources. The lessons were tested in the classroom with Zambian students. These efforts allowed Zambian students to begin to experience scientific research.

Plumbing the Depths to Design a Floating Device
Saami J. Shaibani
The expression "going over like a lead balloon" conjures up an image of abject failure, with or without some measure of ridicule. However, from the perspective of physics, the concept of such a floating device is not completely absurd even if it might be highly impracticable. The research reported here includes an examination of the underlying principles in mechanics, fluid dynamics and thermodynamics to derive the design equation for this type of object. Balloon variables such as size, contents, density and wall thickness are considered in order to determine the nature of the design features involved. The results are not quite as improbable as one might imagine, although they do support the expected lack of feasibility. At all stages, the motivation of the study is to foster an instructive environment that challenges students to expand their awareness of the power of physics as they explore a seemingly daunting exercise.

Recruiting and Retaining Physics Majors
Daryao S. Khatri
In general, recruiting and retaining majors in physics has become a major problem for the physics community. The situation, however, is worse when it comes to the recruitment and retaining of minority students as physics majors.
At the University of the District of Columbia (UDC), we believe that we are close to a solution of this problem. In this regard, we have conducted a pilot study during the summer of 2006 and then an expanded research study during the summer of 2007. At UDC, the program was specifically designed to close the gap in basic math and introductory algebra for incoming freshmen coming from the District of Columbia Public School. The program using recent graduates not only achieved its goals, but produced a number of surprises. One of the surprises was the number of physics majors we were able to recruit and retain as a result of the program. During summer 2006, we were able to recruit and retain two physics majors out of a pool of 12. However, during the summer of 200, we were able to recruit three physics and two chemistry majors out of a pool of 16. All five of them are now working as freshmen teaching assistants in the department, and they all are involved in a number of courses and activities related to their majors. We will report in detail on the various aspects of this program."

Research in Elementary Level Physics Education and Professional Development
Michael R. Fetsko
This paper will discuss my work in the Hampton University Teacher Institute for Research in Physics (TIRP) program in the summer of 2007. The purpose of my work with mentor Alison Baski of Virginia Commonwealth University (VCU) was to develop a unit on atomic physics for VCU elementary education majors. These materials will be tested with the pre-service teachers during their course work with high school students as an introduction to the particle physics unit, and then used as professional development units for elementary teachers participating in the Physics Is Elementary (PIE) program in 2008. The PIE is jointly funded by the Hampton University Center for the study of the Origin and Structure of Matter and Jefferson Lab.

Ring Modulation: The Other Side of Beating
David Keeports
A familiar trigonometric identity expresses the sum of two sinusoidal functions as the product of two other sinusoidal functions. Beating, the production of a time-dependent loudness variation when two sources of similar frequencies are sounded together, is a well known phenomenon. Less well know is the phenomenon of ring modulation, in which amplitude modulation of a

single frequency gives rise to the sum of two distinct and generally dissonant audible frequencies. I will discuss beating and ring modulation as mathematically identical phenomena. Additionally, I will play some audio files demonstrating the transition from beating to ring modulation as the frequency difference between added sinusoidal waves increases.

Seventh-Grade Students' Ideas of Force and Work in Simple Machines
N. Sanjay Rebello
We examined changes in seventh-grade students' conceptions of force and work in the context of a design-based instructional unit on simple machines. The CoMPASS curriculum integrated digital hypertext and hands-on activities with design-based learning experiences. We present results from the analysis of a series of structured interviews with 10 students at three points in the eight-week curriculum. Our results indicated a general trend toward scientific conceptions as students progressed through the curriculum, but also highlighted several barriers to students' conceptual understanding of force and work in the context of simple machines. Most notably we found that the use of the hands-on activities, and scientific terminology vis-à-vis everyday language, as well as the curricular context of simple machines, together may have limited student understanding of force and work.

Simulations as Lecture Tools in High School and University
Rachele G. Dominguez
Much work has been presented on the use of computer simulations as inquiry-based tools. But what is their value if the students do not directly interact with the simulation? In particular, how effective is the use of simulations in a lecture environment? I will present my observations and student feedback on using simulations to supplement lecture material in 10th grade introductory physics classes in Boston Public Schools and large introductory physics classes at Boston University. Work done at Boston Latin Academy in the Boston Public School system is sponsored by the NSF funded Boston Urban Fellows Project.

Solar Energy Can be Effective Even in Ohio
Gordon J. Aubrecht, II
"Meet the Carpenters" is Michelle Aubrecht's submission to Al Gore's global warming awareness contest. The 60-second ad focuses on the Carpenter family's efforts to reduce their personal carbon footprint. One major way is a solar panel installation David Carpenter installed on his family's south-facing roof. This poster will present the contest ad and give highlights of David Carpenter's energy and monetary savings from the solar roof as well as details about how net metering works in Ohio.

Solving the Problem of Physics Self-Efficacy: A Pilot Instrument
Kimberly A. Shaw
A type of belief that has been shown to affect student learning is self-efficacy, which can be described as a person's belief in her/his own ability to accomplish a specific task to a given performance level. Self-efficacy is both content and context dependent: a student may have a high self-efficacy in some domains, and low self-efficacy in others. We are examining the relationships between self-efficacy in physics problem solving, and student performance in that domain. An instrument has been pilot tested in order to examine physics problem solving self-efficacy. Students were asked to rate their confidence in their ability to correctly solve mechanics problems, and then separately asked to solve those problems. Preliminary results from this study will be presented.

Spherical Rare Earth Magnets in Intermediate Classical Mechanics
Al J. Adams
Spherical rare earth magnets (SREMs) present a variety of rich teaching and learning opportunities for both traditional classroom and laboratory settings. Opportunities abound also for activities-based pedagogy. Previous studies have been primarily directed toward the introductory courses and have shown the advantages SREMs offer in demonstrating uniform vs. non-uniform motion, the inverse 4th law dependency of force between dipoles, the influence of the earth's magnetic field on a rolling dipole, and the local potential energy minimization resulting from the dipole-dipole interaction. In this presentation three applications of SREMs in intermediate classical mechanics will be described. Each entails an analytical component that is consistent with the depth and scope of a representative intermediate classical mechanics course. The first is the one-dimensional dynamics of a moving dipole as it approaches a stationary dipole oriented for repulsion. The second is the intriguing case of a rolling ferrous ball colliding with a magnet with two ferrous balls linked magnetically on the side opposite to the collision (Gauss rifle) with a noticeable boost in the speed of the recoiling ferrous ball. The third is the case of a SREM rolling down an incline with noticeable changes in motion due to variations in torque as the dipole rotates in the earth's field. Analytical modeling results are correlated with video-based measurements.

Starting Up a Teacher Share Group with a Bang
Scott C. Beutlich
In January 2007, Physics Northwest, a teacher share group with more than 200 members in the Northwest Chicago suburbs, helped restart Physics West with a spectacular 2-hour demonstration meeting. A group of seven physics teachers from PNW each did five demonstrations. Under normal circumstance this would have been a great evening of sharing ideas. But the evening became exceptionally noteworthy when at the end of the meeting each of the 40 teachers from the western suburbs got information and equipment to do the 35 demos.
My Powerpoint will show the planning of the evening and the excitement of teacher share groups in the Chicago-land area.

Student Problem Solving in Introductory Physics
Bernard Griggs, II
Problem solving is an integral part of students' experience in introductory physics courses. Often, students are instructed to solve problems as a way of learning physics. Their understanding of physics is certainly assessed by having them solve problems. This study seeks to understand how students approach physics problem solving in the context of Matter & Interactions, an innovative introductory curriculum emphasizing reasoning from fundamental physics principles and the microscopic structure of matter. We address two research questions: (1) What general problem solving procedures do students employ? and (2) How is physics content knowledge reflected in student solutions? To answer these questions, we conducted think-aloud interviews with students and analyzed our data using a rubric developed at our institution. We found that students generally struggled to approach problems systematically and had more difficulty solving algebraic problems than numerical ones.

Student Resources for Learning Relativity
Mark P. Haugan
Students bring initial ideas about physical systems and about physics knowledge to learning experiences. Such ideas are conceptual and epistemological resources because instructors may use them productively to enhance student learning. While students of introductory physics may

draw resources from “everyday” thinking, more advanced students may also draw resources from ideas acquired during prior instruction. In this paper, we discuss and demonstrate ways of productively using resources of both kinds in relativity instruction. For example, we elicit students’ initial, naive thinking about time and simultaneity and design subsequent instruction to help them refine their thinking and so develop a principled understanding of the corresponding relativistic concepts. We also demonstrate how to use knowledge of matter’s atomic structure to convey a sense of mechanism underlying phenomena like time dilation to students. The requisite knowledge is a resource for our students because they have studied the Matter & Interactions introductory physics curriculum.

Students' Conceptual Understanding of Quantum Physics in College Level Classroom Environments
Bayram Akarsu
The purpose of this project was to study the potential solutions of the common learning difficulties, insufficient teaching techniques and other significant instructional or conceptual problems encountered while teaching and learning an important branch of physical science, quantum physics (QP), at the senior or junior college year. Both quantitative and qualitative methodologies were utilized in this study. The participants included five physics faculty members with different levels of teaching experience who were teaching one of the quantum physics courses (e.g., Modern Physics, Quantum Physics, and Quantum Mechanics) and 43 senior or junior undergraduate students enrolled in their courses during fall and spring terms of 2006. The findings of this study revealed that students struggle in QP classes mainly because of (1) complex mathematical tools in QP, (2) abstract concepts and nonparallel construction of QP, (3) QP has a bad reputation that negatively affects students prior to taking it, and (4) the pace in curriculum of quantum physics courses is too fast for the students. In order to increase students’ conceptualization of QP concepts, the faculty members who participated in this study suggested that: (1) more time should be spend on solving more abstract conceptual questions, (2) recitation hours for solving more numerical problems need to be dedicated, and (3) revision of curriculum is necessary.

Students project in MARIACHI
Joseph Sundermier
We describe on the experience of having students developing research work at Brookhaven National Laboratory. The projects they were involved in are related to the MARIACHI experiment and include mostly hands on activities in the construction of devices to help the science of MARIACHI. In particular we will report on the development of a electric field monitor, infrasound microphone and the installation of a video capture apparatus. We will discuss the projects and the lessons learned in advising the students through the steps of performing tasks to accomplish the projects.

Teaching Electromagnetic Waves Using Visualizations of the Maxwell Equations
Roberto B. Salgado
Using visualizations of the Maxwell Equations [developed with VPython], key features of the plane electromagnetic wave are motivated and discussed. Emphasis is placed on the patterns of the electric and magnetic fields. Since no explicit equations are written down, this presentation may be useful for an introductory conceptual physics or algebra-based physics course.

Teaching Maxwell’s Equations to Gen Ed Students
Sadri Hassani

Using text, sound, images, and animations we will present Maxwell's equations in such a way that a general liberal-arts student can certainly appreciate, and even partially understand the discussion.

Teaching Opportunities in Physics and Physical Science (TOPPS) at FSU*
Eric J. Moore
The Improving Teacher Quality (ITQ)/TOPPS Project at Frostburg State University (FSU) provides high-quality professional development opportunities for 21 high school, middle, and elementary school science teachers from across Maryland. During one week in July, these Teacher Scholars gained physics content knowledge and developed teaching strategies. They were also encouraged to integrate technology in their teaching and attain “Highly Qualified” status. The fundamental goals of this three-year effort are to enhance classroom teaching and learning effectiveness, and improve student achievement in Physics and Physical Science. Modeled after the nationally proven AAPT/PTRA curricula, the teachers engage in inquiry-based experiments and activities. Moreover, TOPPS enhances their professional development through PRAXIS tutoring, graduate credit mentoring, and evening activities. According to post-survey assessments, 95% of the participants are more confident in teaching physics/science content and 81% have an increase/gain in the level of conceptual understanding of physics.
*Supported by a grant from Maryland Higher Education Commission (MHEC)"

Teaching the Physics of Flight
Stuart Gluck
The physics of flight is a rich and interesting physical science topic, even for students who haven’t yet had high school physics or algebra. However, it can be difficult to balance rigor with accessibility in order to create a fun but rewarding class. It can even be difficult to avoid the common content mistakes in materials developed to present the subject conceptually (e.g., the Bernoulli Principle myth). For more than a decade, Johns Hopkins University’s Center for Talented Youth (CTY) has been offering a very successful and popular Flight Science course to highly gifted fourth, fifth, and sixth grade students. In this presentation, we describe the activities-based approach that CTY instructors use, review the CTY curriculum guide, sample syllabi, and texts and other materials used. Afterwards, participants should possess the resources to develop a course on the topic for a wide range of settings, age groups, and ability levels.

The Central Atlantic Region: Leading Edge in High School Physics
Michael Neuschatz
High school physics enrollments have been slowly but steadily rising across the country for better than two decades, reaching new records and new groups of students as they climb. During this period, the Central Atlantic region—seven states with the Baltimore-Washington metro area roughly at its center—has witnessed outstanding growth, with an aggregate physics enrollment percentage that now far outstrips the national average. This talk will use data from the American Institute of Physics’ recent Nationwide Survey of High School Physics Teachers to compare the backgrounds, current situations and views of high school physics teachers in this region with their colleagues across of the country, and to try and understand what underlies the enrollment growth and what changes may be in store in the future.

The Improvement of Student Learning Based on In-Class Physics Demonstrations
Sergio Flores
In-class demonstrations are a very important physics concepts learning technique. In the department of physics at the University of Texas at El Paso, we have developed lecture

demonstrations that must be used by most of instructors. These demonstrations will be conducted by a demonstration-coordinator or TA. In this way, we expect to improve the student understanding related to difficult topics students do not understand in most physics lectures. The demonstration is set up at the beginning of the lecture to be used at any time the instructor desires. Students are encouraged to participate by being asked about the corresponding prediction of the concept being observed and proved.

The Use of Humor in Enhancing Physics Education and Assessment"
Stanley J. Sobolewski
In an attempt to reduce anxiety during testing, a comparison of means two sided t-test was used to determine if humorous test items made a statistically significant difference in improving test scores when compared to identical tests with no humorous entries. In addition, a questionnaire was given to determine the students' perceptions of humor benefiting them in a testing situation. Four experiments were performed, three in the physics class and one in an introductory algebra class. Humor was used in the title of the test, the directions, and the questions. The author analyzed both the actual performance of students in the assessment process along with the student's perceptions of humor relieving anxiety and helping them to perform their best. The results of using humor showed no statistically significant increase in the testing scores. The students' perception of using humor was significantly positive and encouraging.

The Use of Muon Detectors to Bring High School Physics into the 21st Century
Deborah Roudebush
This paper will outline my classroom use of a muon detector connected through the QuarkNet Cosmic Ray e-Lab to allow my students to be involved in original research. The students have been responsible for calibrating the detector, run performance studies, upload data to the e-Lab server. In the long run students will analyze the data to develop research and will mine the data to search for possible connections.

Tips for Creating a Successful Environment in a Modeling Classroom
Chris J. Smith
Through five years of teaching using the modeling instruction method in my high school physics class I have found that it is not always easy to get students to buy in to modeling method. Over these years I have learned some techniques that complement the modeling philosophy and have helped to build a community of learners in my classroom. You will see how I incorporate lab practicals, explorations, whiteboard presentations, internet HW, and an online community website into the modeling cycle. I will also try to steer you away from some of the mistakes that I have made. If you are a new or experienced modeler or would just like to get a glimpse into one teacher's modeling classroom, then come to see some of the things that I have done to make modeling instruction work for me.

Using Clicker Systems to Conduct Perfectly Anonymous Class Polls
Harry E. Bates
Basic information about students and how they study for exams and rank their experience in a class can be a valuable form of feedback for instructors. Students might be reluctant to reveal information that could be useful to the instructor if they think it would bias the instructor in determining their grade. For example, how much time did you spend studying for the last test? I will discuss the basic technique I have used for anonymous polling using the PRS clicker system and show the results of a sample poll I have been conducting this semester at Towson University.

Using Historical Papers to Motivate Physics Students in High School
Alan Gnospelius
For the past few years, I have assembled a group of historical documents from original sources that I have shared with my students. These documents are in the public domain, and are from scientists such as Franklin, Kepler, Curie and Aristotle. The documents have provoked controversy and discussion in the class, and I have found this to be a strategy that needs to be shared.

Using Mathematical Properties to Identify Discriminating Physics Questions
Eugene Torigoe
While previous studies have revealed that mathematical pretests correlate with success in physics, they were not able to specify the types of mathematical skills which were important for success in physics [1]. For the first time we have been able to identify highly discriminating physics questions by coding the questions based only on mathematical properties. The main property we used to code the questions was based on the importance of the formal representation of an equation in the solution of the problem.
The properties used to identify questions originated from an earlier final exam study [2]. In that study we analyzed numeric and symbolic versions of 10 final exam questions and found common properties of questions that showed large differences in score between the numeric and symbolic versions.
We will discuss and give details of our coding scheme, and suggest possible causal relations for the observed correlations.

Using Real Particle Physics Data in High School Physics Classes
Shane Wood
This poster will demonstrate how real data from high energy particle physics experiments can be used by high school students. The European Particle Physics Outreach Group (EPPOG) has organized particle physics Masterclasses in which students use data from CERN's Large Electron-Positron Collider (LEP) experiments to better understand the world of quarks and leptons. Through the Internet, all teachers and students can access and utilize the LEP event display data housed on the Masterclass website.

Using Students' Understandings of Light to Teach Astronomical Concepts
Sharon R. Blauvelt
Many astronomical concepts are based on student's knowledge of light and the electromagnetic spectrum. Once the basic groundwork is laid, a scaffolding effect can take place in the classroom where one concept can be laid on another to help spiral students to greater understandings on a much higher level. This would include the Hertzsprung-Russell diagram, stellar evolution and stellar spectroscopy. These sometimes abstract astronomical concepts can be difficult for high school students to process and understand. Through my research I hope to show hands-on activities that enhance the classroom environment and show how scaffolding can work in the classroom.

Using Video Assessment of Physics Lessons
James L. Redmond
This poster will include a pictorial, as well as a video presentation of teachers using our PP&T lessons in Light/Color and Electricity and Magnetism with students from grades 7, 8, and 9. These lessons follow a constructivist approach to the teaching of basic concepts in physics. Seventeen teachers from O'ahu, Maui, and Kauai worked on the lessons in an intensive week-

long class using PP&T materials. They then taught these lessons to a Summer Science Enrichment Class at the University Lab School in the summer of 2007 and videotaped the sessions. The videotapes were graded and shared with all members of the team. This approach has proven very instructive to all members of the team and will be used again in the summer of 2008.

What Is a Teacher?
David E. Meltzer
I will discuss various issues related to "teacher effectiveness" and its assessment, specifically in the context of using research-based, guided-inquiry curriculum and instruction in pre-college classrooms. Among the factors often identified as contributing to effectiveness are (1) knowledge of content, (2) knowledge of science "process" skills such as experiment design and analysis, (3) knowledge of "Nature of Science" (practices and philosophies of the scientific community), (4) pedagogical content knowledge (knowledge of issues related to learning of specific concepts), (5) ability to apply general pedagogical strategies that are relatively independent of specific content, and (6) ability to implement effective methods while subject to institutional and logistical constraints. I will discuss some of the mutual interactions of these factors and the challenges they pose to making valid overall assessments. *Supported in part by NSF PHYS-0108787

Why Quantum Mechanics Is Usually Taught Incorrectly
Stuart Gluck
In most classes on quantum mechanics (QM), the conceptual foundations of the theory are misrepresented. Students are typically taught that we know that whenever a measurement occurs the wavefunction collapses via a non-unitary evolution process; in essence, Schrödinger's equation "turns off" for that state transition. However, we don't know anything of the sort. There are consistent, empirically equivalent alternate accounts of QM in which Schrödinger's equation always holds valid and all temporal evolution is unitary. This is one amongst a morass of confusions about the conceptual foundations of the theory typically propagated from one generation of physics educators to the next. In this session, we sort out the myths from what the theory really tells us so you can teach students QM with accuracy and conceptual clarity.