APS Forum on Education
American Physical Society

Summer 2005 Newsletter

IN THIS ISSUE

Greetings from the Chair!

Ramon Lopez

The Forum on Education continues to play an important role in the APS, and we thank our members who provide leadership in all aspects of education. The APS and the Forum have recently created an award to recognize contributions to Physics Education, and we are currently raising funds to endow the award. Any contribution of $100 or more entitles you to honor a teacher who has been influential in your life. A letter will be sent to the teacher and their family from the APS informing them of this distinction. What is more, the Forum has allocated $30,000 in matching funds, so your contribution will be doubled!

I can think of no better way to commemorate this important year in the history of physics than to honor a teacher. And what a momentous year it is. The 100th anniversary of Einstein's "Miracle Year" of 1905 is being celebrated worldwide as the World Year of Physics. I recommend that FEd members visit the World Year of Physics site (http://www.physics2005.org/). There you can submit events of all kinds that will be registered as World Year of Physics events, from special lectures on 1905 for physics students to popular presentations for a public that is fascinated by Einstein.

The FEd has been doing its part to celebrate the World Year of Physics with this issue of the newsletter, and

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special sessions at the APS meetings, like the very well attended "Teaching Special and General Relativity (I & II)" at the April meeting in Tampa. Other sessions highlighting recent developments in physics included "Education and Exploration of the Universe" (April) and "Teaching Classical Mechanics and Non-Linear Dynamics: Highlights from a Gordon Conference" (Mar.) We are also co-sponsoring (with DAMOP) a special session at the summer AAPT meeting.

In total we sponsored or co-sponsored 14 sessions at the March and April meetings, of which 6 were Physics Education Research sessions. The field of Physics Education Research has grown rapidly in the past few years and has been recognized by an APS Council resolution as a field of physics that has a place in physics departments, and practitioners should be evaluated as professionals in other fields of physics are evaluated. Grants, mentoring of students, presentations, and peer-reviewed publications are the means by which we judge the scholarship of all physics faculty.

Given that Physics Education Research (PER) is a growing branch of physics, it was only a matter of time before the APS would provide a venue for publication of research results. This year, a new journal, Physical Review Special Topics: Physics Education Research was launched with the endorsement and support of the Forum. This all-electronic journal will provide a vehicle for the publication of high quality papers that will be held to the standard we expect of the Physical Review. The journal will be open to all who want to read it, and I hope that physics faculty will use this research to improve physics education at all levels, but especially at the undergraduate level.

A particular focus of mine is undergraduate education. Physics is in many ways a leader in undergraduate education, and I see the Forum as an important vehicle for effecting change. Over the coming year the Forum will help disseminate information about effective pedagogy that departments can implement as they improve their programs. As physicists we know the value of building on the research of others. Why should it be any different in education? Those physics faculty who are not physics education researchers (the vast majority) can and should use the results of PER to improve the quality of the education they deliver. And by improving undergraduate physics education we may retain a larger fraction of students as graduate students. In 2000 and 2001 the AIP statistics show a significant increase in Physics undergraduate degrees, but a decrease in Ph. D. degrees. The number of Ph.D. degrees is expected to rise in 2005, but unless we continue to recruit and retain outstanding undergraduate students, the increase in degrees could be ephemeral.

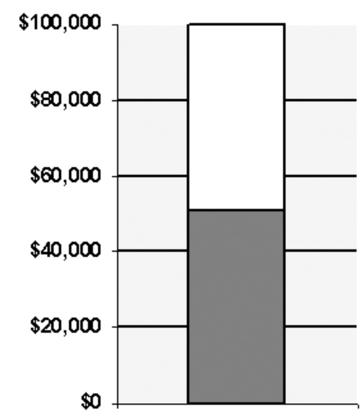
Beyond the academic concerns of physics departments, which is and should be a focus of the APS, there is a need for the involvement of physicists in broader debates about science education. We bring a perspective, and a public esteem, that should be brought to bear to ensure that science education in schools is of high quality and free of the intrusions of pseudoscience, like "Intelligent Design." So get involved. Find out how you can contribute to science education and let the Forum be your partner. If you have an issue, bring it to the attention of a member of the Executive Committee. If you have an idea for an education session at an APS meeting, send an email. For our part, we will continue to raise the profile of education with sessions at APS meetings, publications like this newsletter, and the nomination of outstanding Fellows of the APS. I hope all of you reading this take a moment to consider nominating a colleague who has made contributions to education at the national or international level. And I especially hope that some of you reading this will want to run for office to help maintain the Forum on Education as a lively and member-driven organization.

Ramon E. Lopez is Professor in the Department of Physics and Space Sciences at the Florida Institute of Technology in Melbourne, Florida and Chair of the Forum on Education.

Excellence in Physics Education Award Update

The *Excellence in Physics Education Award* fundraising campaign announced in the Spring Newsletter has reached the halfway mark with over 80 APS members contributing. Although not all Forum members will want or be able to contribute to the Award, we believe that our fundraising goal of $100,000 is modest given that the Forum on Education currently has over 4,000 members. Give more than $100 if you can but do contribute. No other APS award recognizes and honors physics education and this Award cannot be presented until the endowment is fully funded. Because the Forum has agreed to match member contributions dollar for dollar up to $30,000 your contribution counts double. If one in eight Forum members gives $100 we will reach our fundraising goal.

Additional information including downloadable and electronic pledge forms is available on the Forum's web page: http://www.aps.org/units/fed/



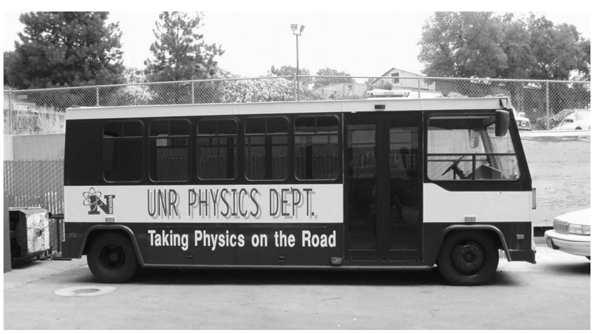
$51,172 as of July 11

Honor a Teacher

Are you indebted to a teacher or mentor for your physics education? Now is the time to make a down payment on this debt. Not only will your donation help establish the *Excellence in Physics Education Award*, but any contribution over $100 can be designated to honor a teacher or mentor who has been influential in your professional training. A letter will be sent by the APS to the honoree or the honoree's family informing them of your gift.

Physics on the Road at the University of Nevada, Reno

David Bennum



"It was a shocking experience!" "I really got a "bang" out of it!" "It just made my hair stand on end!" These are some of the comments I see regularly in thank-you notes from students whose classes I have entertained and educated with the University of Nevada Physics Department's "Taking Physics on the Road" bus.

Throughout my career as a member of the physics faculty at UNR, I have actively sponsored "demo" shows at the campus for visiting elementary, middle and high school classes on field trips or university organized campus tours. Several years ago it became apparent that the number of such visits was declining as school budgets tightened and field trips were considered unaffordable by many schools. To continue what we considered a critical early exposure to physical science for students, the department embarked on a "traveling program". I attended a workshop at Colorado State University sponsored jointly by the ***APS Forum on Education*** and the ***American Association of Physics Teachers (AAPT)*** which brought together directors of successful traveling programs and those aspiring to start new ones to encourage programs related to the "World Year of Physics". We shared experiences and ideas for several days and saw the CSU "Little Shop of Physics" public open house. Several new demos have been added to our repertoire since that visit as well as a philosophy of increased hands-on experience by students.

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We acquired a retired experimental electric shuttle, painted it with logos, refurbished it a bit, and started taking demo shows and hands-on experiments to local schools. Since that time a newer, larger and more modern electric bus has been donated to the project by William Brinsmead, a departmental technician whose help in designing demos has been invaluable. He has a particular interest in electric vehicles and found a retired bus from San Diego that greatly increased the range and reliability of the transport. This newer bus uses a 360-volt Ni-Cd battery system and runs AC motors with a regenerative system. Several grants were awarded to programs such as UNR's from the APS "Physics on the Road" and we were fortunate to be among the list of awardees. We are using the funds to add upgrades to the bus, increase its range and to buy and/or build demos for it that will make it more independent of the department's resources.

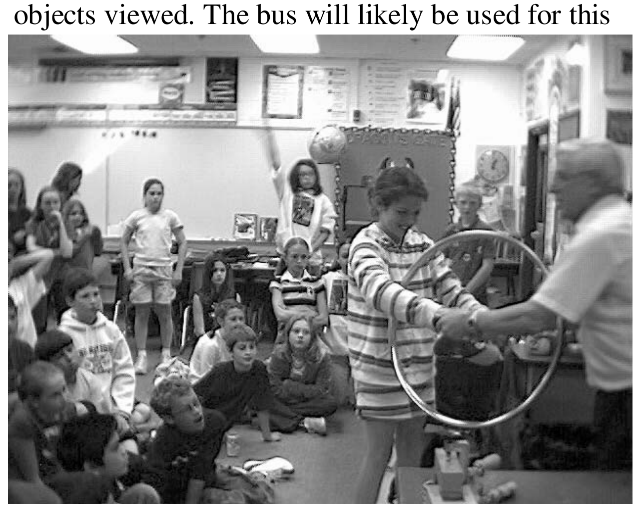
The demos we use cover a broad range of physics concepts including mechanics (moment of inertia, conservation of angular momentum, wave motion in one and two dimensions with large amplitude vibrating string and Chladni plate, standing wave in air column with a "flame wave tube"), light and optics with several laser demos and concave/convex mirrors, thermal physics with liquid nitrogen, Sterling engines, thermo-electric motors, and others. The largest number of demos, because of their spectacular nature, is in the area of electricity and magnetism. The most popular are the Van de Graaff generator, a large exploding wire apparatus which doubles as a dramatic Faraday's law demo (crushing or launching aluminum cans) and various other induction experiments, a Tesla coil, Jacob's ladder and several smaller occasional demos such as motor-generator pairs.

Demonstrations are presented to any class level requested including "dog and pony" wow shows for preschoolers through 2nd grade, and increasing degree of concepts discussions as age/grade level increases. We also always try to leave behind some explanation materials for teachers to help answer questions that arise after we are gone. During this "Year of Physics" we will be setting up a web request page on our science outreach site which will allow teachers and school administrators (or scout leaders and others) to arrange and schedule bus visits to their group.

Part of the grant funds from APS will likely be used to remodel the bus interior with addition of benches for "Exploratorium" type self-guided demos and the addition of an awning to expand the area outside the bus. We envision this as adding science fair and public outreach events to the current classroom and assembly show mode currently used. The electric nature

of the bus gives us plenty of power to run displays independent of outlets.

The other part of the science outreach program that I have been actively promoting is astronomy viewing for schools and the public. Currently we take portable telescopes ranging in size up to a 14-inch aperture Schmidt-Cassegrain telescope with computer guidance to schools or other public access sites and do free viewings. We try to be sure that viewers understand what they are looking at and some details about the objects viewed. The bus will likely be used for this



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purpose also, though currently the transport is by private vehicles.

Both of these programs have been staffed not only by me but a group of undergraduate and graduate physics and science education majors who have volunteered their time and talents. The college students report that they not only enjoy helping K-12 students appreciate and understand science but have learned from the experience themselves. Projects of this nature are "win-win" for everyone involved.

David Bennum is Professor of Physics and Vice-Chair at the University of Nevada, Reno. He recently received the University of Nevada's "Distinguished Outreach Faculty Award for 2005."

Check out
http://scienceportal-one.org/index.php?ontheroad

Bachelor's Degrees in Physics: What Do Our Graduates Do?

Roman Czujko, Director, Statistical Research Center, AIP
Jack Hehn, Director, Education, AIP

Physics students are characteristically smart, tenacious, and accustomed to engaging in difficult problem solving activities. These attributes serve them well when they look for a job, and employers tell us they understand and appreciate these attributes. Many physics students continue their education beyond the Bachelor's degree, but only about 30% go directly to graduate school in physics. Within five to seven years after earning a bachelor's degree, two out of three have either earned an advanced degree or are full-time students pursuing an advanced degree. What other field can claim such a remarkable rate of academic achievement? (http://www.aip.org/statistics/trends/highlite/bachplus5/figure1.htm)

In the last decade there has been a continuing dialogue in the physics community about the value of a bachelor's degree in physics and the characteristics of a program of study that will prepare a physics major for a productive career in science and technology, a workforce of great importance to the American economy. Physics students commonly pursue a broad range of careers after earning their degrees, but few will ever have a job title of "physicist." Many bachelor's degree recipients succeed on their own with little assistance or advice from faculty, with the exception of how to succeed in graduate school. There is evidence that productive changes are taking place in physics departments that provide students with more information and more encouragement about their future.

Physics Departments and the professional and learned societies that serve physicists and scientists in related fields are focusing more attention on undergraduate physics majors. In 2003 The National Task Force on Undergraduate Physics (NTFUP) published a report entitled "Strategic Programs for Innovations in Undergraduate Physics: Project Report" (Spin-UP) by Hilborn, Howes and Krane, that details many constructive environments for undergraduate students in "thriving departments" (http://www.aapt.org/Projects/ntfup.cfm). Within the report are descriptions of programs of study in specific physics departments that can be used as examples of effective practice. Much of this information is summarized in a Physics Today article entitled: "Why Many Undergraduate Physics Programs Are Good but Few Are Great" (http://www.physicstoday.org/vol-56/iss-9/p38.html) A companion project looked at successful programs in two-year colleges (http://www.aapt.org/Projects/spinup-tyc.cfm).

Career information about science and technology is available from many of the professional societies.

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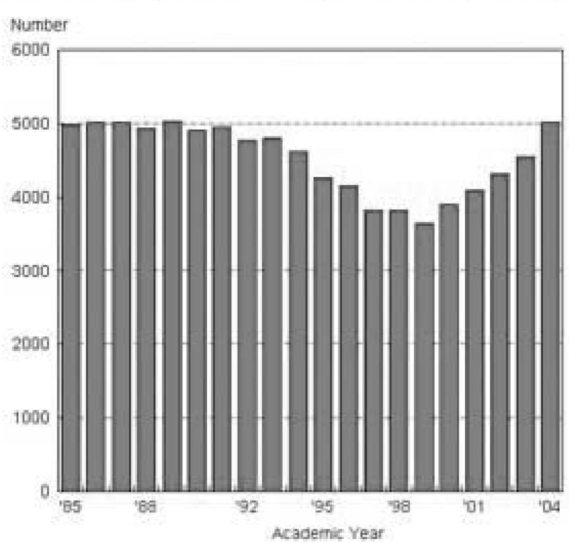
One good example is the Physics Today Career Network (http://www.aip.org/careersvc/). A general source of information about science and technology careers is the Sloan Foundation (http://www.careercornerstone.org/aboutsccc.htm)

There have been significant changes in the number of physics bachelor's degrees awarded. That number can be said to be "exploding." During the late 1980's and early 1990's, the number of these degrees awarded each year bounced between 4,900 and 5,000. However, the number of these degrees awarded began to decline in 1991, in large part, as a reaction to the severe international recession that affected all fields and much of the industrialized world.

The number of bachelor's degrees in physics bottomed out in 1999 at 3,646. However, over the last 5 years, the number has exploded by more than 37% reaching 5,000 for the first time in 15 years (Figure). Based on the number of juniors majoring in physics that department chairs reported, we expect that the number of bachelor's degrees in physics in the class of 2005 will be larger still. To a significant extent, the recent increase must be credited to the practices and programs described earlier in this article.

Number of physics bachelors awarded, 1985-2004.



Happily, the increase in bachelor's degrees is also showing up in graduate enrollments. In fact, over the last 6 years, the number of US citizens entering physics graduate school (see Table 1) has increased even faster than the increase in physics bachelors. Why has the domestic enrollment increased so fast and what about the quality of these students?

Table 1: Entering physics graduate students by citizenship, fall 1998 to fall 2004.

Academic Year	Foreign	US Citizens
Fall 2004	1294	1746
Fall 2003	1457	1711
Fall 2002	1339	1535
Fall 2001	1434	1343
Fall 2000	1485	1228
Fall 1999	1328	1182
Fall 1998	1251	1166

There are several factors that are probably affecting graduate enrollments among domestic students. Despite the strong job market during the late 1990's, we saw an increase in the number of students who delayed entry into graduate physics programs, i.e. they entered graduate school after working for one or more years. More recently, we have seen an increase in the proportion of new graduates at the bachelor's level who are going directly into physics graduate programs.

It is reasonable to wonder whether the quality of the US students has declined as their numbers entering graduate programs have increased so dramatically. Unfortunately, we do not have data on this issue. However, we have had conversations with the chairs of several prestigious physics departments in Research 1 universities. These chairs reported that after their department had selected the students to whom they would send acceptances for their PhD program, they noticed two phenomena: first, that the number of domestic students in their acceptance pool was large and growing; and second, that the quality of the students being admitted had actually increased. Thus, one is forced to ask if many physics departments have improved the quality of their undergraduate program at the same time as actively recruiting more students and making those undergraduate feel like members of the department.

Even with all of this good news, some cautionary comments are in order.

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For the last several years, the US economy has been in a recession. In general, this recession is comparatively mild. However, it is unique in that electrical engineers and IT professionals are among the hardest hit during this downturn. Typically, people with college degrees, especially in engineering and the physical sciences, have much lower unemployment rates than the national average for all workers. However, during the first quarter of 2004 the electrical engineers had an unemployment rate equal to the national average, systems analysts were higher still, and programmers had an unemployment rate of 9%.

Why are these statistics important? They are important because these are precisely the kinds of jobs that physics bachelor's degree recipients are most likely to get when they go to work in the private sector. In fact, we have already been seeing some of the effects of this economy on the employment of these recent graduates. Historically, over 80% of those receiving physics bachelor's degrees who enter industrial employment find jobs in the science and engineering (S&E) enterprise. However, of new graduates (classes of 2002 and 2003) who entered the workforce, fewer than 60% found employment in science and engineering.

Clearly, hundreds of recent physics bachelor's degree graduates are disappointed in their initial employment prospects. But, the problem goes beyond disappointment. Physics bachelor's working in science and engineering got paid about $12-15,000 more in starting salaries than did those who did not enter the S&E workforce (see top two bars of the figure at http://www.aip.org/statistics/trends/reports/summer2005a.pdf). How long can these poor job prospects continue before sophomore and junior majors begin to switch to other fields?

Establishing mechanisms to stay in touch with your graduates (alumni) provides many benefits to a department. Connecting graduates of your department to current students is a powerful tool to encourage and motivate those students. Some departments bring physics bachelor's degree recipients back to the department four to six years after graduation to talk with students in an informal setting and/or to serve on departmental advisory boards. The alumni can talk to your current students about what they are doing, the excitement of their jobs, how to find similar positions, and how their physics education has helped them in their careers.

The faculty will also benefit from hearing these comments from the workplace. It will remind them that physics degrees lead to more than graduate school, and it will give them an opportunity to self assess the effectiveness of the program of study for the broad range of career paths that physics bachelor's commonly pursue.

A strong Society of Physics Students (SPS) or Sigma Pi Sigma chapter may assist in these connections between students and alumni (http://www.spsnational.org/). Providing information about "what graduates are doing" on the web can also be a very powerful recruiting tool directed at prospective students and their parents; an excellent example is provided by Sonoma State University (http://www.phys-astro.sonoma.edu/people/graduates/GradsAchievements.html).

Spin-UP makes the case that a strong sense of community is an important aspect of any "thriving" department. The welfare of our physics community is deeply dependent on our ability to recruit, prepare, encourage, and motivate the next generations of physicists.

Roman Czujko has been the Director of the Statistical Research Center of the American Institute of Physics for the last 13 years. He is a Fellow of the American Physical Society.

Jack Hehn has worked in science education policy with emphases on undergraduates programs and departments of physics over the last 14 years with appointments at AAPT, NSF/DUE, and AIP. He is a Fellow of the American Physical Society.

California Political Science Education *Lawrence Woolf, General Atomics*

If you're a curriculum developer and want your grade K-8 science instructional materials to be adopted for use in California, you'd better not mention either the National Science Education Standards (NSES) or the AAAS Benchmarks for Science Literacy. Because if you do, your materials can't be adopted.

Welcome to the strange world of state science education policy. I've taken an active role in California science education policy for the past 7 years and in this article will share my story on how I got involved, what I've tried to do, what I've actually accomplished (in conjunction with the efforts of many others), and some lessons that are applicable to anyone interested in K-12 science education.

My involvement in science education began in 1992 when my company, General Atomics, started an education outreach program, in which scientists and teachers worked together to develop a number of educational modules. I helped develop and present a Materials Science module at a variety of science education conferences, and later developed additional modules and materials. To further my understanding of science education, I attended the 5-day 1997 Teacher Scientist Alliance program, headed by then APS education and outreach director Ramon Lopez, the current FEd chairperson.

In about 1997, California began developing state science education standards. The final draft version differed significantly from the NSES in both content and philosophy. As an example of the differences between the California Science Standards (CSS) and NSES: according to the CSS, students in grade 3 should know that "Science experiments show that there are more than 100 different types of atoms, which are presented on the periodic table of the elements." In contrast, the NSES includes this topic in its grade 5-8 standards: "There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter."

California is an adoption state (for grades K-8), one of 22. In adoption states, the state determines the instructional materials that school districts can purchase using state funds. In California, the state curriculum commission sets the criteria for determining how these materials are selected. Other committees then review and judge the science instructional materials that are submitted for adoption. In 1998, new criteria for adoption of K-8 science instructional materials stated that they must meet every single grade level standard at a particular grade to be considered for adoption - if an instructional material missed just one of the grade level standards, it couldn't be adopted for use in California.

Once developed, the final version of both the CSS and the criteria for adoption of K-8 science instructional materials had to be approved by the State Board of Education (SBE) to become state policy. In discussions with teachers and science education leaders from around the state, I knew that many disagreed with parts of both the CSS and the criteria for adoption. I therefore took the initiative and wrote a science education petition summarizing the major points of discontent, and distributed it via various email conduits. The result was a flood of responses from over 350 science educators and scientists from throughout the state who signed onto the petition via email, many adding their personal opinions. I manually collected these responses and organized them into a coherent document. I did this for two reasons: to document the disagreement for historical reasons and to use this as a mechanism to try to influence the SBE.

Next I traveled to Sacramento to present this petition to the SBE at their public hearing on both the CSS and the criteria. Individuals must call the SBE ahead of time and notify them of your intention to testify. You have 2 minutes to make your case to the board, which presents some problems. If you talk about the general issues, you don't have time to justify your concerns with concrete examples. On the other hand, if you mention specific examples, you don't have time to speak to the overriding concerns. I have found it useful to mention the main concern in one or two sentences followed by 3-4 one-line examples that provide rationale for the concern. In addition, you must carefully practice your talk because, like at an APS meeting, you will be cut off after your 2 minute allotment.

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Despite my testimony and that of others, the CSS were approved. The criteria for adoption of K-8 science materials were also approved, which ultimately resulted in no inquiry-based or NSF-funded curricula being approved for adoption, in large part because they did not meet every CSS at a particular grade level.

During the discussion among SBE members following public testimony, I was quite surprised to find that some members viewed hands-on science education as unstructured and unscripted playing around with little or no rigorous learning occurring. From my perspective, it appeared that SBE members had never been exposed to high quality inquiry-based science education curricula, pedagogy, or research. This deficiency clearly needs to be addressed. So that policy makers at the state and district level can make informed decisions, the science education community needs to communicate the rationale and evidence for effective science education methodology to them. A recent article in the California School Boards Association magazine (Ref. 1) on science education may help in this regard.

The next major issue that arose a year or so later was the California Science Framework, a document that is meant to show how the CSS should be implemented in the classroom. I disagreed with many parts of the Framework, including:

- "science must be taught 'for the sake of science'" because it "disciplines the minds of students."
- "Ohm's Law, one of the guiding principles of physics..."
- "The life's work of many scientists is replicating other scientists' experiments in order to test their conclusion."

Well, once again, my testimony (and that of others) to the SBE to reject the Framework was ignored and the Framework was approved.

My most recent interaction with state science education policy concerned an issue that garnered national attention in 2004, including articles in the Washington Post and the San Jose Mercury News. Every seven years in California, the state adopts new science instructional materials for grades K-8, and sufficient time had passed since the last adoption that the state curriculum commission was tasked to develop new criteria for the adoption of K-8 science instructional materials. Among other things, these new criteria stated:

- "The only standards that may be referenced are the California Science Standards. There should be no reference to national standards or benchmarks or to any standards other than the California Science Standards."

- Curricula must show "A table of evidence in the teacher edition, demonstrating that the California Science Standards can be comprehensively taught from the submitted materials with hands-on activities composing no more than 20 to 25 percent of science instructional time …"

Since research-based hands-on science instructional materials generally use more than 25% of time for hands-on activities, this ruled out their ever being approved for adoption. And just to confuse the issue further, the new criteria also encouraged "publishers to select research-based pedagogical approaches."

Well, needless to say, this riled up more than a few folks in the science education community and spurred two major efforts. First, 3 different groups, consisting of science educators, university professors, and members of the business community, independently started emailing each other to try to formulate a strategy about how to deal with this issue. I brought these 3 groups together electronically so that we could present a united and cohesive front. Second, I worked closely with Bruce Alberts, President of the National Academy of Sciences, to develop a position paper on this issue that could be widely distributed; this culminated in a letter to the SBE opposing the new criteria that was signed by the chancellors of the University of California, Stanford, and the California Institute of Technology, and the CEOs of Intel, Bechtel, Adobe Systems, Genentech, and Pixar, and George Lucas. I had the privilege of reading this letter to the SBE at public testimony about this issue. The net result of these efforts and that of many others was that some of the most egregious issues in the criteria were modified. The most significant was that the revised criteria now read, in a major reversal of policy, that instructional materials must "include hands-on activities composing at least 20 to 25 percent of the science

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instructional program." But you still can't mention any standards but the California standards.

How do these things happen? State committees and commissions are often greatly influenced by just a few people in positions of power or influence. In California, an influential member of various commissions has stated (Ref. 2): "What has been left unsaid is that real scientists don't actually spend very much of their day "observing" and "measuring." They read! Reading for understanding of content is the core process skill of science, and there is no substitute for practice at an early age. … Hands-on investigative activities ought to be sprinkled into a science program like a 'spice'; they cannot substitute for a 'main dish'. The best "hands-on" program would be one in which students can get their "hands on" an informative textbook!"

So what enduring lessons can be gleaned from these experiences?

I have found that testifying at the meeting where the SBE must make their decision to approve or reject the policy issue in front of them to be only marginally effective. There are 2 reasons. First, most SBE members have thought about the issue, are at least somewhat aware of both sides of the issue, and generally seem to have their minds made up prior to the meeting. Therefore it is prudent to send comments to SBE members well in advance of their meeting to educate them on the upcoming topic. Second, the state has a strict timetable that the SBE is not inclined to disrupt. For example, the timetable for textbook adoptions requires approved adoption criteria by a certain date.

On the other hand, getting involved can make a major difference, as in the case noted above where the criteria were altered from "no more than" to "at least" 25% hands-on science. This change will presumably result in hands-on science programs being adopted for use in California in the near future, ending a 7-year drought.

I'd recommend that scientists interested in improving K-12 science education take a critical look at their state's standards, framework, criteria for adoption of instructional materials, and the materials actually adopted. These are real constraints that affect every classroom teacher and student. If you determine that changes are in order, find out when or if the state has scheduled a review or revision of the item and become involved in that process. It takes significant effort to navigate the complexity of state science education policy, but the payoff is certainly worthwhile.

References:

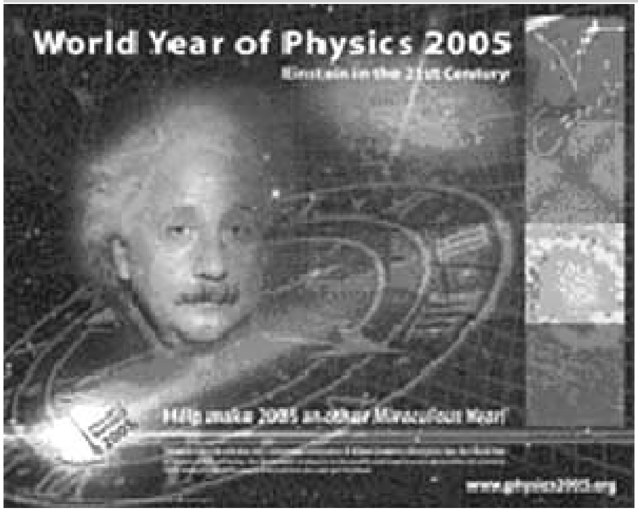
1. http://www.csba.org/csmag/Spring05/csMagStoryTemplate.cfm?id=65

2. http://www.usc.edu/hsc/dental/ccmb/usc-csp/Metzebergdiscussion.pdf

For more information about the activities discussed in this article, go to: http://www.sci-ed-ga.org and click on "K-12 education."

For additional information about California instructional materials adoptions, go to: http://www.cde.ca.gov/ci/cr/cf/imagen.asp

Lawrence Woolf is a research physicist and program manager at General Atomics. As part of his voluntary education efforts, he has written numerous education modules, developed a variety of education materials, performed curriculum reviews for NSF-funded middle and high school science programs, and participated in many NSF education review panels.



World Year of Physics 2005 *Jessica Clark, American Physical Society*

History

The celebration in 2005 of the World Year of Physics was proposed by the European Physical Society in 2000 to commemorate the 100th anniversary of 1905, Einstein's "miracle year" during which he published an incredible series of scientific papers, remarkable for their breadth and enduring consequences. He took the first step toward a theory of space and time, known as Special Relativity, built the foundation for the quantum theory of light with an analysis of the photoelectric effect, provided the definitive proof of the existence of atoms by his explanation of Brownian motion, and ended that remarkable year by identifying the equivalence of matter and energy, encapsulated in the world's most famous equation, $E = mc^2$. The International Union of Pure and Applied Physics (IUPAP) passed a resolution during its 2002 General Assembly in Berlin, Germany, declaring 2005 the "World Year of Physics." On June 10, 2004 the General Assembly of the United Nations declared 2005 the "International Year of Physics" and the 108th Congress of the United States passed resolutions declaring 2005 the World Year Of Physics.

Purpose

Physics organizations around the globe are planning a variety of programs in 2005 to raise public awareness of the contributions of the physics discipline and to promote the study of physics. In the United States, the phrase "Einstein in the 21st Century" has been added to emphasize that his discoveries are relevant for science in this century.

Key Collaborations in US

While the APS serves as the lead organization for the World Year of Physics 2005 in the United States, the year would not be possible without the joint efforts of the entire physics community—AIP, AAPT, SPS, NASA, NIST, the National Science Foundation, the Department of Energy's Office of Science, and innumerable others. At the APS, the World Year of Physics Team consists of Jessica Clark, James Riordon, Vinaya Sathyasheelappa, Alan Chodos, Judy Franz, and inexhaustible interns.

<u>APS Projects</u>

National office-driven projects are PhysicsQuest for middle schools, Radius of the Earth/Eratosthenes for high schools, Physics on the Road for schools at all levels, and Einstein@Home for everyone.

PhysicsQuest

Arranged as a treasure hunt, PhysicsQuest was a set of four experiments designed to promote awareness of basic physical principles in the areas of harmonic motion, the diffraction of laser light, magnetism, and soap bubble configurations on a wire frame. It was made possible by financial support from the NSF, the Department of Energy's Office of Science, and Cadmus Communications. Over 5,000 participating classrooms received a kit with experimental materials, including a diffraction grating and laser, an in-depth teacher's guide with treasure maps and activity handouts, and a 7-minute video featuring an actor playing Albert Einstein describing the wonders of solving puzzles and mysteries with physics.

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Using these materials the students determined the exact time of day and the position on the grounds of the Institute for Advanced Study in Princeton, NJ where a "treasure" will be delivered. A classroom was randomly selected from the submitted results to travel to the IAS and receive the prize.

At the appointed time and place on May 21, nine students from the physical science class at St. Albert Catholic Schools in Council Bluffs, Iowa were presented with iPod Shuffles and a five-inch programmable telescope for their classroom. Incidentally, these students had chosen to participate in the PhysicsQuest as an extra-credit assignment.

They worked on it before and after school for a week. Given the success of this project and the availability of resources, PhysicsQuest will run again in Fall 2005, and we hope to be able to continue with new PhysicsQuest projects each year.

Eratosthenes

The Eratosthenes Project challenged high school students to measure the size of the Earth using shadows.

Over 700 high school classrooms from across the US, Canada, and Mexico were paired together. Each pair measured the angle of the sun, in the same way that the Greek philosopher Eratosthenes did more than 2000 years ago in Alexandria, Egypt—by comparing the length of an object to the length of its shadow, measured at local noon.

The students calculated Earth's radius using the known north-south distance between the two schools and the angle of the sun at each location. Using the data submitted by participating classrooms, a grand average result was determined to be 6563 km, only 6% off from the accepted value of 6371 km—not bad for a stick, a shadow, and a little mathematics! For participating, each teacher was sent a commemorative certificate and World Year of Physics lapel pins for their students.

The winning class watches a physics demo show at the Institute for Advanced Study.

The winning class (and teachers) meets with John Bahcall at IAS.

Community-Driven Projects

There are many other projects organized independently throughout the physics community. Virtually

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every physics-oriented organization within the AIP member societies have organized programs or raised awareness of the World Year of Physics celebration. For example, the Optical Society of America (OSA) displays an enormous banner with the World Year logo on the side of their building facing the main exit to one of the busiest subway stops in Washington, D. C. It is hard to imagine that anyone who uses that exit is unaware of the World Year of Physics.

The events and programs organized by the physics community are numerous and varied. The APS-maintained website, http://www.physics2005.org/, tracks these events using the Event Finder. There are also event ideas for those still wishing to organize something before the end of the year. The website serves as THE resource in the US for information on the World Year of Physics. The site is maintained by Vinaya Sathyasheelappa (vinaya@aps.org), the World Year of Physics 2005 Coordinator.

***Dr. Jessica Clark** has been trying to figure out how the world works since age five when she determined that, given the size of Earth and the number of children living on it, there could be no Santa Claus (much to the dismay of her 10-year-old brother). Since then, Jessica received her B. S., M.S., and Ph.D. in physics from the College of William and Mary in Virginia. Her research involved studying the internal workings of the proton, one of the basic building blocks of the atom. Jessica now works to bring the excitement of physics to the public as the American Physical Society's public outreach coordinator and as the editor of PhysicsCentral.com. With the World Year of Physics 2005 (a global celebration of Albert Einstein's annus mirabilis), Jessica works to bring an understanding of Einstein's importance in our everyday lives to the public. clark@aps.*

Undergraduates Celebrate the World Year of Physics!

Gary White, American Institute of Physics

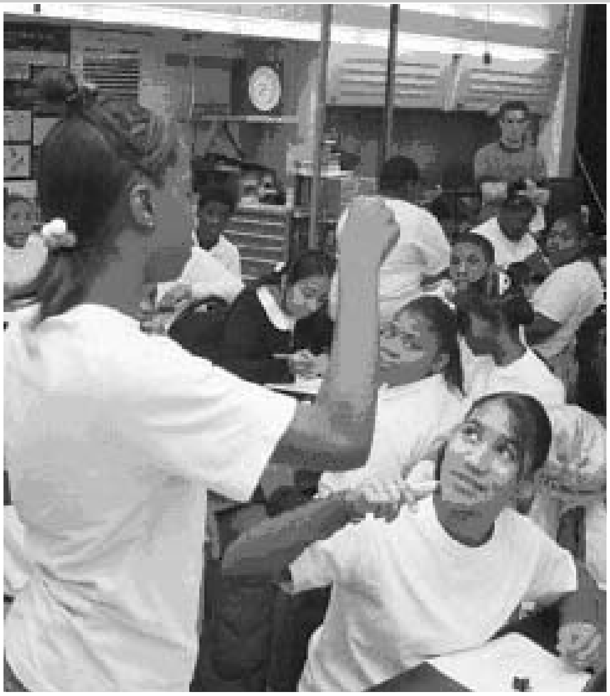
The celebration of Einstein's Miracle Year is about half over, but it seems as though physics students nationwide have already indulged in a full year or more of activities. Loads of outreach events, regional physics meetings, and research events mark this year as an exceptionally good time to be doing physics.

Outreach Engages Thousands in Science

Imagine a roomful of kids eagerly connecting wires to batteries and bulbs to see if their prediction for making light is right. If this image seems unlikely to you, just ask the physics students at Chicago State University for help in visualizing it. Geraldine Cochran, Tim Vanderleest and Virginia Hayes wrote the outreach proposal funded by the SPS through the Marsh White Outreach Award program, with guidance from Professors Mel Sabella and Justin Akujieze. They have a knack for this stuff, including middle school and high school visits, a rocket-launch, and science fair assistance. To see more about their efforts and those of other groups, see http://www.spsnational.org/programs/mwrecipients04.htm

Hundreds of Undergraduate Physicists meet in 2004-5

Want to know where a great swath of future physics graduate students can be found? Try an SPS zone meeting where undergraduate physics majors share their research, listen to cutting edge physics talks, and socialize. There were 17 zone meetings across the country this past year like the one below in Louisiana, complete with student presentations from nine campuses, a public Einstein lecture, and a crawfish boil!

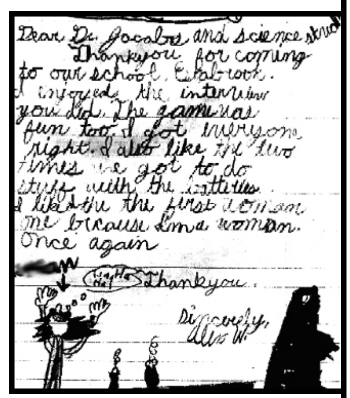


As another example, check out the SPS Zone 3 Spring Meeting at http://www.spsnational.org/societynews/zone_03_report.htm, which was hosted by The College of New Jersey with help from Drew University. There were 87 participants from the following institutions: Drew University, East Stroudsburg University, Georgian Court University, Lehigh University, Lycoming College, New York University, Rider University, Rutgers University at Camden, Seton Hall University, The College of New Jersey and the University of Delaware. Events included a tour of the laboratories and a riveting question-and-answer session with four recent physics graduates who had progressed in non-traditional physics careers. For details from other zone meetings, see www.spsnational.org/societynews/meetings.htm .

Undergraduate Research Involves Thousands

Thousands of undergraduates participate in physics research each year, some at their own campus and others through the NSF supported Research Experiences for Undergraduates (REU) program. When it is time to present their research many students choose to participate in national physics meetings such as the recent APS meeting in Tampa Bay. Students from the University of Central Florida descended upon the meeting as well and submitted a full report, including an interview with string theorist and author Brian Greene http://www.spsnational.org/societynews/aps_05april_report.htm

Another class at Estabrook Elementary in Ypsilanti, Michigan, was really impressed with the electrifying science exhibits "Zap It!" led by Dr. Diane Jacobs and her students at Eastern Michigan University; one student showed her enthusiasm in a handwritten letter (at right) that speaks volumes. For more details go to http://www.spsnational.org/programs/


Dear Dr. Jacobs and science stud
Thankyou for coming
to our school, Estabrook.
I enjoyed the interview
you did. The game was
fun too. I got everyone
right. I also like the two
times we got to do
stuff with the batteries.
I liked the the first woman
me because I'm a woman.
Once again
Thankyou.
Sincerely,
Alex W.

Want to know more about bucky-dumbbells? Ask Olga Ovchinnikov, an undergraduate at the University of Tennessee working with Dr. Robert Compton. What about the ascending double cone? Sohang Gandhi at the University of Central Florida, working with Dr. Costas Efthimiou, has completed the definitive treatment of this ubiquitous science demonstration. Sohang is kneeling at right in the photograph, posing with the rest of the APS undergraduate presenters and their glowing WYP2005 LED pens.

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How do you get your students involved?

Who can resist a Top Ten List, especially when it chock-full of ways to get your students engaged in the World Year of Physics? Try some of these ideas out for size:

Top ten ideas for celebrating the World Year of Physics:

10) Solve a physics problem to win prizes; see the Physics Challenges at http://scitation.aip.org/tpt/

9) Put a WYP message and the website in your email salutations. www.physics2005.org

8) Sponsor a local physics trivia contest, http://www.physics2005.org/events/physicstrivia/questions.pdf

7) Get a free Einstein poster as long as supplies last; email us sps@aip.org

6) Join in the WYP discussion threads at The Nucleus, www.compadre.org/student

5) Conduct your own science demonstration event in a local school or mall. Get ideas here: http://www.spsnational.org/programs/mwrecipients05.htm

4) Attend an SPS Zone meeting (http://www.spsnational.org/societynews/meetings.htm)---there were 17 last year, so there's probably one near you this year

3) Check out the WYP events calendar, or post your own event at http://www.physics2005.org/events/index.html . There's something for everyone, from drama and music to pumpkin flinging and open houses to conferences and renowned lecturers.

2) Go shopping for WYP T-shirts, WYP promotional kits, cool multi-LED pens, etc. Email us at sps@aip.org or see http://www.spsnational.org/societynews/2005WYP_shirts.htm

And the number 1 way to celebrate the World Year of Physics is…

1) Detect gravity waves! Sign up for Einstein@Home; see http://einstein.phys.uwm.edu/ for details. (next article)

Gary White received his Ph.D. in nuclear theory at Texas A & M University (TAMU) in 1986, but would rather talk about his more recent work on the physics of Spandex. Lately, his interests have also migrated towards pedagogy, especially the use of science research as a teaching and outreach tool. In addition to a 3-year stint teaching mathematics at TAMU, he has taught physics and astronomy at Northwestern State University of Louisiana, and now is the Director of the Society of Physics Students and the Assistant Director of Education for the American Institute of Physics.

Einstein@Home: Astrophysics for the Masses

James Riordon, American Physical Society

One of the great challenges the physics community and scientists in general face is informing the general public about the importance of scientific research, both for our future and in our everyday lives. Formal classroom education and informal educational efforts are among the time tested ways to address the challenge. In recent years, however, new ideas have been developed that go beyond simply educating the public. Distributed computing projects allow anyone who owns a personal computer to make a real and vital contribution to scientific research. Such projects often include informal science education components. Perhaps more importantly, people who join the computing efforts are participating in real scientific research and developing increased appreciation for the benefits that science offers.

It is with these things in mind that the American Physical Society spearheaded the launch of the world's first physics research-based distributed computing project, Einstein@Home, as one of the cornerstone projects for the World Year of Physics 2005. Einstein@Home relies on donated computational power from private PCs to analyze gravitational wave data for signals emanating from extremely dense, rapidly rotating neutron and quark stars.

Einstein's General Theory of Relativity predicts that accelerating massive objects should radiate gravitational waves. New detectors in the US and Europe have now been built to detect those waves. Supernova stars, colliding black holes, and other violent events likely produce the largest gravitational bursts and are good candidates for detectable signals.

Rotating quark stars and neutron stars should also emit gravitational waves, if they are not perfectly spherical. Unlike the sudden bursts of violent events, rotating aspherical objects would create continuous gravitational waves, at twice the objects' rotational frequencies. The signal frequencies would gradually decrease as gravitational radiation saps the rotational energy. This phenomenon has already been confirmed circumstantially through the observation of the spin down of binary star pairs. Detecting continuous waves with gravitational observatories, however, presents extraordinary computational challenges.

Some known pulsars may emit gravitational signals, but it is likely that most strong sources of continuous gravitational waves are not detectable via conventional astrophysical observation techniques, such as visible, x-ray, or radio astronomy. Ideally, researchers would like to perform whole sky, point-by-point searches for continuous wave sources. The computational demands of this kind of search would be daunting even for the most powerful supercomputers currently in existence.

Distributed computing projects have recently been developed to address certain types of computationally intensive problems by tapping into the excess computational power of privately owned PCs. SETI@Home is one of the first and most popular distributed computing efforts. Participants install a screensaver-based program that downloads and analyzes small portions of data collected from the Arecibo radio antenna in Puerto Rico to search for signals indicative of intelligent activity in space. Other distributed computing projects are currently underway to model protein folding (Folding @Home), search for prime numbers (the Great Internet Mersenne Prime Search), and model the Earth's climate (ClimatePrediction.net). The computational capacities of SETI@Home and several other projects currently exceed the power of the world's fastest supercomputer, IBM's BlueGene/L, sometimes by factors of two or three. Typical distributed computing projects achieve their capacities by involving tens to hundreds of thousands of PC owners. Clearly, the potential for large computational capacity and extensive public participation makes distributed computing an ideal tool for scientific research, public outreach, and informal education.

In early 2004, the APS World Year of Physics team approached LIGO spokesperson Peter Saulson with a proposal to promote a distributed computing effort for gravitational data analysis as a flagship project in the World Year of Physics 2005 celebration. By mid 2004, Bruce Allen of the University of Wisconsin-Milwaukee was leading an international team of scientists and engineers in writing code and assembling hardware for the project. Primary institutions contrib-

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uting to the project include the LIGO Scientific Collaboration (LSC), the Albert Einstein Institute in Berlin, the University of Glasgow, the Massachusetts Institute of Technology, and the University of Pennsylvania. Allen and LSC director Barry Barish officially announced the launch of Einstein@Home on February 19, 2005.

Einstein@Home, like SETI@Home, is a screensaver-based program. Participants obtain software from the Einstein@Home web page. After they install it, the program downloads several megabytes of gravitational wave data. When a personal computer is idle for a period of time specified by the computer user, the Einstein@Home screensaver is activated and the data analysis algorithm runs. The program automatically uploads the analysis results to one of the Einstein@Home servers and requests more data.

The Einstein@Home screensaver displays a rotating image of the celestial sphere with the major constellations outlined. Red points on the sphere indicate locations of supernova remnants, and purple points indicate known pulsars. Three L-shaped markers represent the directions that the gravitational wave observatories that contribute data to Einstein@Home are pointing: a small red marker represents the 600 meter GEO600 interferometer observatory in Hanover Germany; a green marker represents the 4 km interferometer in Livingston Louisiana; and a blue marker represents the 2 km and 4 km interferometers in Hanford, Washington. A moving, gun sight marker indicates the locations in the sky where the computer is actively searching for gravitational wave signals.

Einstein@Home was built on the Berkeley Open Interface for Network Computing (BOINC), a distributed computing framework developed by SETI@Home pioneer David Anderson. The BOINC-based system allows users to contribute to multiple distributed computing projects, in proportions that the user selects. This allows people who currently subscribe to SETI@Home and other projects to dedicate a portion of their computer's time to Einstein@Home as well.

In a matter of four months Einstein@Home has become one of the largest and fastest growing distributed computing projects in the world. As of June 1, 2005, over 80,000 people had signed up to participate in Einstein@Home, and nearly 45,000 participants, representing approximately 140 countries, have completed at least some data analysis. The project typically analyses data at a rate of about 80 teraFlops (80 trillion floating point operations per second) or more, significantly outpacing IBM's record-setting BlueGene/L (70 teraFlops).

An informal survey indicates that most of the Einstein@Home participants are male scientists and engineers. The APS is currently working to diversify the user base through paid advertising, direct mailing, and media promotion. Articles featuring Einstein@Home have appeared in major newspapers and magazines around the world, and the project has been the subject of numerous radio and television broadcasts.

Einstein@Home presents an ideal opportunity for formal and informal education. Message boards on the Einstein@Home web page host lively discussions of physics at levels ranging from elementary introductions to graduate student subjects. Instructors at the Southern University of Baton Rouge reported at the 2005 APS annual meeting in Tampa, Florida that Einstein@Home has helped increase student interest and enrollment in physics classes addressing gravitation and related topics. In Israel, Zvi Paltiel of the Weizmann Institute of Science has organized explanatory material in Hebrew and arranged lectures and workshops encouraging high school students to join Einstein@Home.

It is particularly appropriate, as we celebrate the centennial of Albert Einstein's annus mirabilis, that Einstein@Home is helping to search for signs of gravitational waves predicted by Einstein's Theory of Gen-

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LIGO Hanford WA

LIGO Livingstone LA

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eral Relativity. Although Einstein did not complete it until 1916, the path to General Relativity began with his work on Special Relativity in 1905.

Einstein's miraculous year serves as the inspiration for the World Year of Physics 2005 celebrations, but Einstein@Home will live on after the celebrations conclude. With a little luck, the program will begin to find gravitational sources in coming years. Regardless of the ultimate outcome, the project will continue to grow as a vital scientific, educational, and outreach effort.

To learn more about Einstein@Home and join the project, visit the World Year of Physics 2005 home page at www.physics2005.org.

James Riordon is the head of media relations for the American Physical Society. He was responsible for the initial conception of Einstein@Home as a World Year of Physics 2005 project. He worked as a free-lance science writer for seven years prior to his position at the APS, and began his career as an applications physicist with the short-lived Superconducting Super Collider in Waxahachie, Texas.

4 Corners States High School Students celebrate WYP

Hans Dieter Hochheimer

The Four Corners Section of the American Physical Society has organized a High School Essay competition in the 4 Corners States. The topic is "Einstein in the 21st Century." We received a $400 mini grant from the Forum of Education of the APS, which has helped enormously to start a successful drive for additional financial support. We have received about 200 entries and are now in the process to judge the entries. There will be one winner from each state. The winners will be invited to participate in our annual meeting, October 14-15, 2005 in Boulder, Colorado, where they will present their winning essay and receive and award of $ 100 each. The names of the winner and the title of their winning essay will be published.

Section on Teacher Preparation

A Note from the Teacher Preparation Section Editor

Chance Hoellwarth

In many cases, the most direct influence we have on future teachers is through undergraduate physics courses. In the first article in this issue, Lillian McDermott, Paula Heron and Peter Shaffer discuss how existing courses often fail to meet the needs of future teachers. They argue that special courses are needed both for K-8 teachers (instead of standard introductory courses) and for high school teachers (in addition to standard introductory courses). The next two articles describe courses and curricula designed especially for future elementary teachers based on Physics by Inquiry and Physics for Elementary Teachers.

Chance Hoellwarth is Assistant Professor of Physics at California Polytechnic State University (Cal Poly), San Luis Obispo.

Preparing K-12 teachers to teach physics and physical science

Lillian C. McDermott, Paula R.L. Heron and Peter S. Shaffer

The task of preparing K-12 teachers to teach science is an important (though often unacknowledged) responsibility of science faculty. In recent years, a steadily increasing number of physics departments have begun to recognize the need to take a more active role in the professional development of K-12 teachers of physics and physical science. The APS and AAPT, together with the AIP, have endorsed this trend with supportive statements and with a proposal to NSF that led to the creation of PhysTEC. However, if these developments are to lead to a long-lasting positive impact, it is necessary to recognize the inadequacy of the preparation usually offered in physics departments and to reflect on the characteristics of instruction that has been shown to be more effective.

I. Inadequacy of current preparation in physics departments

Most physics departments do little for prospective elementary and middle school teachers. The only courses generally available are almost entirely descriptive. A great deal of material is presented, for which these students have neither the background nor the time to absorb. The net effect is to reinforce a tendency to perceive physics as an inert body of information to be memorized, not as an active process of inquiry. The addition of “hands-on” activities is not enough to prepare elementary school teachers to teach basic physical science in a way that is meaningful to their students.

Most high school physics courses are taught by teachers who have not majored in the subject. Often they are not much better prepared than university students who have taken a standard introductory course. Although this course covers the content of high school physics, it is not adequate preparation for teaching the same material. The breadth of topics allows little time for acquiring a sound grasp of the underlying concepts. The routine problem solving that characterizes most introductory courses does not develop the reasoning ability necessary for handling the unanticipated questions that may arise in a classroom. The accompanying laboratory courses generally do not address the needs of teachers. Often the equipment is

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not available in high schools and no provision is made for laboratory experiences that utilize simple apparatus. A more serious shortcoming is that experiments are mostly limited to verification of known principles. Students have little opportunity to start from their observations and go through the reasoning involved in formulating these principles. It is possible to complete a laboratory course without confronting critical conceptual issues or having experience with the scientific process.

The relatively few students who decide early that they want to teach physics in high school may major in physics (perhaps with fewer course requirements). However, the abstract formalism that characterizes upper division courses is not of immediate use in the precollege classroom. Courses on "cutting-edge" topics may be motivational but do not help teachers distinguish between memorization and substantive understanding.

It is tempting to believe that enriching the standard introductory physics course with innovative, research-based materials will adequately prepare future high school teachers. Such "reformed" courses may be more engaging than standard courses but they fail to address many of the intellectual issues that confront high school teachers of physics. Moreover, most physics courses have a major shortcoming. Many teachers cannot, on their own, separate the physics they have learned from the way in which it was presented. If taught by lecture, they are likely to lecture, even if it is inappropriate for their students.

II. Need for special physics courses for teachers

Neither a modified descriptive course for elementary teachers nor a reformed introductory course for high school teachers offers the right type of preparation. There is a need for special physics courses for teachers from the elementary through high school grades. These courses should be laboratory based and have intellectual objectives and an instructional approach that are mutually reinforcing. The topics should be relevant to the K-12 curriculum and taught in a manner that is consistent with how teachers are expected to teach. This perspective on teacher preparation results from a distillation of what the Physics Education Group at the University of Washington has learned from more than 30 years of experience in preparing preservice (future) and inservice (practicing) teachers to teach physics and physical science at the elementary, middle, and high school grades. [1]

A. Intellectual Objectives

Teachers should be given the time and guidance necessary to develop concepts in depth and to construct a coherent conceptual framework. They need to be able to formulate and apply operational definitions so that they can recognize precisely and unambiguously how concepts differ from one another and how they are related. Such conceptual clarity is not the outcome of a typical introductory course but is vitally important for teachers.

There is ample evidence by now from research that success on numerical problems is not a reliable indicator of functional understanding, (*i.e*., the ability to do the reasoning underlying the development and application of concepts). [2] Although high school teachers should be able to solve the types of problems found in typical introductory texts, the emphasis in courses for K-12 teachers should not be on mathematical manipulation. The development of quantitative reasoning ability, which should be a goal at all grade levels, does not automatically occur before or after enrollment in college. For example, it has been shown that students in university physics courses often cannot reason with ratios and proportions. [3] The ability to do proportional reasoning and interpret the meaning of a ratio in terms of physical quantities (*e.g.,* g/cm^3) is a critically important skill for all who teach science from elementary through high school. Teachers should also be able to use and interpret formal representations (such as graphs, diagrams, and equations) that are appropriate to the grades that they teach. They should be able to relate representations to one another, to physical concepts, and to real world phenomena.

An understanding of the nature of science should be an important objective for all teachers. They must be able to distinguish observations from inferences and to do the reasoning necessary to proceed from observations and assumptions to logically valid conclusions. They need to recognize what is considered evidence in science and what is meant by an explanation.

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They should understand what is meant by a scientific model – how it is constructed and used and what its limitations are. Teachers need to be given the opportunity to examine the nature of the subject matter, to understand not only what we know, but on what evidence and through what lines of reasoning we have come to this knowledge. The scientific process is most effectively taught through direct experience.

The objectives above are appropriate for all students but expectations for teachers should be greater. They need to have a deeper conceptual understanding than their students are expected to achieve. They must be able to set learning objectives that are intellectually meaningful and developmentally appropriate for their students. They need to be able to recognize and learn how to help students overcome difficulties that research has shown to be common. They must develop the judgment necessary to evaluate instructional materials (*e.g.,* science kits, textbooks, laboratory equipment, and computer-based tools). This type of pedagogical content knowledge is not developed in standard physics courses, nor in science methods courses offered by departments of education.

B. Instructional Approach

If the ability to teach by inquiry is a goal of instruction, teachers need to work through a substantial amount of content in a way that reflects this spirit. A useful instructional approach for this purpose can be summarized as guided inquiry. Teaching is not by telling but by asking carefully structured questions to help students do the reasoning required to develop a functional understanding.

Science instruction for young students is known to be more effective when concrete experience establishes the basis for the construction of scientific concepts. [4] We and others have found that the same is true for adults, especially when they encounter a new topic or a different treatment of a familiar topic. Therefore, instruction for prospective and practicing teachers should be laboratory-based. However, "hands-on" is not enough. Unstructured activities do not help students construct a coherent conceptual framework. Carefully sequenced questions are needed to help them think critically about what they observe and what they can infer. When students work together in small groups, guided by well-organized instructional materials, they can also learn from one another.

The instructional materials in a course for teachers should be consistent with those used in K-12 science programs, but the curriculum should not be identical. As mentioned earlier, a course for teachers should develop an awareness of common student difficulties. Some are at such a fundamental level that, unless they are effectively addressed, meaningful learning of related content is not possible. Serious difficulties cannot be overcome through listening to lectures, reading textbooks, participating in class discussions, or consulting references. Like all students, teachers need to work through the material and have the opportunity to make their own mistakes. When difficulties are described in words, teachers may perceive them as trivial. Yet we know that often these same teachers, when confronted with unanticipated situations, will make the same errors as students. As the opportunity arises during the course, the instructor should illustrate instructional strategies that have proved effective in addressing specific difficulties. Without specific illustrations, it is difficult for teachers to envision how to translate a general pedagogical approach into a specific strategy that they can use in the classroom.

Because it is critical that teachers be able to communicate clearly, group discussions and writing assignments should play an important role in a physics course for teachers. Providing multiple opportunities for teachers to reflect upon and to describe their own conceptual development can enhance both their knowledge of physics and their ability to formulate the kinds of questions that can help their students deepen their understanding.

III. Implementation of special physics courses for teachers

There are a number of challenges that must be met in implementing a teacher preparation program in a physics department, especially at a large, research-oriented university. The argument may have to be made to the department and higher administrative units that the proposed courses are at an intellectual level worthy of the credit offered. It is necessary to

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show that the demands on the students match, or exceed, those of other physics courses at comparable levels. There are also other complications. Laboratory-based instruction is necessary and classes must be small enough to foster interaction among the students and between the students and instructor. Such classes are more expensive than large lectures but are a worthwhile investment for teachers whose potential influence is much greater that that of other students. Another problem may be low class enrollment. In particular, it is often difficult to identify future elementary school teachers. They are unlikely to decide, on their own, to take physics. This problem may be alleviated by encouraging the participation of non-science majors, for whom the course could satisfy a science requirement.

It is also unlikely that it will be possible to fill a class for prospective high school teachers with physics majors who plan to teach. Most high school physics teachers were not physics majors and, at best, may have majored in chemistry or mathematics. The situation among prospective teachers is similar. It is both practical and highly desirable that participation in the course by students majoring in other sciences and in mathematics be strongly encouraged. The course can be open to all students who have taken the standard introductory physics course. For science majors who may not be ready to make a commitment to high school teaching, it may be useful to add the course to the list of electives in their major. The range of preparation can vary broadly because the emphasis is not on quantitative problem solving but on concept development and reasoning. The presence of non-majors may help make the entire class more willing to forego a reliance on formulas and to think more deeply about the physics involved.

IV. Conclusion

The separation of instruction in science (which takes place in science courses) from instruction in methodology (which takes place in education courses) decreases the value of both for teachers. Even detailed directions cannot prevent misuse of excellent instructional materials when teachers do not understand either the content or intended method of presentation. Since the type of preparation that teachers need is not available through the standard physics curriculum, a practical alternative is to offer special courses for teachers. The instructors in such courses must have a sound understanding of the subject matter, of the difficulties that it presents to students, and of effective instructional strategies for addressing these difficulties. Unless faculty are prepared to devote a great deal of effort over an extended period to develop their own inquiry-oriented curriculum, they should take advantage of already existing instructional materials that have been carefully designed and thoroughly tested with teachers. Special courses may require additional resources but it is vitally important (and in their long-term interest) that physics departments make this investment in K-12 education.

Acknowledgments

The views expressed above are based on the work of many past and present members of the Physics Education Group, including K-12 teachers. Our comprehensive program in research, curriculum development and instruction has been supported by the University of Washington Physics Department and the National Science Foundation.

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2. See L.C. McDermott and E.F. Redish, "Resource Letter PER-1: Physics Education Research," *Am. J. Phys.* **67**, 755–767 (1999). Although most of the studies cited refer to students at the university level, similar difficulties have been identified among younger students.

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Physics by Inquiry: A research-based approach to preparing K-12 teachers of physics and physical science

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The Physics Education Group at the University of Washington (UW) has been conducting special courses for K-12 teachers for more than 30 years. We have developed a sequence of academic-year courses for prospective elementary and middle school teachers and another sequence for prospective high school teachers. [1] We also conduct an intensive NSF-funded six-week Summer Institute for Inservice Teachers that has similar goals. The materials used in both our preservice and inservice courses are drawn from *Physics by Inquiry (PbI),* a self-contained, laboratory-based curriculum that we have developed for use in university courses to prepare K-12 teachers to teach physics and physical science. [2] The emphasis in this paper is on elementary and middle school. However, most of the discussion is applicable to the preparation of high school teachers.

I. Illustration of research-based instructional approach

We have selected electric circuits as a context in which to illustrate the instructional approach that has guided our development of *PbI* and our special courses for teachers. This topic is included in all K-12 standards-based science curricula. In particular, activities based on batteries and bulbs are common in elementary school. The equipment is inexpensive. There is a solid research base and a documented record of effectiveness. [3] An additional motivation for this choice of topic is the availability of several published articles that should be helpful to faculty who may want to use the curriculum.

A. Investigation of conceptual understanding

Research by our group on student understanding of electric circuits has extended over a period of many years. Since the results are well known by now, only a brief discussion of one question is presented here. In Fig. 1 are three circuits containing identical bulbs and identical ideal batteries. The question asks for a ranking by brightness of the five bulbs and an explanation of reasoning. The correct response is A=D=E>B=C.

This question was administered to more than 1000 students in introductory calculus-based physics. Before or after standard instruction in lecture and laboratory, student performance was essentially the same. Only about 15% of the students have responded correctly.

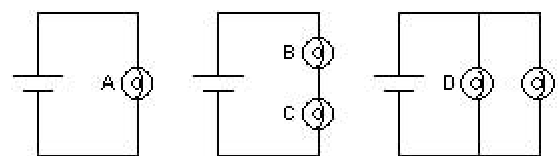

Figure 1: The five bulbs are identical and the batteries are identical and ideal. Rank the five bulbs from brightest to dimmest. Explain your reasoning.

The same question produced similar results when administered to high school physics teachers and to university faculty in other sciences and mathematics, all of whom had studied introductory physics. Analysis of the responses enabled us to identify specific difficulties. Two common mistaken beliefs were that the battery is a constant current source and that current is "used up" in a circuit. Most responses indicated lack of a conceptual model for a simple circuit. Reliance on rote use of inappropriate formulas was common. When the same question was posed to graduate students in the UW Physics Ph.D. program (many of whom are TA's in introductory physics), about 70% answered correctly. These findings motivated the development of the *Electric Circuits* module in *PbI* and the corresponding tutorial in *Tutorials in Introductory Physics*. [4]

B. Instruction by guided inquiry

To prepare teachers to teach the topic of electric circuits by inquiry, we engage them in the step-by-step process of constructing a qualitative model that they

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can use to predict and explain the behavior of circuits consisting of batteries and bulbs. [5] The students are guided through carefully sequenced activities and questions to make observations that they can use as the basis for their model. They begin by trying to light a small bulb with a battery and a single wire. They develop an operational definition for a complete circuit. Exploring the effect of adding more bulbs and wires to the circuit, they find that their observations are consistent with the assumptions that a current exists in a complete circuit and that the relative brightness of identical bulbs indicates the relative magnitude of the current. In other experiments—some suggested, some of their own devising—they find that the brightness of individual bulbs depends both on how many are in the circuit and on how they are connected to the battery and to one another. They construct the concept of electrical resistance and find that they can predict the behavior of many, but not all, circuits of identical bulbs. They recognize the need to extend their model beyond current and resistance to include the concept of voltage (later refined to potential difference).

As bulbs of different resistance and additional batteries are added, the students find that they need additional concepts to account for the behavior of more complicated circuits. They are guided in developing more complex concepts, such as electrical power and energy. Through deductive and inductive reasoning, the students construct a model that can account for relative brightness in any circuit consisting of batteries and bulbs. Throughout the entire process of model development, the curriculum addresses specific difficulties that have been identified through research.

Teachers need to synthesize what they have learned, to reflect on how their understanding has evolved, and to try to identify critical issues that need to be addressed for meaningful learning to occur. As they progress in their investigation of electric circuits, the students are given many opportunities to express their ideas in writing.

C. Assessment of effectiveness

Although many of the elementary teachers in our courses have had considerably less preparation in physics than students in the standard introductory courses, their performance on qualitative questions has been consistently better. The circuit in Fig. 2 provides a good example of what teachers without a strong mathematical background, but with good conceptual understanding, can do. The students are asked to rank the bulbs according to brightness. Reasoning on the basis of a model based on the concepts of current and resistance, almost all elementary teachers who have taken our courses predict correctly that E>A=B>C=D. This question is beyond the capability of most college and university students who have had standard instruction in introductory physics.

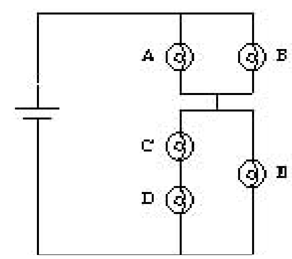

Figure 2: The five bulbs are identical and the batteries are identical and ideal. Rank the five bulbs from brightest to dimmest. Explain your reasoning.

Other evidence for the effectiveness of this approach comes from the University of Cyprus, where the performance of two groups of prospective elementary school teachers was compared. (Fig. 3.) Both groups were taught by instructors who understood the material well and who taught in a manner consistent with constructivist pedagogy (*i.e.,* the students were engaged in constructing their own understanding). One of the groups had studied electric circuits in *PbI.* [6] This group consisted of two classes: one had just completed study of the material; the other class had done so the previous year. The second group had just completed the topic. They had been given “hands-on” experience with batteries and bulbs but the instruction they had received had not been guided by findings from research. Specific difficulties had not been explicitly addressed nor had the same emphasis been placed on the development of a coherent conceptual model.

Both groups were given two types of post-tests: one consisted of free-response questions that asked for explanations of reasoning; the other contained multi-

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ple-choice questions taken from a multiple-choice test that has since been published. [7] Both classes of students who had studied the material in *Physics by Inquiry* had mean scores greater than 80% on both tests. In the other group, mean scores were slightly above 40% on the multiple-choice test and less than 20% on the free-response test. [8] Courses in which educational methodology is emphasized without sufficient emphasis on concept development seem to be no more effective than standard physics instruction.

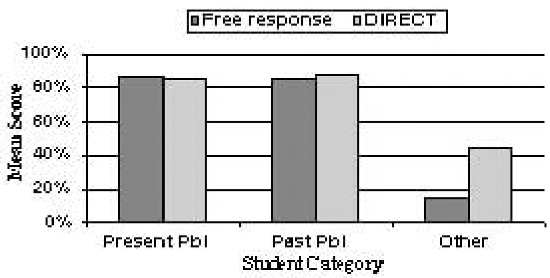

Figure 3: Student performance on free response and on multiple-choice questions on a post-instruction survey on electric circuits. The survey was administered to preservice elementary school teachers at the University of Cyprus. Two main groups of students were included in the survey: those who had used *Physics by Inquiry* (*PbI*) and those who had not. Some of the students had studied *PbI* one year before taking the test (Past *PbI*). All the others (Present *PbI* and Other) had just completed their study of this topic.

II. Courses in physics and physical science for teachers

Results from research convinced us of the need to offer special physics courses for teachers. In all of these courses, all instruction takes place in the laboratory. There is no lecturing and only simple equipment is used.

The course for elementary school teachers does not proceed through the traditional physics sequence (kinematics, dynamics, electricity and magnetism, waves and optics). Instead, the topics have been selected to provide a firm foundation for teaching elementary school physical science. The module *Electric Circuits* discussed above is one example. In *Properties of Matter,* which probably is the best module with which to begin a course for elementary school teachers, students begin by constructing operational definitions for mass, volume, and density. They apply these concepts in predicting and explaining outcomes in situations of gradually increasing complexity, culminating with sinking and floating. *PbI* also includes modules on heat and temperature, magnetism, light and color, the sun and moon, and other phenomena encountered in daily life.

In the course for high school teachers, the students revisit many of the main topics in the introductory physics course (which is a prerequisite). These include kinematics, dynamics, waves, optics, electric circuits, and a few topics from modern physics. Graduate students in physics, mathematics, and other sciences often participate in this course, either as enrolled students or TA's. The course has provided a very positive environment for the preparation of future faculty to work productively with K-12 teachers.

In all of the modules in *Physics by Inquiry,* there is a strong emphasis on the development of important scientific skills, such as distinguishing between observations and inferences, controlling variables, proportional reasoning, deductive and inductive reasoning, *etc. PbI* fosters the simultaneous development of physical concepts, reasoning ability, and representational skills within a coherent body of content. The teachers go through the reasoning in depth and are guided in synthesizing what they have learned into a coherent conceptual framework. Since effective use of a particular instructional strategy is often content-specific, instructional methods are taught by example. If teaching methods are not studied in the context in which they are to be implemented, teachers may be unable to identify the elements that are critical. Thus they may not be able to adapt an instructional strategy that has been presented in general terms to specific subject matter or to new situations.

In addition to the courses described above, we offer a weekly Continuation Course that is open to all teachers within commuting distance of the UW who have participated in any of our preservice and inservice courses. The Continuation Course provides an oppor-

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tunity for teachers to learn more physics and to consult on how best to apply what they have learned to K-12 classrooms. More importantly, the teachers develop a sense of community and mutual support. Teaching K-12 physics and physical science is often a professionally isolated activity. The Continuation Course has proved to be a major contributor to the long-term sustainability of our teacher preparation program.

III. Conclusion

The instructional approach, which has been illustrated in the context of electric circuits, has proved effective with teachers at all levels from elementary through high school. The process of hypothesizing, testing, extending, and refining a conceptual model to the point that it can be used to predict and explain a range of phenomena is the heart of the scientific method. It is a process that must be experienced to be understood.

We have been able to show that the demands in our courses for teachers match, or exceed, those of other physics courses at comparable levels. We have found that the sense of empowerment that results when teachers have developed a sound conceptual understanding of the science content that they are expected to teach greatly increases their confidence in their ability to deal with unexpected situations in the classroom.

Acknowledgments

This paper draws on the cumulative experience of past and present members of the Physics Education Group. Lezlie S. DeWater, and Donna Messina, K-12 teachers with our group, have made major contributions. We appreciate the support provided by the University of Washington Physics Department and the National Science Foundation.

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5. The instructional sequence can be found in the *Electric Circuits* module in Volume II of *Physics by Inquiry.* (See Ref. 2.)

6. A Greek edition of *Physics by Inquiry* was used.

7. P.V. Engelhardt and R.J. Beichner, "Students' understanding of direct current resistive electrical circuits," Am. J. Phys. **72**, 98-115 (2004).

8. This study is discussed in greater detail in the last article in Ref. 3.

Lillian C. McDermott, Peter S. Shaffer, and Paula R.L. Heron are faculty members in the Physics Education Group in the Physics Department at the University of Washington. The group consists of physics graduate students, postdocs, faculty and K-12 teachers who conduct a coordinated program of research, curriculum development, and instruction to improve student learning in physics (K-20). The group is engaged in ongoing research on the learning and teaching of physics that has resulted in more than 50 research articles. For more than 30 years, they have been deeply involved in the preparation of prospective and practicing teachers to teach physics and physical science by inquiry. The group has also published research-based tutorials to improve the effectiveness of instruction in introductory university physics.

Physics for Elementary Teachers: A New Curriculum

Steve Robinson, Fred Goldberg and Valerie Otero

In accordance with the No Child Left Behind (NCLB) act of 2002[a], it will soon be required that all elementary students are assessed in science content by the end of their fifth grade year. It is recognized that few elementary teachers are prepared for this, especially in the physical sciences. [1] Realizing this, many teacher preparation programs are replacing traditional science requirements for pre-service elementary teachers (usually a two semester sequence in any single lab science) with a cluster of one-semester content courses, including one in physics or physical science. Thus university physics departments are increasingly being called upon to implement a course exclusively for this audience. This can be quite a challenge since this is not the audience to which physics courses are traditionally targeted and it is desirable that such a course model the inquiry-based pedagogy that elementary teachers are expected to use in their own classrooms. Further, physics faculty may be unfamiliar with these inquiry-based methods of teaching.

The Physics for Elementary Teachers (PET) curriculum[b] has been designed to address this challenge. It can be taught as a one-semester (75 hour) university course for prospective elementary teachers, or adapted for use as a workshop for practicing teachers. The course uses a learner-oriented, guided inquiry-based pedagogy that helps prospective and practicing teachers develop a deep understanding of physics ideas that are closely aligned with those they will be expected to teach in their own classrooms. A unique aspect of the course is that it also contains embedded components that allow students to examine important aspects of the effective learning of science in three contexts; that of their own learning, the learning of elementary students, and the processes by which scientists develop knowledge.

The development of the PET curriculum was guided by current research on how students learn most effectively. For each learning goal, PET provides a sequence of activities designed to elicit and build on students' prior knowledge, to provide opportunities for them to test their initial ideas, and to guide them towards the development of ideas that are closely aligned with the ideas of scientists. In the PET classroom, students spend most of their time working in small groups, performing experiments, manipulating computer simulations, making sense of their observations, and then sharing ideas in whole class discussions. The instructor's role is to guide whole class discussions, to help set classroom norms that support the development of ideas based on evidence, and to promote participation by all students.

The physics learning goals for the PET course were selected from the middle school level of the National Science Education Standards [2] and the AAAS Benchmarks for Scientific Literacy [3], with a special emphasis on those with strong connections to the elementary level. Overarching themes of interactions, energy, and forces were chosen to give the curriculum an integrated, coherent, structure. The curriculum also addresses, both implicitly and explicitly, benchmarks and standards associated with the nature of science. In addition, the learner-centered pedagogical structure of the curriculum aligns well with national standards for teacher professional development·

The PET curriculum is centered on the theme of interactions between objects/systems. PET students describe each observed interaction in terms of energy changes and transfers. They also use "energy diagrams," which are graphic representations of their descriptions (Figure 1). The complexity of these descriptions is scaffolded throughout the entire curriculum, starting with simple changes in kinetic energy in interactions between rigid bodies, and ending with more complex situations in which there are chains of interactions happening in parallel, with several different types of energy changes and transfers occurring simultaneously. The construction of verbal and written explanations is also scaffolded through the curriculum. Initially PET students are given substantial guidance, in the form of model explanations, guiding questions, and practice in critiquing others' explanations. This support is gradually faded until finally they are simply presented with a phenomenon to be explained with little or no guidance.

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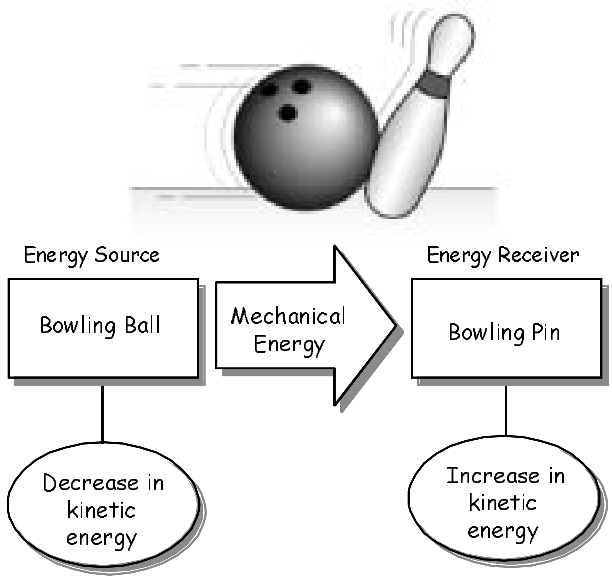

Figure 1: A moving bowling ball strikes a stationary bowling pin. In terms of energy, during this interaction the bowling ball (energy source) decreases in kinetic energy and transfers mechanical energy to the bowling pin (the energy receiver). The bowling pin increases in kinetic energy.

A part of the curriculum is devoted to helping students develop ideas equivalent to Newton's 1^{st} and 2^{nd} Laws, describing the effect of interactions on the motion of an object in terms of the external forces exerted on it. It is well known that many students have ideas that mix together the scientific concepts of force and energy, and so the PET curriculum pays particular attention to helping students differentiate these ideas, yet still see the close connection between them. The idea of a 'field of influence' is introduced to explain action-at-a-distance forces, but is also used in the energy description of such interactions, in which the field itself becomes a source or receiver of energy.

The first six cycles of activities in PET address physics content learning goals in the areas of mechanical interactions, force and motion, gravity, magnetism, electric circuits and electromagnetism, light and heat. The final short cycle revisits many of the interactions examined earlier in the course and starts by developing ideas of transient and equilibrium states in a system. The cycle concludes with students developing a quantitative description of energy conservation by using a special tool in the computer simulators (Figure 2). Each cycle consists of a set of activities in which students are guided to develop their own ideas by trying to explain the outcomes of experiments, and by coming to consensus as a class. At the end of the idea development process students are given a 'Scientists' Ideas' sheet to confirm to them that the ideas they have developed are closely aligned with those of the scientific community. The final activity in each cycle allows students to practice applying their newly developed ideas to explain both familiar and new phenomena. The curriculum makes extensive use of embedded homework assignments to help students develop, and practice using, their ideas. These homework assignments often involve using web-based computer simulators, or watching short movies of simple experiments, provided on a 'Student Re-

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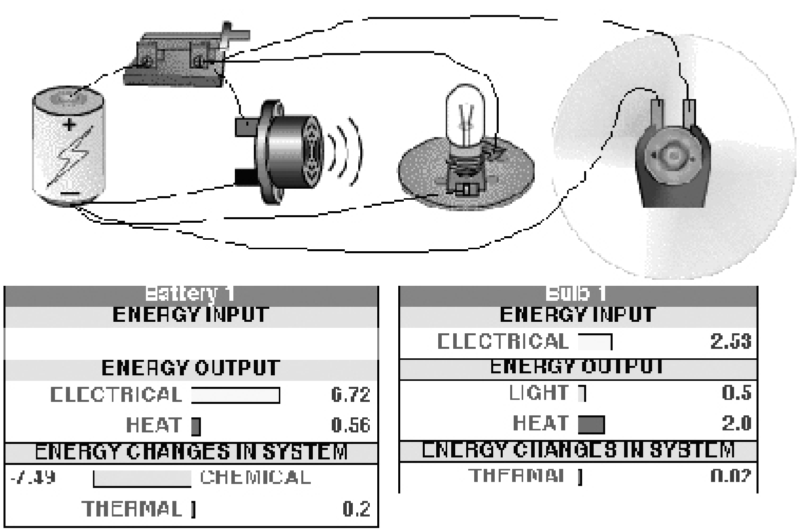

Figure 2: This simulator shows a battery in parallel with a buzzer, bulb and motor/fan. Students can select any circuit component and display an energy graph showing the energy input, energy outputs and energy changes within that component.

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sources' CD.

Embedded throughout the course are activities and homework assignments that explicitly address the curriculum goals for 'learning about learning.' Most of these activities involve PET students analyzing short video segments of elementary students as they work through physics activities that are similar in nature to activities contained within the PET curriculum. Such activities are included in PET to serve two purposes. First, by evaluating the learning of other students, PET students have the opportunity to gain an in-depth understanding of their own learning process. Second, as prospective and practicing elementary teachers, the activities give PET students the chance to apply their physics knowledge in the relevant context of their chosen profession (see figure 3). Other activities prompt students to reflect on what elements of the PET classroom and course structure have facilitated their own learning. Finally, one entire cycle of the PET course (in which students are guided to construct a domain model of magnetism), provides the context for an activity that explicitly examines the 'nature of science'; that is, the processes by which science knowledge is generated, and the nature of that knowledge itself.

So far, the PET curriculum has been field tested at over twenty two-year and four-year institutions, has been adapted for a science methods course in schools of education, and has been offered as a workshop for practicing elementary teachers. (For the latter version, special activities have been included that teachers can use in their own elementary classrooms.) Preliminary data from pre/post diagnostic testing has shown significant improvement in student understanding of the physics target ideas, as well as a greater appreciation for the value of the guided inquiry-based pedagogy modeled by the course.

To support faculty who wish to implement the PET course an extensive web-based Teacher Guide has been developed, together with a framework for a professional development workshop. The developers are also offering workshops and tutorials at national meetings of the AAPT (including upcoming meetings at Salt Lake City and Anchorage). For more information on the PET curriculum and further opportunities to learn about it please visit the web page at cpucips.sdsu.edu/web/pet.

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[a] Public Law 107-110-2002.

[b] The development and field-testing of the PET curriculum has been supported by National Science Foundation grant 0096856.

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Figure 3: The picture on the left shows PET students investigating the conditions necessary to light a small bulb using a battery and wires. The picture on the right is from a classroom video showing elementary students performing similar experiments.

Browsing the Journals

Thomas Rossing

- "The future of physics education research: Intellectual challenges and practical concerns" is the title of a guest editorial in the May issue of *American Journal of Physics*. The authors posit that during the past century more progress has been made in understanding the physical world than understanding student learning of our discipline, possibly because learning is more complex than most physical processes.

  Systematic studies of student learning have revealed a wide gap between the objectives of most physics instructors and the actual level of conceptual understanding attained by most of their students. Physics education research has led to the development of instructional materials and methods that have been subjected to repeated testing, evaluation, and redesign.

- Nobel laureate Carl Wieman advises new teachers to "minimize your mistakes by learning from those of others" in an article in the April issue of *The Physics Teacher.* Other ideas include: "Student beliefs are crucial for learning"; "Listen to your students"; "Make your students your active partners in the learning process;" "Focus on reasoning and discourse;" and Be flexible." "Remember that teaching is like politics. There will always be a few vocal students who dislike both you and physics no matter what you do and other students who love you."

- "Surviving graduate school" is the title of an article in the February issue of *Physics World.* The path to a Ph.D. involves an educational phase transition: you are no longer instructed by others, but instead you teach yourself. Among the bits of advice in this article are the following: "'Never' means three months" (be prepared for changing demands and revised expectations). "Build your apparatus in the center of the room" (regardless of the direction in which you start, you rarely know where you'll end up). "Don't make it better than necessary" (the best scientific apparatus is one that falls apart the day after you finish using it). "Over-extend yourself" (if you really know what you are doing you shouldn't be doing it).

- "Quantum physics explains Newton's laws of motion" is the title of a feature article in the January issue of *Physics Education*. Newton was obliged to give his laws of motion as fundamental axioms, but today we know that the quantum world is fundamental and Newton's laws can be seen as consequences of fundamental quantum laws. Fermat's principle is the source of the key quantum idea. Just as light "explores all possible paths between emission and reception," Nature commands objects such as molecules and footballs to explore all paths.

- Instructors can use interactive Java applets to present science in a concrete and meaningful manner to nonscience majors, an article in the May/June issue of *Journal of College Science Teaching* reminds us. Although most science teachers argue that learning best occurs when students are engaged in active manipulation of their environment and have an accompanying laboratory for that purpose, a lab for nonscience majors may not always be practical. Java applets may be an alternative way of presenting online demonstration experiments to large classes of nonscience majors. A Java applet is a "little application" developed by a programmer. In addition to using applets for classroom demonstrations, interactive homework assignments can incorporate applets. For example an applet allows students to manipulate the mass, length, and amplitude of a pendulum and observe its response. Applets are especially attractive for distance learning.

- The violin playing of Albert Einstein is explored in an article in the May issue of *The Physics Teacher.* He was given violin lessons at an early age, but he became really interested in music at age 13 when he made the acquaintance of the Mozart sonatas. In Berlin he met musical greats such as Fritz Kreisler and Artur Schnabel. One of his chamber music partners was Hungarian-born Nicholas Harsanyi, who taught at the Westminster Choir School in Princeton. At one point he asked Einstein to serve as vice-president of the Princeton Symphony. Einstein demurred, saying, "What would happen if the president died?" Later, Einstein agreed and served in the job from

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1952 until his death.

What kind of a fiddler was Einstein? Harsanyi described Einstein's tone as "accurate but not sensuous." Einstein valued the Wednesday night chamber music sessions at his house on Mercer Street, and would go to extremes with his calendar to keep that night free for music.

- A new twist on Young's classical double-slit experiment is reported in the April issue of *Physics World*. Using slits in a metal screen, scientists in Amsterdam found extra effects due to the excitation of surface waves running along the screen (*Phys. Rev. Lett.* **94**, 053901). This causes the overall intensity of the interference pattern to vary periodically with the wavelength of the incident light. The cause of the effect apparently lies at the entrance of the slits rather than at the exit. To avoid the effects of surface waves, light can be polarized so that the plane of polarization is parallel to the slits. In this arrangement no surface plasmon waves can be excited and no intensity modulation will occur.

- Brief biographies of four recipients of the AAPT Citations for Distinguished Service appear in the June issue of *American Journal of Physics*. Recipients are Patricia Allen (Appalachian State University), George Amann (F.D.Roosevelt High School in Rhinebeck, NY), David Maloney Indiana University-Purdue University, Ft. Wayne), and Robert Romer (Amherst College).

- Scientists who teach have a unique opportunity and an ethical obligation to ensure that the scientific and technical basis for analyzing natural and man-made threats is communicated to citizens, a thoughtful editorial in the March/April issue of *Journal of College Science Teaching* argues. Whether it is a tsunami, an earthquake, a chemical plant disaster (such as the one in Bhopal, India) or a nuclear disaster (such as the one in Chernobyl, Ukraine), we can help the international community prepare more adequate disaster warning capabilities and response networks.

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