APS physics

Forum on Education

American Physical Society

Fall 2007 Newsletter

Thomas D. Rossing, Editor

IN THIS ISSUE

From the Chair

David Haase

There are two items for the Chair to discuss in this issue, both important to the interests of members of the *Forum on Education*.

The first item is an email titled "On APS' Responsibilities," which APS President Leo Kadanoff sent to the APS general membership in August. Because this email addressed the role of the APS in education, the FEd Executive Committee collectively crafted a response. Both the Kadanoff email and FEd response are copied below. Please do read both and send any comments to me at david_haase@ncsu.edu.

The second item is the recent survey about the *FEd Newsletter*. I thank Ernie Malamud, Karen Cummings, David Meltzer and Larry Woolf for creating and analyzing the survey, which drew 504 respondents from our 4,600 members: a good response rate.

The responses show that our members have a wide range of interests in physics education–from the undergraduate classroom, to education research, to K-12 education and teacher training, to standards, policy and outreach. The highest interest topics were introductory and advanced undergraduate physics. Members are satisfied with three issues per year and the lengths of the articles. There are hints that we should pay attention to making the articles easily accessible in html and pdf formats. We should also seek more ways to make the content accessible, for instance, through introductory e-newsletters that link to the on-line articles. The *FEd Newsletter* is valued as a source of current information as well as an archived journal of record.

Our response to the survey results is that we will continue to produce the *FEd Newletter* on a regular schedule, and with new help from APS, publish it in pdf and html formats. New issues will be advertised through email to the membership. Recently Larry Woolf and David Meltzer have completed a keyword index of archived issues, which will be posted on the FEd website. We will continue to accept suggestions for improvement and articles.

Specifically, we wish to increase our pool of *Newsletter* Editors and Co-Editors. If you have interest in supporting and enhancing the Newsletter please contact me.

I am pleased that the *Newsletter* is valued by the membership. I am equally impressed by the dedication of the newsletter editors and the authors that make the *Newsletter* a reality. We owe them many thanks for their accomplishments.

On APS' Responsibilities

Leo Kadanoff, APS President 2007

As a tax exempt organization, APS has a legal responsibility to serve the public welfare. We fulfill this obligation in five main ways: journals, meetings, informing the government, informing the public, and in helping education. The senior leadership of APS is in reasonable agreement on the first four; we have some disagreement about the last. I go in the order named.

1. Journals: We publish the *Physical Review* family of journals, including *Reviews of Modern Physics* and *Physical Review Letters*. Our per-word prices are very low; our impact upon professionals is very high. In addition, we maintain all the back issues and make them available on-line.

2. Meetings: We conduct a diverse set of professional meetings. Our largest meeting has reached 7,000 registrants.

3. Informing the government: Our Washington office informs public officials about APS positions on a variety of public issues, including and especially funding for science. The office acts under the guidance of Council and committees of experts.

4. Informing the public: APS provides information for various different "publics"–our members, industrial scientists, chairs of physics departments, teachers, young students, ... The last two activities have been materially increased in response to the National Academy of Sciences report "Rising above the Gathering Storm". This report asks for increased governmental spending upon research and education aimed at the physical sciences and mathematics. The goals of this report have been incorporated in the policies and planning of both parties, congress, and the executive branch.

5. Education: *The Gathering Storm* report's emphasis upon education reflects a broadly felt worry that our educational system is not up to U.S. needs for a knowledgeable workforce and citizenry.

APS has long contributed to improving education. We have outreach activities aimed at schoolchildren, including successful web sites and contests. Our meetings include workshops for teachers. Together with the American Institute of Physics and the American Association of Physics Teachers (AAPT), we oversee and aid two programs, PhysTEC and P-TEC, aimed at improving and promoting the education of future teachers of physics and physical science. APS' flagship program, PhysTEC, is supported by the National Science Foundation, private donors, and ourselves. We oversee teacher-training at ten universities and colleges, each based upon a cooperation between its physics department and its school of education. In each case, an experienced teacher helps bring in the real world.

We have reached a crossroad in planning future educational programs for APS' PhysTEC, our flagship program, is set to diminish by 60% as NSF support runs out next year. On the plus side, we have hired a new full-time person to work on education. Working jointly with AAPT, we have in planning an important new program aimed at doubling the number of physics majors, while guiding these new majors toward teaching and a wide variety of other occupational goals. However, for the next year, only 5% of the present education spending has been allocated for new education programs.

There is considerable discussion within APS leadership about whether education should be a core APS activity. One side of the discussion points out that APS has traditionally focused upon research while AAPT has teaching as its central concern. Further, U.S. education is a huge problem and APS can hardly make a dent in any part of it.

On the other side, some of us argue that this is the time to make use of promised increased governmental investment in both science and education. In this view, it is APS' responsibility to respond by bringing into being new and expanded programs aimed at improving science education. This ongoing discussion is likely to focus upon the practical question of whether we shall support educational programs with our own resources or rely upon (and wait for) funding from government and private donors.

In parallel, physics departments all across the U.S. are likely to have discussions about their own educational missions. These discussions might focus upon increased numbers of physics majors, new teaching goals, new teaching methods, as well as broader and more flexible curricula. They may also be aimed at reaching out to students interested in teaching careers and perhaps students whose main aims are knowledge and good citizenship.

If you have comments about these issues please write to me at LeoP@aps.org

Reply from the Forum on Education, August 21, 2007

Dear Dr. Kadanoff:

This letter, approved by the Executive Committee of the APS Forum on Education, is written in response to your recent August 1, 2007, email "On APS' Responsibilities." The Forum on Education represents over 4,600 members who have interests in supporting physics education. They are not only teachers, but they participate in informal education, education research, and education policy making at all levels. Members of the Forum on Education represent a cross section of all the APS divisions and topical groups.

We strongly support the APS' responsibility and obligation to education. The Education responsibility is expressed directly in the APS Mission:

"In the firm belief that an understanding of the nature of the physical universe will be of benefit to all humanity, the Society shall have as its objective the advancement and diffusion of the knowledge of physics"

The diffusion of knowledge contains an imperative of education. Not only is knowledge acquired diffused to other researchers to build upon, but is disseminated to a large general audience both formally (in class rooms) and informally, through media, science on the road, science centers and museums, open houses at University Physics Departments and National and Industrial Research labs, hands-on science demonstrations in shopping malls and in many other ways.

As part of the APS mission we believe that APS resources (member dues, income from journals and investments) should be used to further science education in the United States. Besides fulfilling our mission, there are many practical reasons for doing this. Outreach to the public to increase science literacy is essential to have a citizenry that is able to think logically on the compelling issues facing our society. Increasing awareness and appreciation of science will surely increase support for science through elected officials. On a more local level, people through school boards can influence school curricula, course content and requirements for teacher certification.

Through meetings, journals, public education and governmental advisory activities, the American Physical Society supports the health of the US physics research enterprise. This enterprise will founder if the US does not produce its share of educated scientists and an educated citizenry that supports science activity and funding. Our universities, the source of most American physics research, depend on students prepared and motivated to learn. As other parts of the world improve their education and research systems, the US will no longer be able to depend on attracting foreign-born undergraduates and graduate students to bolster our physics research.

It may seem that the APS can make only a dent in improving education. Nevertheless, education is everyone's business, every dent counts. The APS, however, holds a special place in the education, research and political environment. Our members bring to the education process not only a deep and abiding knowledge of the science, but also an equally deep appreciation of the scientific process. It is true that major paradigm shifts are required to make physical science systemic in our schools, but APS is in a position to use its own resources to create pilot programs and provide leadership in physics education. The success of programs such as PhysTEC should be built upon, not laid to rest. PhysTEC and the comPADRE digital library are but two examples of how APS has built close, synergistic relationships with the AAPT, the AIP, and the SPS.

We urge that the APS embrace education in the sciences as a primary responsibility, and in doing so, convince other scientists and scientific societies of the importance of science education to the health of our field.

Please do not hesitate to call upon me or the rest of the Forum on Education leadership for information or advice as you and the APS Board discuss this fundamental issue.

David G. Haase
North Carolina State University
Chair of the APS Forum on Education

From the Editor

This is the space where Letters to the Editor should go, but no one sent us any, so a letter from the editor will occupy the space. Where are your letters? *A Forum on Education* should be just that; a place for members to share their opinions about physics education with others. Please send us your letters; it is YOUR newsletter.

Today (October 25) I was startled by a headline on the front page of the *San Francisco Chronicle* that read "**Science in lower grades near extinction**." WHAT? According to a new survey of 923 Bay Area elementary school teachers by researchers from the Lawrence Hall of Science and WestEd, an education think tank based in San Francisco, about 80 percent of elementary teachers in the Bay Area said they spent less than an hour each week teaching science. Sixteen percent of the elementary teachers said they teach no science at all. Ten times as many teachers say they feel unprepared to teach science than feel unprepared to teach math or reading.

How can this be in an area that has the Exploratorium, the Lawrence Hall of Science, San Jose's Tech Museum of Innovation, the Computer History Museum, and some of the best schools in the country?? As a newcomer to this area and sheltered in the ivory tower of Stanford University, I am apparently out of touch with reality. "It's alarming because it's a very short amount of time per week dedicated to a subject that's considered a core subject in schools," commented the lead researcher in the study. One teacher commented that the demands of No Child Left Behind have made it almost impossible to devote enough time to science. A few teachers try to "shoehorn" science into reading and math lessons.

Should this be a wakeup call for those of us who are concerned about the future of science in the United States? Most of us had the benefit of science in our early years. I attended a small town school where we enjoyed few of the advantages of modern schools, but we certainly were exposed to science and encouraged to read science books. Why else would we be physicists?

APS Award for Excellence in Physics Education

Kenneth Krane, Oregon State University

The 2008 APS Award for Excellence in Physics Education will be given to the Physics Education Group at the University of Washington. The award citation reads:

"For leadership in advancing research methods in physics education, promoting the importance of physics education research as a subdiscipline of physics, and developing research-based curricula that have improved students' learning of physics from kindergarten to graduate school." The awardees will be honored at the April 2008 APS meeting with a symposium immediately preceding the FEd reception and business meeting.

The University of Washington group, which is led by faculty members Lillian McDermott, Paula Heron, and Peter Shaffer, has included many graduate students, postdocs, and visiting faculty members and K-12 teachers. Its mission, as described in its web site (http://www.phys.washington.edu/groups/peg/) involves research into the teaching and learning of physics at all levels, curriculum development, and instruction, in particular helping present and future college (including teaching assistants) and K-12 faculty to improve physics teaching. Their efforts have produced two widely-used curricula: *Tutorials in Introductory Physics*, which can supplement traditional instruction in small-group discussion sections in introductory courses, and *Physics by Inquiry*, which offers inquiry-based activities targeted at the preparation of K-12 teachers.

Through a long series of publications going back nearly 30 years in the *American Journal of Physics* and other journals, the group has described its pioneering efforts to gain a better understanding of how students learn (or, more often, fail to learn) essential concepts of physics. Using appropriate diagnostic testing coupled with one-on-one interviews, their robust and replicable research has revealed how alternative pedagogic approaches can confront these learning difficulties and often lead to improved conceptual understanding. In the process, their successes have served to legitimize and popularize physics education research done within physics departments (rather than within schools of education), and as a result there are now many such groups operating in physics departments that owe their very existence to the model established at the University of Washington.

The APS Award for Excellence in Physics Education was established to honor a group or team that has exhibited a sustained commitment to excellence in physics education. The award, which was given for the first time in 2007, was established with major support from the Richard Lounsbery Foundation, Vernier Software, WebAssign, Physics Academic Software, PASCO Scientific, and numerous individual contributors.

Small Wonders

Christopher Chiaverina

When *The Physics Teacher* magazine editor, Karl Mamola, asked if I would like to edit a new column for the magazine that would, in Karl's words, "be devoted to very brief contributions that describe all sorts of creative physics teaching ideas such as, but not limited to, simple experiments and demonstrations," I jumped at the chance. Like most teachers of physics, I enjoy learning about and sharing unique approaches to physics teaching with others. I concurred with Karl's suggestion that the column be called "*Little Gems,*" for the name reflects the fact that the activities were to be useful, engaging and to the point.

This fall will mark the beginning of the fourth year for *Little Gems.* Both Karl and I have been gratified by the number of truly creative experiments, demonstrations and teaching tips that have been submitted since the column's inception. The teaching ideas, which have dealt with virtually every aspect of physics, have arrived from all over the world. In fact, the material for the very first column came from Spain.

Adolf Cortel, a frequent contributor to *TPT,* shared a remarkably simple method for demonstrating additive color mixing. As Figure 1 illustrates, different color stickers are attached to opposite sides of a black 3cm-x-3cm card. The card is fashioned into a simple turbine by bending opposite corners (Fig. 2). When the remaining corners are held between opposing fingers, the simple turbine is set spinning by blowing on the turbine's fins.

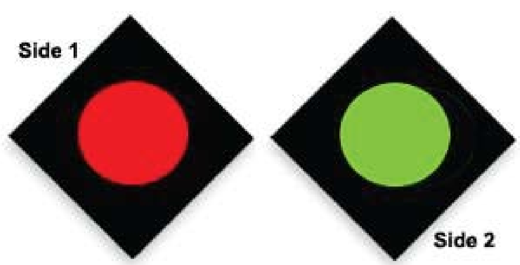

Figure 1

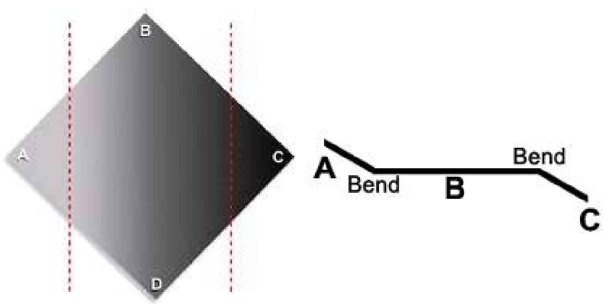

Figure 2

The result: colors combine as light reflected from the stickers is presented to the eye in rapid succession. Due to persistence of vision, our retina retains an image for a short time after the source of light has come and gone. When a flash of light from a red sticker impinges on the retina, the sensitive cones that are activated by the light continue sending signals to the brain for a fraction of a second. If green light from the other sticker strikes the retina within this time, the brain will interpret the combination as yellow.

When yellow and blue stickers are used, white is perceived. The light reflected from the yellow sticker activates both the red and green sensitive cones, whereas the blue sensitive cones are activated by the light reflected from the blue sticker. The combined activity of the three color receptors is perceived as white.

Later that year, an extraordinary group of Japanese physics teachers known as the Stray Cats shared plans for what might be the world's simplest motor. Consisting of a battery, rare earth magnet, wire, and nail, their version of a motor dating back to the days of Michael Faraday became an instant hit with the readers of *TPT.*

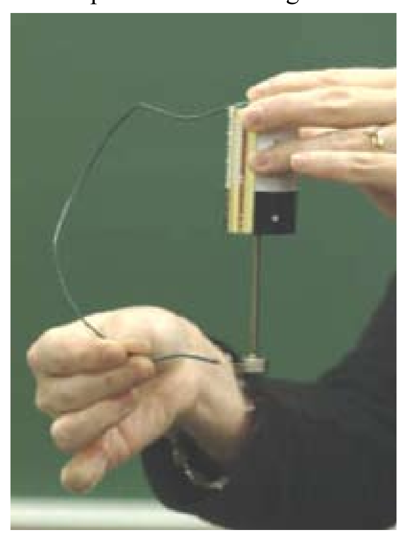

Figure 3

When the four components are assembled as shown in Fig. 3, the magnet sticks to the head of the nail and the tip of the magnetized nail is attracted to the ferromagnetic bottom of the battery. Holding one end of the wire to the top of the battery and touching the other end to the side of the magnet allows a current to flow through (and/or along the surface of) the magnet as shown in Fig. 4. The charge carriers moving in a magnetic field experience a Lorentz force. The resulting torque sets the magnet and nail spinning.

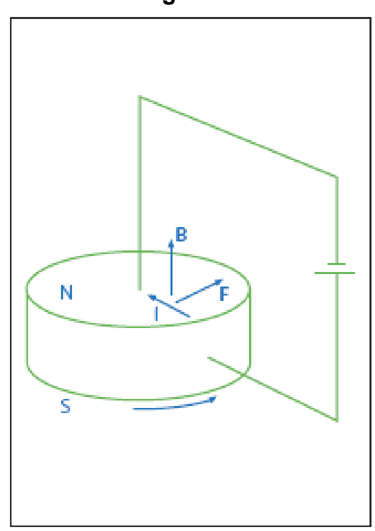

Figure 4

Not long after the Stray Cat-inspired piece on the homopolar motor appeared in *Gems*, *TPT* readers offered a variety of new "spins" on the intriguing device. Dave

Kagan jokingly said that he found it difficult to hold the battery, wire, nail and magnet assembly and proposed an arrangement that he claims requires less dexterity (see Fig. 5). Kagan's upright homopolar motor consists of a spherical rare earth magnet perched on top a few coins, which in turn are supported by a battery.

But the homopolar story does not end here. In the February 2006 *Gems* column, Robert Beck Clark recounts how he used most of the same elements found in a homopolar motor to produce a generator. As shown in Fig. 6, he slid a rare earth ring magnet over the shaft of a nail. With the magnet snugly positioned next to the head of the nail, the assembly was placed in the adjustable chuck of a Dremel® tool. When the magnet was spun, a measurable emf (~23 mV) was produced between the outer edge of the spinning magnet and the shaft of the nail.

Figure 5

And leave it to the Stray Cats to come back with yet another ingenious device using rare earth magnets: a "motorcar" consisting of two rare earth magnets attached to the ends of a battery. When placed on a conducting sheet, the car is propelled by the electromagnetic force (Fig. 7).

Figure 6

Some *Gems* illustrate concepts that are simply out of this world. In their "Planets and Galaxies on Soap Films," Alexsandro Jesus Ferreira de Oliveira and Eduardo de Campos Valadares presented a way to use droplets of water on the surface of soap films to simulate cosmic events. The capture of a satellite by a planet and the collision of galaxies with the formation of a new one with spiral arms are examples of phenomena that may be demonstrated with water and a little dishwashing liquid.

Figure 7

In Fig. 8, two droplets of water on a soap film simulate the orbits of double stars. Water droplets on soap films also offer a unique way to visualize the distortion of the space-time due to the presence of a "large" mass, thus making general relativity more accessible.

Figure 8

Applying the philosophy of waste not, want not, Gordon Gore suggested a use for spent chemical light sticks (*Little Gems* March 2005). He found that even after the light-producing chemical reactions occurring in the light sticks had run their course, the residue in the sticks would fluoresce when exposed to ultraviolet light (see Fig. 9). The last we heard, Gordon was saving used light sticks for eventual use in a display.

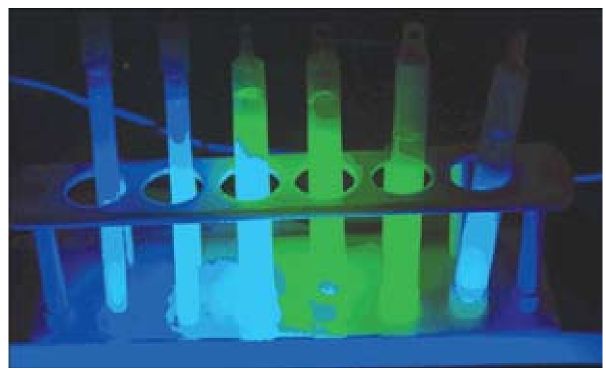

Figure 9

Students sometimes find projectile motion puzzling and need concrete evidence that the motion can be broken down into two independent components. In his March 2007 *Gem*, Bob Froehlich describes a simple and inexpensive device he uses to generate a parabolic trajectory of water droplets that, when frozen with a stroboscope, allows students to observe stop-action projectile motion from any vantage point (Fig.10). The apparatus consists of a standard doorbell around which latex tubing is wrapped. As water flows through the tubing, the clapper vibration causes water to be expelled through an eyedropper nozzle in droplets synchronized to twice the frequency of the exciting voltage.

The resulting droplet pattern can be upwardly angled to allow the students to observe not only the change in the separation between droplets in the y-direction but, with the aid of an overhead mirror, the constancy of the spacing between droplets in the x-direction (Fig. 11).

Figure 10

One consequence of diffraction is the limit it places on the eye's ability to resolve the images of two closely spaced sources of light. If the overlap of the individual diffraction patterns is too great, the images will no longer appear distinct.

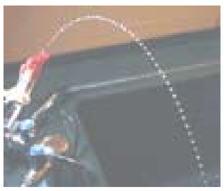

Figure 11

To demonstrate the eye's limited resolving power, Deerfield High School physics teacher Diane Riendeau has her students produce pixilated images from dominoes (*Little Gems*, May 2007). Using templates created by Oberlin College professor Robert Bosch, students assemble images of Abraham Lincoln, the Mona Lisa, the Statue of Liberty and Martin Luther King (Fig 12).

According to the Rayleigh resolution criterion for a circular aperture, the human eye can just resolve images if the angular separation between objects is of the order of 10^{-4} radians. After producing their domino art, students apply this standard to predict the appropriate viewing distance.

Figure 12

Sometimes the phenomena presented in *Little Gems* are a bit perplexing. Take for example the case of Antonio Serrano's report of a cymbal being excited by a camera flash. He found that when a standard camera flash is set off a few centimeters from a cymbal or, for that matter, any metal plate with a high Q, the metal would ring (Fig. 13). Several readers have submitted possible explanations, but so far there is no consensus as to the cause of the ringing.

As you can see, the material submitted to *Little Gems* is both varied and fascinating. Do you have some novel phenomena or creative teaching ideas that you would like to share with the readers of *The Physics Teacher* magazine? If so, don't delay. Write them up today!

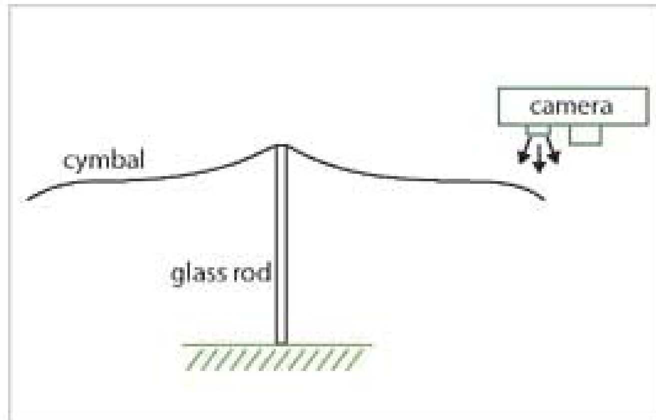

Figure 13

Photo Credits

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Figure 5: Upright Homopolar Motor, Printed with permission from David Kagan, *Phys. Teach*. **43**, 68 (2005), Copyright 2005, American Association of Physics Teachers

Figure 6: The Simplest Generator from the Simplest Motor?, Reprinted with permission from Robert Beck Clark, *Phys. Teach*. **44**, 121 (2006), Copyright 2006, American Association of Physics Teachers

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Figure 12: Get to the Point…Quicker, Reprinted with permission from Diane Riendeau, *Phys. Teach*. **45**, 313 (2007), Copyright 2007, American Association of Physics Teachers

Figure 13: Hearing a Camera Flash, Reprinted with permission

from Antonio Serrano, *Phys. Teach*. **43**, 309 (2005), Copyright 2005, American Association of Physics Teachers

Chris Chiaverina holds an M.S.Ed. in physics from Northern Illinois University. He recently retired from high school physics teaching after 34 years in the classroom. He spent the last decade of his teaching career at New Trier High School in Winnetka, IL where he served as director of The Connections Project, an initiative that employs interactive exhibits to demonstrate linkages among the arts, mathematics, and science. Chiaverina has written articles on physics education for a variety of journals, is co-author of four textbooks, and has served on the editorial board of The Physics Teacher *magazine. In 1997, The American Association of Physics Teachers presented him with its Award for Excellence in Pre-College Physics Teaching. In 2002, Chiaverina served as President of the American Association of Physic Teachers. He is currently editor of* Arbor Scientific's CoolStuff *online newsletter and* The Physics Teacher *magazine's "*Little Gems*" column.*

Exciting FEd Sessions Planned for the APS March Meeting in New Orleans

Ernie Malamud, Chair, FEd Program Committee

The FEd Program Committee of Olivia Castellini, Peter J. Collings, David G. Haase, Paula Heron, Ken Krane, Andrew Post-Zwicker, and Larry Woolf, has been hard at work planning an exciting series of FEd Session and other events at the March and April APS meetings.

At the **March 10-14 Meeting** in New Orleans (Monday through Friday) the FEd will sponsor four sessions you won't want to miss. **Mark your calendars**!

Ken Krane has organized a focus session, Tuesday March 11, from 11:15 to 2:15: **"How to develop an Education Component for an NSF Proposal."** Randy Ruchti, returning to Notre Dame after a rotator position at NSF, will lead off with an invited talk followed by "CAREER" NSF awardees who will give contributed talks about the education component of their projects.

On Tuesday, March 11 from 11:15 to 2:15 will be the first of two sessions (J7) "Undergraduate Nanotechnology and Materials Physics Education" organized by Peter Collings and Larry Woolf. Invited speakers include Robert Chang (Northwestern University), Greta Zenner (University of Wisconsin, Madison), Jeffrey Collett (Lawrence University), Fiona Goodchild (University of California, Santa Barbara), and Pradeep Haldar (University of Albany).

The second of these sessions (Q7) will follow on Wednesday at the same time. Speakers include Emily Allen (San Jose State University), Gregory Salamo (University of Arkansas), Chris Hughes (James Madison University), Michael Dubson (University of Colorado, Boulder), and Janet Tate (Oregon State University).

The confluence of three recent trends has opened up opportunities for innovation in undergraduate materials-related physics education. First is the increasing amount of interdisciplinary materials science and technology at the interface of physics, chemistry, biology, materials science, nanotechnology, and engineering that is relevant to the undergraduate physics curriculum. Second, much has been learned about how students learn, and this knowledge has affected both physics instructional materials and methods. Third, many new educational approaches have begun at the undergraduate level, covering new instructional materials, teaching styles, courses, and ways of organizing departments and colleges. These trends are occurring in small and large institutions, in different departments, across departments, and in interdisciplinary research centers.

These sessions explore recent advances in undergraduate education in the areas of nanotechnology and materials physics. Topics covered include new curricular developments at the introductory, intermediate and advanced undergraduate level, incorporation of nanotechnology and materials physics research into undergraduate programs, and teaching and learning issues associated with nanotechnology and materials physics programs. Speakers represent a wide range of disciplines, several types of institutions, and very different programs.

For Thursday morning (March 13), from 8 to 11, Olivia Castellini, Senior Exhibit Developer at Chicago's Museum of Science and Industry has put together a session (U7) **"Physics Demonstrations and Strategies for Teaching and Public Outreach."** Wendy Crone, Professor of Engineering Physics at the University of Wisconsin, Madison, will begin the session with a talk "Bringing Nano to the Public." Until recently Crone was the Director of Education for the Interdisciplinary Education Group (IEG) of the Materials Research Science and Engineering Center (MRSEC). The IEG develops educational materials on nanotechnology and advanced materials for formal classrooms (middle school through undergraduate) and for public outreach. The IEG collaborates with researchers, industry, museums, and teachers to produce cutting-edge curriculum tools, demonstrations, exhibits, teacher training programs, student internships and web dissemination of nanoscale science and technology. Over the past 3 years, Wendy has been a contributing partner in the Nanoscale Informal Science Education (NISE) Network, a museum partnership to develop exhibits, visualizations and public forums for public audiences.

The other four invited speakers are educators in the greater New Orleans area. Murty Akundi is Chair of the Physics and Engineering Department at Xavier University of Louisiana, a historically black college located in New Orleans. His talk is "Preparing students for successful undergraduate science careers." XUL is extensively involved in outreach and has two key summer programs aimed at improving student performance in college level physical science courses. The first program is for incoming college freshman; the students complete a short course that reviews basic science and prepares them for the challenges and critical thinking skills of their college coursework. The second program is aimed at high school teachers and focuses on giving teacher strategies to better prepare their students for science courses on the collegiate level.

Stephen Collins teaches physics and astronomy at the Academy of the Sacred Heart, an independent preparatory school for girls in New Orleans founded in 1887. He will present a talk "Fundamentals of Science Teaching." Following him, John Thacker from the nearby LIGO observatory where there is an outstanding outreach program, will present "Gravity–The Engine of the Universe." Robert McGuire is a senior member of the education department staff at SciPort Discovery Center, a hands-on science museum located on the riverfront in Shreveport and will present "Sparks Fly With Physics."

A major focus of the FEd is to improve the teaching of physics on all levels by connecting researchers and educators. Leading educators from both formal and informal science education communities will present effective techniques for presenting science to both classrooms and public audiences. By having such a diverse group of speakers, the FEd offers March Meeting attendees valuable insight into innovative ways of teaching physics that the scientific research community can utilize in their own teaching and outreach. James McGuire, Chair of the Department of Physics and Astronomy at Tulane University, will chair this session.

There are also a set of interesting contributed papers on "Physics Education, In and Out of the Classroom" to be presented Wednesday, March 12 from 11:15 to 2:15 and Poster Papers on Education topics in Poster Session K1.

The Gathering Storm: Latest Forecast

By Norman R. Augustine

Several years ago, with the strong leadership of the American Physical Society, an effort was initiated to acquaint Washington policymakers with the state of research in the physical sciences, mathematics and engineering. That is, to acquaint policymakers with the fact that the federal budget for such endeavors has, in real dollars, languished for two decades and the number of U.S. citizens studying these topics has continued to decline. This is in sharp contrast with the situation in the biosciences which saw a doubling of research funding in recent years followed, unfortunately, by a period of moderate decline which once again is being followed by increases. Needless to say, it is of the utmost importance that the growth sought in the physical sciences not be achieved at the expense of research being conducted in the biosciences. But it is also of the utmost importance that our nation's investment in the physical sciences be markedly accelerated.

Approximately two years ago, responding to a bipartisan request from members of the House of Representatives and the Senate, the National Academies initiated a study of America's competitiveness that focused on two questions: "Are we on a path to remain competitive in the new global economy?" and "What do we need to do to be more competitive?" The group conducting the study was comprised of 20 members with backgrounds as university presidents, CEO's, Nobel Laureate researchers, former presidential appointees and state superintendents of schools. One of the members was subsequently appointed Secretary of Defense. The group, which became known as the "Gathering Storm" committee after the first part of the title to its 500-page report, focused on jobs and the connection of basic research to the creation of jobs.

Numerous economic studies have revealed that a major part of the growth in the nation's GDP (read jobs) and productivity has been attributable to advancements in science and engineering. Given America's marked disadvantage in the cost of labor, it is widely agreed that the nation must excel at innovation–that is, being first to market with sought-after goods and services. Underpinning this strategy will be our prowess in research as the source of new knowledge; in engineering as the transfer mechanism from new knowledge to new products and services; and in entrepreneurship as the means of taking new products and services to market.

The "Gathering Storm" committee offered 20 specific actions that could be taken by the federal government–and in many cases paralleled by state and local government–that would help reverse what the committee concluded was a dismal competitiveness outlook for the nation. The highest priority of these actions was to improve K-12 math and science education, principally by producing teachers who have their primary undergraduate degrees in math and science, with a teaching certificate as a secondary but important credential. The second highest priority recommendation was to double the fundamental research budget in mathematics, the physical sciences and engineering in real terms within seven years. Following the report's release, the President included many of its recommendations in his State of the Union address and subsequent budget submission to the Congress. Early action was taken by the House and Senate, including funding a number of the more critical initiatives in the continuous resolution then before the Congress. More recently, legislation implementing more of the 20 proposed actions has been authorized with strong bipartisan support, as reflected by a vote of 367 to 57 in the House and by a unanimous consent resolution in the Senate. A total of $43 billion was authorized for the next three fiscal years. Much, however, remains to be accomplished. This includes obtaining approval of the proposed program in the appropriations process, initiating coresponding actions at the state and local levels, and sustaining this overall effort for another ten to twenty years.

While these actions represent an encouraging beginning in addressing a concern that was barely on the Washington radar screen two years ago, America's economic competitors have not been standing still either. Reflective of the latter, this past year the World Economic Forum dropped America from first to seventh place in its ranking of various nations' preparedness to benefit from advances in information technology; the number of U.S. citizens studying engineering declined still further; the remnants of the legendary Bell Labs, birthplace of the laser and transistor and home of many Nobel Laureates, were sold to a French firm; the largest initial public offering in history was conducted by a Chinese bank; another $650 billion was spent on U.S. public schools while the performance of those about to graduate on standardized science and math tests declined further; American companies once again spent three times more on litigation than on research; and in July, for the first time in history, foreign automakers sold more cars in the United States than did American manufacturers.

There are many ingredients that combine to make up America's competitive strength. High among these are labor costs, the education of our citizens, the strength of our fundamental research enterprise, and the "innovation friendliness" of our governmental policies. The latter include but are not limited to the ease of obtaining specialty visas, our tax policy, our protection of intellectual property, and our litigation environment.

Of particular concern is the fact that many of America's parents and students seem unaware of the perilous state of our K-12 educational system, particularly as it relates to math and science. The Trends in International Mathematics and Science study conducted several years indicated that when it comes to self-perception American youth excel. U.S. high school seniors ranked number one among students from the 20 participating nations in believing that they are doing well in mathematics and number three in agreeing that they were doing well in science. The problem is that in the actual mathematics examination, the same group of students finished 18th out of 20 and in the science examination, 17th out of 20.

A more recent survey conducted by the Public Agenda found that of those respondents expressing an opinion, 62 percent believe that U.S. students are "far behind other countries in math and science." But when asked if their local schools should offer more math and science, 70 percent say, "Things are fine as is." Worse yet, 76 percent of students and 50 percent of parents state that math and science are irrelevant to the students' lives. With regard to the task of increasing the funding of academic research and development, U.S. industry has been devoting a declining share of its investment in R&D to support work conducted in academia, recently reaching a low point of about one percent of industrial R&D spending. The primary reason for this is, of course, the intense pressure imposed by the equity markets upon industrial firms to produce near-term profits. In fact, in one recent survey by the National Bureau of Economic Research, 80 percent of the senior financial executives questioned said that they would be willing to forego funding R&D in order to meet their public projections of near-term profitability. The problem is exacerbated by the previously mentioned stagnant funding of mathematics, the physical sciences and engineering by the federal government.

The problem is not the lack of worthy ideas to fund: the National Science Foundation indicates that it can now support only one in five of the research proposals it receives, with the vast majority of the rejected proposals being deemed meritorious by peer reviewers. Clearly, the solution to this part of the competitiveness dilemma is to increase investment in fundamental research by the federal government with industry continuing to invest in the "D" of R&D and our universities continuing to be the primary performers of fundament research. Indeed, the past year has seen remarkable progress towards making this a reality; however, fixing the nation's competitiveness dilemma in what Tom Friedman has so aptly termed "the flat world" is a very long-term undertaking. There will presumably be no Sputnik, Pearl Harbor or 9/11 wake-up calls. This is one of those challenges that we must simply recognize ourselves.

Winston Churchill once said that you can always count on the Americans to do the right thing–after they have tried everything else. This is one issue where we had better get it right the first time.

Norman R. Augustine is Retired Chairman and Chief Executive Officer, Lockheed Martin Corporation and Chair, Committee on Prospering in the Global Economy of the 21st Century, Committee on Science, Engineering, and Public Policy, Division on Policy and Global Affairs, The National Academies Gathering Storm Committee.

Many interesting FEd Sessions are being planned for the APS April Meeting in St. Louis

Ernie Malamud, Chair, FEd Program Committee

The FEd Program Committee of Andrew Post-Zwicker, David G. Haase, Ken Krane, Larry Woolf, Olivia Castellini, Paula Heron, and Peter J. Collings has been hard at work planning an exciting series of FEd Session and other events at the March and April APS meetings. Speakers are invited and abstracts are coming in.

At the **April 12-15 Meeting**, held at the Adams Mark Hotel in downtown St. Louis (Saturday–Tuesday), the FEd is organizing two focus sessions, and seven invited sessions, four of which are co-sponsored with other APS units.

The focus session **"Frontiers in Physics Education Research,"** organized by Paula Heron and Peter Shafer, highlights recent empirical and theoretical developments in the field. An invited talk, "Effectiveness of different tutorial recitation teaching methods and its implications for TA training" will be given by Robert Endorf of the University of Cincinnati and will be followed by contributed papers from physicists conducting research on learning and teaching in undergraduate classrooms.

Davis Haase is organizing a focus session: **"What is the Future of Advanced Physics Laboratories in the Undergraduate Curriculum?"** Leading off the session is an invited talk by Jeff Dunham of Middlebury College: "The Place of the Advanced Laboratory in Undergraduate Education." The session is intended to increase discussion about the present state of these laboratory courses, and consider examples of how they should be carried forward in light of budgetary constraints, the rise of undergraduate research programs and changes in curricula.

Cosponsored: sessions are with FGSA **"Programs to prepare Teaching Assistants to Teach"** (Tuesday, April 15, 1:30 PM); with DNP **"Undergraduate Education in Nuclear Physics"** (Sunday, April 13, 8:30 AM); with FPS **"How to communicate physics to the general public using books and articles"** (Saturday, April 12, 10:45 AM); and with DPB **"The US Particle Accelerator School."** (Sunday, April 13, 10:45 AM.)

Speakers and titles for the joint DNP/FEd session are Warren Rogers (Westmount College) "Tenth anniversary of the very successful Conference Experience for Undergraduates;" Sekazi Mtingwa (MIT) "Nuclear Science Workforce Needs for a Future with Nuclear Energy;" and John Shriner (Tennessee Tech University) "Undergraduate Research at an Undergraduate Facility."

The US Particle Accelerator School provides educational programs in the field of beams and their associated accelerator technologies not otherwise available to the community of science and technology. The USPAS conducts graduate and undergraduate level courses at U.S. universities, holding two such programs per year, one in June and the other in January and has welcomed students from all corners of the world, from universities, laboratories, private companies, government and the military. Some of the students have been in the field for many years and are interested in a "refresher" course, while others are full-time students looking for additional classes to add to their education. Qualified teachers are chosen from national laboratories, universities and private industry. Major universities, in partnership with the national laboratories, underwrite the offerings and provide the necessary quality control. Through this administrative framework, universities across the nation can offer our high-quality advanced technology courses. The session will begin with a talk by William A. Barletta, Director of the USPAS "USPAS overview and educational mission;" his talk will be followed by Evgenya Smirnova, last year's Outstanding Doctoral Thesis Research in Beam Physics awardee who will speak about the student experience at the USPAS, and Mike Syphers of Fermilab on the teacher experience.

Saturday, April 12, 1:30 PM the FEd session is on the popular subject of **"Physics Demonstrations and Strategies for Teaching and Public Outreach."** Sample demonstrations and discussion of various approaches will be presented from both the formal and informal science education communities. The three presentations are: "Youth Exploring Science" by Diane Miller, Senior Vice-President of the St. Louis Science Center, "The Modeling Physics Instruction Program" by James Cibulka of Bayless High School in St. Louis, and "Active Learning in a Large General Physics Classroom" by Rebecca Trousil from Washington University.

A major new initiative of APS is an effort to double the number of bachelor degrees in physics to address critical national needs including K-12 education, economic competitiveness, energy, and security. Essential areas of increase are in the number of highly qualified high school physics teachers and in the fraction of physics majors held by women and under-represented minorities. The session **"Why we should double the number of undergraduate degrees in physics"** will discuss this important issue and proposed implementation. Theodore Hodapp, APS Director of Education & Diversity will lead off with "Statistics and Rationale for the Doubling Initiative," followed by Robert Hilborn. (University of Nebraska-Lincoln) "Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP)," and David Boulware, (University of Washington) "How we did it at the University of Washington"

This year's winner of the **Excellence in Physics Education Award** is the University of Washington's Physics Education Research Group: Paula Heron, Lillian McDermott and Peter S. Shaffer. The Excellence in Physics Education Award session is scheduled for Monday, April 14, at 3:30 PM where talks by the winners and others impacted by their trailblazing work will be featured. The session will be followed by the FEd Business meeting and Reception. At the Business Meeting new Executive Committee members will be introduced and Fellow certificates presented. Ken Krane, Chair of the Award Committee, is organizing this session.

The Elements of Science Education Reform

By Gerald F. Wheeler
Executive Director*, *National Science Teachers Association

Fifty years ago our nation rose to the challenge of the Soviet launch of Sputnik. Today, we find ourselves back at the starting gate: Our nation's student achievement in science is, in a word, unacceptable. While corporate leaders, politicians, and educators have made a collective investment in reform efforts over the last three decades, we have still not seen real increases in our students' understanding of science.

So what do we have to do differently to achieve successful reform in science education? I believe we must meet four crucial challenges. We must (1) increase the science content knowledge of all teachers of science, (2) develop a shared understanding of and focus on the most important ideas and skills students should learn, (3) raise parents' awareness of the real needs our children will face in the 21st century, and (4) address these problems at a scale that impacts our whole education system rather than a few districts or classrooms.

***Challenge One: Teachers need to know the science they have to teach*.**

The overall failure of teacher preparation programs to provide teachers adequate science content knowledge is clear (Allen 2003). Significant numbers of science teachers in the classroom lack degrees or even college coursework in science, especially at the elementary level (NCES 2002; Weiss et al 2001). And with shifts in teaching assignments, teachers with a background in one discipline may be forced to teach another. The bottom line is too many of our nation's science teachers don't have a deep enough understanding of the science they teach.

Most studies of the relationship between teacher content knowledge and student achievement are constrained by uncertainty with regard to whether the content teachers learn, say in a college course, matches the particular content they have to teach (Allen 2003). Even so, several studies have suggested that as teachers' understanding of science increases, so does student achievement (Darling-Hammond 2000; Chaney 1995; Druva and Anderson 1983). And, research aside, it makes sense that teachers need to understand the science they teach. They need to know the most central ideas in a topic or discipline, deal with contingencies that arise as their students explore the real world, present students with phenomena that can make scientific ideas real for students, and help them find models and analogies that help clarify those ideas. Knowing how to teach and understanding how students learn are very important, but that knowledge must be connected to specific science content.

Challenge Two: We need a national focus on the most important ideas and skills.

We've got, arguably, good standards in the *National Science Education Standards* (NRC 1996) and *Benchmarks for Science Literacy* (AAAS 1993). These documents have laid out a carefully crafted description of the ideas and skills all students will need to participate actively and thoughtfully in a society that depends on science and technology. But while *Standards* and *Benchmarks* have, admirably, focused on conceptual understanding of a set of important ideas, they simply cover too much. One group of researchers has estimated that it would take as much as 22 years of schooling to adequately cover all the content in the *Standards* (Marzona 1998).

And the state-based standards developed in the wake of the national standards only got bigger! Consequently, science teachers (and professional development providers) have far too many concepts to address and assessment writers have too many domains to assess. The result is that important ideas do not get the treatment they deserve, and students are left with a poorly understood collection of facts and algorithms, soon to be forgotten. Further complicating the problem, each state's standards are different. A next generation of standards is needed, to provide national focus on a smaller core of the most important ideas.

Of course, national consensus is difficult. But while common wisdom suggests that states will always "do their own thing" when it comes to education, a recent survey conducted by NSTA revealed strong support for nationally shared focus. The survey, conducted in NSTA Express, asked science educators if they thought a uniform set of national science content standards that every state would be required to use would be a good idea. A resounding 71% agreed, while 27% disagreed. And the next generation of standards could respect the rights of states and local communities by centering on the ideas and skills that all states have declared important.

One strategy is to use the NAEP 2009 Framework as a de facto national vision of standards. Because all the states will be focused on doing well on the NAEP assessment, we could probably get general agreement on the 2009 framework. And this framework would give all stakeholders–assessment writers, curriculum producers, and professional developers–a common base to build upon. At the national level, we would have something that we can invest in without bankrupting ourselves. We could invest in assessment items for the 2009 framework and in promising practices (and programs) that support that framework. This could gives us a truly functional set of national science standards without taking on the political battles at the state level.

Challenge Three: Parents need to be aware of their children's real needs.

Young adults entering into their 21st century careers and lifestyles are going to experience a world very different from their parents. Science and technology will have an increasing impact on politics, the economy, and on our personal lives. The politicians get it, business leaders get it, and, of course, educators get it. The challenge is that parents don't get it.
A recent report by the Public Agenda (Kadlec, 2007) shows that parents in a two-state survey are aware of the importance of math, science, and technology for our country's future but remain complacent about the need for their children to take more rigorous courses. Most parents are pleased with the status of science education in their schools, 70% reporting that "things are fine as they are." There's no reason to believe that these survey results would be different in a national survey.

In order for reform to succeed–for student achievement in science to increase–we need a culture shift. But what is the most effective way to encourage this shift? Public-service announcements are expensive and often ineffective. With the exceptions of "got milk," "use seatbelts," and "stop smoking" few initiatives show positive results. The vague warning of a strange new high-tech world just doesn't cut it. The report *Rising Above* *the Gathering Storm* by a stellar group of business and academic leaders doesn't cut it either. In short, America needs another Sputnik. Politicians, business leaders, and educators must find a way to energize parents and make them see the immediate importance of reform.

Challenge Four: We need to impact a nation, not a classroom

If our nation is to make significant advancements in science education reform, we have to change our *strategic* thinking about reform. The final challenge is to address the scale of problem: addressing the real needs of nearly two million teachers of science.

Even our most successful professional development programs suffer logistical constraints of time and cost. As a result, they reach only a miniscule proportion of our nation's science teachers. In the 50 years since Sputnik education reform has focused on events for small groups of science teachers. NSTA is no exception. We have prided ourselves on the quality of programs that brought one- or two-dozen science teachers together for a summer event. While we shouldn't abandon these smaller efforts, we must realize that they will never reach a scale that will produce a substantial increase in student achievement.

To meet the scale of the problem, we need innovative programs that can act both nationally and locally. At any single school site, many different content needs exist among a small number of teachers (they teach different content, or have different backgrounds). But at a regional or national scale, we can move closer to a critical mass of teachers who need, for example, to learn more about genetics. So we need programs that can meet those common needs for large numbers of teachers in disparate locations. On the other hand, we also need programs that can meet the needs of smaller groups of teachers in a particular school or district. The key is to think strategically about the kinds of partnerships and modes of delivery can best address these different problems.

Improving science education in a significant and scalable way will require innovative ideas and steadfast commitment from all stakeholders. We cannot continue to do the same thing over and over again and hope for different results. But by facing the four challenges mentioned above, we can start to find new ways to improve our students' understanding of science and prepare them to meet the challenges of the 21st century.

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Blogging in the Physics Classroom[1]

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Abstract

Studies have shown that students leave introductory physics courses almost universally less excited about the topic than when they came in. This article details an experiment to address this problem: a course weblog or "blog" which discusses real-world applications of physics and engages students in discussion and thinking outside of class. Students who read, commented on, and were involved with the blog maintained their initially positive attitudes towards physics in contrast to the typical deterioration in attitude seen in students who did not participate in the blog study.

Introduction

Students' attitudes towards physics, aptly described as belonging to the hidden curriculum[2], have been shown to deteriorate in the normal course of instruction by several studies (and in disciplines other than physics as well)[2-4]. This is alarming since educational research has established a clear link between student attitude and learning[5,6]. To this end, we have examined the effectiveness of a course blog in shaping and guiding students' attitudes in an introductory physics course.

There are compelling arguments for using a blog[7]: (1) blogging can introduce a broad range of topics outside the classroom that cannot be covered in class due to time constraints, (2) blogging tends to increase student excitement for learning and ownership of the process, (3) blogs open up discussions to students who may not otherwise participate in class, and (4) blogging encourages discussion outside of class with a wide variety of viewpoints. Blogging also provides a way for students and instructor to interact, particularly outside of the classroom[8]. And blogging helps students "see knowledge as interconnected as opposed to a set of discrete facts"[9]. In other words, blogging, more so than other tools, appears to be a way to address the "hidden curriculum" and affect student attitude in a positive and concrete way.

Course Implementation

The blog was integrated into the course as follows: since reading the blog would be on top of the numerous assignments, reading quizzes, and exams that introductory physics students already had to complete, I decided to assign the blog as extra credit. The course instructors posted several times a week to the course blog. The content of the blog mainly focused on how the physics we were currently studying applied to the ``real world" and other fields besides physics, and often integrated a wide variety of physics applets and videos available on the web. For example, a post about friction discussed how geckos are able to scale walls, and a post about electricity featured a YouTube video of lightning striking a car with a subsequent discussion of Faraday cages. Students received a few points of extra credit per week for (1) reading the posts to the course blog during the week and (2) for posting comments to one or more posts. The criteria for student comments were that they be a thoughtful and articulate reflection on the blog post, about a paragraph in length that tied in outside information relevant to the topic in question; the outside information usually resulted in additional research on the topic by students.

Results

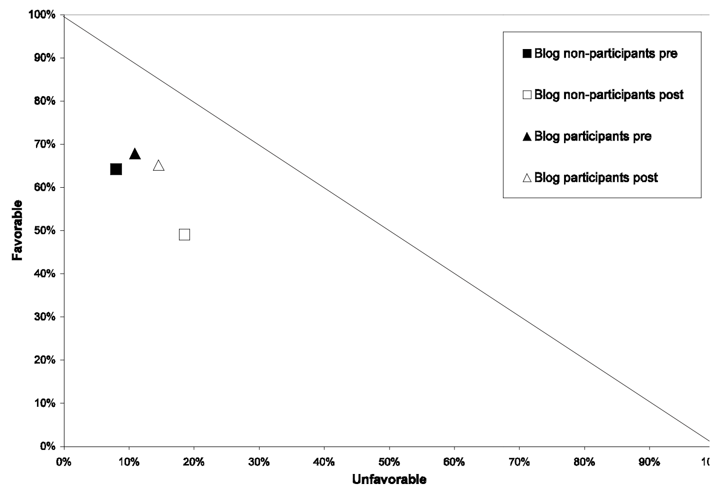
Student attitudes were probed with a 5-pt Likert scale survey which was administered as a pre and post test. The results were statistically analyzed using a dependent-samples t-test with a calculation of effect size (treating the Likert survey results as interval data) and as binomial Agree-Disagree plots or Redish plots2 (treating the Likert survey results as ordinal data). Since the brevity of this article does not allow a full presentation of the results, I give one semester's results as an example. Results are for "reality-link" questions from the attitudinal survey, or those questions which probe students' ideas of how physics relates to the real world.

Group	Number	Mean	Effect Size
Blog Participants –pre Blog Non-participants-pre	(n=58) (n=37)	70.9% 70.7%	Not statistically significant
Blog Participants–post Blog Non-partici-pants-post	(n=58) (n=37)	70.0% 60.7%	ES = 1.59

Table I: Results from "reality-link" questions for the attitudinal survey, based on a samples-dependent t-test. The difference between the blog and non-blog reading groups was not statistically significant for the pre-test but statistically significant with $p < 0.001$ for the post-test. Scores have been normalized so that 50% represents a neutral response on the Likert-style attitudinal survey with 100% being the most favorable response possible.

The same data as given above in Table I is presented above right as an Agree-Disagree plot:

Figure I: A-D plot for an average of "reality-link" questions for blog participants vs. non-participants.



Conclusion

Students felt that overall, the blog was helpful in learning the material covered in the classroom, made physics more interesting, and was generally enjoyable. Many students related that the blog was their favorite component of the course. These encouraging results reflect the sustained positive attitude of blog participants on the "reality-link" type questions. Over the course of four semesters, students who regularly read and posted to the blog maintained their initially positive attitudes about physics, whereas students who did not read the blog suffered a general deterioration in attitude (similar to what was seen elsewhere). Blogs, therefore, seem to be a powerful tool to address students' attitudes towards physics.

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The Road From Bell Labs Researcher to High School Science Teacher

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It seems as if everywhere I look there are reports, discussions and debates over the state of science education in America. Issues of curriculum, instruction format, learning style and gender, to name just a few, are debated and examined up and down the educational line. I have little or no formal training in these matters, and choose not to discuss them here.

Since the 5 years I have been teaching high school science however, I have often been asked for advice regarding the career shift I had made. Technically trained individuals are contemplating similar moves and are clearly hesitant or worried about what they might or might not be getting into. I am writing this article with those people in mind.

I had a productive and wonderfully enjoyable career at Bell Laboratories during the years 1980 to 2001. Having obtained my PhD in physical chemistry doing picosecond spectroscopy, I continued in the research area at Bell Labs developing new and improved ultrashort pulsed laser systems. I was able to collaborate with amazingly talented people, and over the 20+ years I spent there, wrote roughly 50 journal articles in areas of short pulse lasers, molecular dynamics, nonlinear optics, and fiber optics. Furthermore, we were encouraged to present our work at professional conferences and write patents were applicable, all of which I did.

By 2001, the telecom bubble had begun to deflate, and it was clear to many in the research area that life was rapidly changing. Some left to academic jobs, others to competitors, and many people just retired. Lucent offered early retirement packages on at least a few occasions, and without being coerced at the age of 47, I took the offer of full retirement. I harbor no bitter feelings or resentment about my career at the Labs, and quite to the contrary, consider myself quite fortunate to have had the opportunity to work there and to leave under such generous conditions. Many of my colleagues were not so fortunate.

My intention at that point was to do technical work with another telecom company, but shortly after I arrived, that company went out of business. I subsequently took a consulting job, but soon realized that the whole industry was going through a very tough time. I had always enjoyed public speaking and giving technical talks but I didn't want to move my wife and 3 teenage children in order to find a university job where I would have to fight for funding and start a research program all over again. Why not teach high school locally I thought!

In New Jersey, we have something called the "Alternate Route", which is a state sponsored program that allows professional people outside of education to enter the field via a certification process without going back to school and obtaining a formal education degree (if one wishes to teach in private school, no certification is necessary). The way it works is quite simple. First you take a standardized test (the Praxis) in your subject area to prove that you know the material. This should pose no problem except sometimes questions are asked on material you haven't thought about for 30 years. Next get hired by a school. Then during your first year of work you must take 200 classroom hours of education instruction (at night in my case) which is provided by the state at numerous locations. After completing one year of teaching and the 200 hours of instruction, one is awarded a full teaching certificate, the same certificate that you would have obtained if you pursued a teaching career in college. What a great deal! Many states have similar programs. The only problem is that when you look a little closer, you find that by 3 years out, less than half of the people going "the alternate route" are still teaching.

Contrary to what some people may think, teaching is incredibly hard work. Teaching is a skilled trade, one which requires practice, instruction and nurturing. There are very few people who are instinctually natural at it, and even those people improve dramatically with time.

For many different reasons, teaching is not for everyone. Perhaps the saddest sights I can remember are those of bitter and angry ca.

60 year old laid-off engineers in need of work, turning to education as a last resort. Many would point blank confess this to me in casual conversation. It is very unlikely that these people will have the patience, energy or attitude necessary to succeed. By succeed I unfortunately do not mean to become a good teacher, but rather merely being able to maintain sustained educational employment.

So what are the challenges of the classroom and why are they so difficult to master for many? You can find the answer in any number of text books on the subject, but to fully understand the nature of the beast, you must work it out for yourself, often making painful and stressful mistakes the first few times around. Many scientists come into a high school thinking that the course material is trivial, and to a large extent it is. What they don't appreciate is the ability to present the material to teenagers in a day to day way, so that they can understand and maintain motivation, is by no means trivial. Once you have lost them either in attitude or content, a whole floodgate of other problems arise and the proverbial horrific 1st year teaching results. Every veteran teacher can sympathize with how initially hard it can be, but one must be able to rapidly and willingly learn from your mistakes. You must be able to take advise from your peers and supervisors constructively and make rapid and effective improvements.

One of the largest failed expectations was that the ability to deliver an effective and vibrant technical talk to your technical peers should somehow be translatable to the high school classroom. I like to draw an analogy to the difference between a gourmet chef fussing and perfecting a meal to that of a short-order cook cranking out 3 blue-plate-specials a day, 24/7 in the local dinner. While it helps to be upbeat, animated and enthusiastic in either case, the goals are totally different, yet every bit as admirable.

There are many features of classroom teaching that must be understood and implemented. Children have a very well defined attention span. Their attention ebbs and flows depending on the time of day, and minute by minute in the class. Techniques that work with this fact and don't ignore or fight it are critical. Students need to be stimulated with worthwhile educational material that is both doable and challenging. Students have to get up and work with their hands, work collaboratively, work visually, work verbally, work with math and abstraction. Ultimately, the students have to feel good about what they are learning and the time they are spending with you.

When teaching in public school, the expectation is that you work with all types of students, from the most needy to the most talented. You learn that there are challenges and rewards associated with all ability and age groups. You may ultimately prefer to work with one group or another, but the reality of our public system requires flexibility. A mandate expressed by one job applicant that "I do not teach the dummies!" is definitely out of line, out of place and out of touch with reality.

Unfortunately, many alternate route teachers initially find themselves in less than ideal schools or school settings. While in math and science there is more need for qualified teachers than in the humanities, nevertheless this can still be a problem. A good deal of attrition occurs at this point. Learn what you can and move on. Any good teacher must be flexible and have a strong survival instinct.

As anyone who has changed careers in mid life can attest to, it is psychologically very hard to go from a respected senior position back down to that of a total novice. Often I would be stunned to see 25 year-olds working far more effectively than myself. Nevertheless, these thoughts are best put aside, and the 25 year-old approached and asked for advice. I had no problem doing this, but many I fear would.

And yes, after the classroom skills are mastered, you will find that the students, their parents and the administration will come to value the professional experience that you have had in fields of science and technology. You will be able to use the correct terminology and jargon the way textbook-only learned knowledge will never enable one to do. You will have the depth and perspective to enrich the curriculum and guide students into possible professional technical careers. The students can tell the difference, and will look up to you and in some cases admire you for where you have been and what you have done. You will become a positive role model and turn people who where science-phobic into people who are if nothing else, appreciative of science. You will go home exhausted on a typical day, but feel that you have really earned your pay and done something worthwhile.

Browsing the Journals

Thomas D. Rossing, Stanford University

•Many U.S. educators think that the country's decentralized management of education by state and local government bodies is hampering nationwide efforts to improve science, technology, engineering, and math (STEM) education, according to a report in the 4 May issue of *Science*. But a draft plan, drawn up by the National Science Board, suggests a way to get around that problem without abandoning local control over schools. The proposal recommends creating a federally chartered body with representatives from the state, the federal government, and the the education and business communities. The proposal comes from a blue-ribbon commission co-chaired by physicist Leon Lederman.

•ACT scores of 1.3 million high school students in the class of 2007 indicate that a growing number of high school graduates are prepared for college level courses in science and mathematics, according to a story in the August 16 issue of *NSTA Reports*. Students earned an average composite score of 21.2 on the college admissions and placement, up from 20.8 in 2003 and 21.1 last year. Scores improved in all four of the required subject-area tests: science, English, mathematics, and reading. Each test is scored on a scale of 1 to 36, with the composite score being the average of the four required test scores.

•Singapore's hopes of becoming a regional center for higher education suffered a setback when the University of New South Wales in Sydney announced it is abandoning plans to establish a comprehensive university there, according to a story in the 1 June issue of *Science*. UNSW Asia opened its doors last March with 148 students, less than half of the 300 it had hoped for. The university will assist current students in transferring to its Sydney campus or to other Singapore institutions.

•"Is there a future for physics?" is the title of an editorial in the July/August issue of *Physics in Canada*. "Whether truth, absolute truth, should or should not (or can or cannot) be discovered by scientists is a matter for the poet to reflect upon. For the research scientist the search for truth is a single-minded and an all-encompassing one." A highly respected scientific journalist recently expressed concern that physics may be limited theoretically by the limits of quantum mechanics and practically by economic considerations that say the next generation of useful experiments will become impossibly expensive.

•The July issue *Physics Education* includes special features on Space Flight and on Air. It includes two articles on the history of space flight, as well as two articles on the physics of flight. (One article treats fixed and rotating wings; the second one deals with flapping wings).

•Before children can even speak, they develop commonsense assumptions about the physical world that can persist into adulthood and clash with scientific discoveries according to a paper in May 18 issue of *Science*. For example, because objects fall down if not held up, kids may have trouble accepting that the world is round, reasoning that things on the other side should naturally fall off. When both adults and kids obtain knowledge from others, they judge claims based on how much they trust the source of an assertion. It suggests that science will meet resistance in societies where alternative views are championed by trustworthy authorities, such as political or religious leaders.

•"When Science Suddenly Mattered, in Space and in Class" is the title of a story in the September 25 issue of *The New York Times*" reviewing the changes in science education in the past 50 years since the launching of Sputnik. For many, Sputnik was proof that American education, particularly in science, had fallen behind. Congress passed the National Defense Education Act in 1958, providing college scholarships and other help for aspiring scientists, engineers =, and mathematicians. Some of the nation's eminent scientists collaborated on new ways to teach high school physics, chemistry, and biology. According to Shirley Malcolm, director of education and human resources at AAAS, "We lived many years off the investment of the race for space, but today there is a kind of complacency."

Charles Holbrow is among experts on science education who say that the hands-on approach to science teaching does not mesh well with the No Child Left Behind law, the Bush administration's major education initiative, which emphasizes standardized tests and focuses on reading and math. Other experts, such as Leon Lederman, champion the "physics first" approach to teaching science. "Biology is the most complicated of all subjects, and it is based on chemistry and physics."

•Another story recognizing the effect of Sputnik on science education in the United States was heard on All Things Considered on National Public Radio (NPR) October 1. America's scientific community, which had long been pushing for a new direction in science education, seized on the national mood to rejuvenate the curriculum. David Hawkins answered critics who said that there was no time for reforms, no time to "reinvent the wheel." "Not everything is known, as yet, about the wheel, either the mathematics of it or the physics," Hawkins wrote. Washington gave the new science curriculum an infusion of more than a billion dollars when it passed the National Defense Education Act in 1958. The era saw the beginning of a federal involvement in education that would spread out in all directions in the coming years. But that burst of enthusiasm was overtaken by new demands. Many educators feel that the U.S. is again losing its science lead to countries such as Korea and Italy where more advanced degrees are awarded.

•Discipline-based education research seeks to marry deep knowledge of the discipline with similarly deep knowledge of learning and pedagogy. Within the engineering community, according to a Forum article in the 31 August issue of *Science*, the ultimate aims of such research include the creation of education programs that attract more students to the study of engineering. In the 1990s, centers for research on engineering education opened on several campuses with foci ranging from foundation research to innovative approaches to curriculum, learning teaching, and assessment. The *Journal of Engineering Education* was repositioned to focus on publishing scholarly research in engineering education.

•Facing a projected need of 30,000 new math and science teachers in the next decade, California Governor Arnold Schwarzenegger sought and won pledges from the state's two public university systems to tackle the problem in return for increased state aid, according to an article in the 1 June issue of *Science*. The 23-campus California State University (CSU) system, which produces about 60% of the state's teachers, agreed to double its output of 750 math and science teachers by 2010. The University of California (UC) system agreed to quadruple the 200 students now graduating from its 10 research-oriented campuses with science and math teaching credentials. Training lots of teachers will require wrenching changes for most UC campuses, their science departments, and individual faculty members.

•Physicist Leon Lederman calls climate change a "menace" that, like the Soviet satellite, will spur more science, according to a story in the October 15 issue of *U.S. News and World Report*. Fifty years after the Soviet satellite initiated the space age, scientists and educators are again arguing, as they were in the years before Sputnik, that the United States is falling behind its competitors in producing scientists and engineers. Lederman, who received the 1988 Nobel Prize in physics, has now turned his attention to finding new ways to inspire science and math teachers. Lederman has argued for teaching physics before chemistry and biology. He would also like to see more scientists running for Congress. We need more scientists going into Congress. "There's a huge difference between being an adviser and being an elected official," he points out.

•Thousands of schools are straining to meet the standards of the No Child Left Behind law, according to a story in the October 16 issue of *The New York Times*. More than 1000 of California's 9500 schools are branded chronic failures, and the numbers are growing. "What are we supposed to do? Shut down every school?" asked the director of high schools in the gang-infested neighborhoods of east side Los Angeles. In Florida, 441 schools could be candidates for closing. In New York State, 77 schools were candidates for restructuring last year. Some districts, like those in New York City, have moved forcefully to shut large failing high schools are break them into small schools. Under the No Child law, a school declared low-performing for three years in a row must offer students free tutoring and the option to transfer. After five years, such schools are essentially treated as irredeemable, with the law prescribing starting over with a new structure, new leadership or new teachers.

•The September issue of *Physics Education* includes a special feature on "Water". Included are papers entitled "Exploration glaciology: radar and Antarctic ice," "Clouds," " Bouncing steel balls on water," "Some simple observations on buoyancy," "Archimedes' principle in action," "A strange fountain" and others.

Physics Teacher Education Coalition

Section on Teacher Preparation

John Stewart

For the past year, I have had the pleasure of being involved in the ComPADRE project for the National Science Digital Library as editor of the Physics Teacher Education Coalition (PTEC) collection. ComPADRE contains a diverse collection of resources for students, teachers, and physics. The PTEC collection will be discussed in a future newsletter dedicated to the PTEC organization. This edition of the newsletter contains articles that offer a broad overview of ComPADRE and its partner organizations. First, the director of ComPADRE will offer a general overview and then editors of a number of specific collections within ComPADRE will discuss special features of their collections. Finally, the director of the Science Education Resource Center (SERC) will describe her collection and its relation with ComPADRE. Future teachers and physics departments preparing future teachers should be aware of ComPADRE as a valuable source of sound educational resources and support.

John Stewart is an Assistant Professor of Physics at the University of Arkansas. He has a long association with Arkansas' PhysTEC project and is currently editor of the ComPADRE PTEC collection.

Introducing ComPADRE

Bruce Mason

The ComPADRE project (Communities for Physics and Astronomy Digital Resources in Education, http://www.compadre.org) is developing an online place to gather and share educational resources in physics and astronomy. Started in 1997 by the AAPT as the Physical Sciences Resource Center (http://psrc.aapt.org), it became part of the NSF's National Science Digital Library (http://nsdl.org) in 2003. This collaboration of the AAPT, APS, AAS, and AIP/SPS gathers teaching resources, learning activities, and education research, organizes these resources through the work of editors and librarians, and presents them to the world. Users of the library can find materials here, but also can suggest resources, create private or public collections, and share their expertise through discussions, comments, and reviews. The project's efforts were recognized in 2005 by ComPADRE being selected as an NSDL "Pathway" for physics and astronomy. Pathways are key partners of the NSDL and responsible for significant portions of the library.

The ComPADRE library is organized into collections targeted at specific audiences. In these specific collections, editors gather materials suitable for their audience and describe them using a vocabulary their users will best understand. Each collection also provides tools and services focused on their goals. The editors of three of these focused collections, for undergraduate physics students, for pre-college teachers, and for the producers and consumers of physics education research, describe their collections in the articles below. These articles give a broader picture of the ComPADRE collections and materials. Other existing collections focus on physics for the general public, on resources for faculty teaching introductory astronomy, and on quantum physics. New collections under development include those focused on advanced undergraduate laboratories, introductory undergraduate physics, and relativity. Editors for other topical collections are needed to continue to grow the library. Since these collections share the same technical infrastructure, all the collections can share resources and tools that best meet their goals.

Another important aspect of ComPADRE is the connection to the work of others in science education. An excellent example is the development of learning activities with the Science Education Resource Center (SERC) at Carleton College. The article on SERC describes this effort to build connections between online resources, effective pedagogies, and examples of teaching and learning activities. Other collaborations include hosting the online presence of PTEC and the Adopt-a-Physicist program. Using simple web connections, the ComPADRE library also automatically provides the search results of other resource collections such as MERLOT, the BQ-Learning/Physlets/Open Source Physics database, the PADs collection, the NSDL, and the Astrophysics Data System education collection. Leveraging and connecting existing resources is an important goal of digital libraries.

ComPADRE is a growing effort and we are always looking for ideas and suggestions. Comments can be emailed to the editors or to me, or can be made through the contact form available on every page of the collections.

Bruce Mason is an Associate Professor in the Homer L. Dodge Department of Physics and Astronomy at the University of Oklahoma and Director of ComPADRE.

Teacher Resources on the Nucleus

David Donnelly

The Nucleus (www.compadre.org/student) is the ComPADRE collection targeted at undergraduate students majoring in physics and astronomy. It is assumed that undergraduates majoring in physics and astronomy might follow a wide array of career paths, so the types of resources included in the collection are correspondingly broad. From its inception, the collection has had two primary goals: Providing resources that will enhance the learning experiences of undergraduates, and providing tools and resources that will facilitate the establishment of an online community of physics and astronomy undergraduates.

The resources included on *The Nucleus* take a variety of forms, and can be classified in three broad categories. The first category of resources includes the same kind of digital resources contained in all of the ComPADRE collections. These can take the form of simulations, tutorials, and references and are classified by subject. In addition, each resource has metadata associated with it that allows it to be searched by learner level (for example, general public, high school, lower undergraduate, or upper undergraduate), resource type, subject area, and keywords. Users can also search other collections in ComPADRE, as well as other digital libraries. The second category of resource included on *The Nucleus* is books. This collection started out by including textbooks that might be used by undergraduates, but it is expanding to include a wider variety of textbooks, as well as popular books on science by authors such as Steven Hawking and Richard Feynman. The book section will also have reviews and comments submitted by users. The third class of resources can be thought of as "opportunities." The collection currently houses two searchable databases. One database contains research opportunities. These are typically summer internships or other research opportunities that would be of interest to undergraduates. These opportunities are searchable by keyword, discipline, and state. The collection typically has had well over 100 opportunities posted each year the database has been operational. The second database lists scholarships that would be of interest to undergraduates and is, again, searchable by keyword, state, qualifications, etc.

The other area of focus of the collection is on building an online community of students. To facilitate this, the collection offers a number of activities in which students can participate and tools to allow students to communicate. Most of these resources are housed in a section of the web site called "The Lounge." Here, a user will find polls, contests, discussion forums, and a monthly physics challenge. The polls may be related to popular culture (e.g. what's your favorite movie), student life (e.g. what's your favorite physics class), or physics knowledge. For example, our current poll is: The objects below are all released from rest at the same time at the top of a smooth ramp. Which one gets to the bottom first? a basketball, a hula hoop, a skateboard, a one gallon can of ketchup, or a one gallon can of soapy water. Users are asked to respond to the poll, and then discuss their response in the discussion forums. The contests are usually related to physics, but often have a humorous aspect to them. One of the most popular contests was the physics haiku contest. Many imaginative entries were submitted, and the four winners are listed below:

Classic mechanics,
To be so old and still work;
Will you retire?

Radiative heat
Streams forth from the dark abyss--
From whence does it come?

Now and then she squints
At the sight of bright sunlight
Photons hit her eyes

Rosy shoots of Dawn
Display the beauty that is
Rayleigh Scattering

The monthly physics challenge was modeled on the physics problems presented in "The Physics Teacher." As an example, this month's challenge is shown below.

Three objects are released from rest at the top of an incline. The three objects are:

1. A uniform sphere of mass M and radius R
2. A uniform cylinder of mass M, length L and radius R.
3. A disk of thickness L and radius R whose mass density depends on radial distance from the axis of the disk as follows:

$$\rho(r) = \frac{3M}{2\pi L R^2}\left[1 - \frac{r^4}{R^4}\right]$$

In what order do the objects reach to bottom of the incline?

Another tool available for community building is the student club section of the collection. In this area, physics clubs from anywhere can establish a web presence. The tool for creating a club page is simple and easy to use. The majority of the clubs listed are SPS chapters, but there are also high school physics clubs and other organizations listed.

As the collection continues to grow and evolve, additional sections and resources are planned. Two areas that are currently under discussion are a searchable database of job opportunities for people who have bachelor's degrees in physics and astronomy. There are several sites that list job opportunities for people with graduate degrees, but none that target undergraduate degree holders. The other area under discussion is a section that will provide resources for students who are engaged in teaching. In many physics departments, part of the teaching duties, particularly laboratory sections, are carried out by undergraduate students. *The Nucleus* would like to provide resources for these students to enable them to teach more effectively, and perhaps consider teaching as a potential career path. Development of this section will be tied closely to The Physics Front.

The Nucleus continues to grow and evolve in an effort to meet the needs of its users. The editors of the collection are always interested in bringing more users to the collection, and in receiving user feedback. Faculty are encouraged to make their students aware of the collection and the resources it provides. Students are encouraged to visit the site, make use of the resources, and participate in the community.

David Donnelly is chair of the physics department at Texas State University. He has been at Texas State University since September, 2000. His research interests are novel materials and processes for electronic and opto-electronic applications. He also has served as editor of The Nucleus *since 2002.*

Snapshot of the Physics Front

Cathy Mariotti Ezrailson

The Physics Front (http://thephysicsfront.org) collection is the physics and physical science online library developed for pre-college teachers within the ComPADRE Digital Library Pathways Project. *The Physics Front* serves a broad spectrum of users that include new and crossover physics teachers, pre-service as well as in-service teachers of physical science and physics for grades K through 12, teacher preparation instructors in universities as well as students of physics and physical science. Participation in *The Physics Front* collection also extends to physics departments involved in the preparation of pre-service teachers and the support of in-service teachers and their students.

Objectives for the *Physics Front* collection include:

- Providing easily-accessible, quality resources for teachers of physics and physical science at all instructional levels.
- Providing explicit examples of pedagogically sound labs, lesson plans, activities and other resources organized within a unit format.
- Soliciting, collecting and sharing the best of teacher-deveoped materials.
- Helping to reveal, address and provide guidance to help teachers address their naïve physics preconceptions.
- Supporting and mentoring new physics and physical teachers and cross-over teachers at all instructional levels.
- Creating a community and forum for teachers and preparers of teachers to communicate and share resources and materials.

Materials within the collection are organized into units which are organized by specific subject and are intended as exemplary examples of web resources for that topic. Resources were included based upon quality of content, ease of use, and alignment with standards and with best practice pedagogy for the teaching of physical sciences. These resources are intended to enrich teachers and their students' experiences as they learn physics. Example unit elements that can be arranged to build curricula are suggested and activities, labs, lesson plans, simulations, assessments as well as content and curriculum support are also included. Although there are common needs among the various audiences that *The Physics Front* serves, special care is taken to suggest and organize access to physics resources separately and appropriately for elementary and middle school teachers and their students.

Other materials included in *The Physics Front* are standards-aligned lesson plans, lab and classroom activities organized by grade level and course type; reference materials with evidence-based pedagogical models to promote and encourage the process of inquiry; comprehensive manuals and other curriculum sets designed to support new and crossover teachers of physics and physical science at all instructional levels. Recognizing that time can be a scarce commodity for K-12 teachers, the editorial staff is especially committed to helping to organize resources in an easily accessible format.

The challenges and successes of teaching physics at all levels are shown through example and modeled for the teacher. Additionally, there are online tools to be used to gather, organize and share items in *The Physics Front* such as the filing cabinet and message board. Users register and create a profile to gain full access to all materials. The filing cabinet is an area that can be used to effectively mentor teachers and/or students and point them toward resources. In addition mentors will be able to upload their best materials, labs, simulations and other creative materials into *The Physics Front*. *The Physics Front* editorial staff will review, process and add these exemplary teacher-made materials to the collection.

The Physics Front collection is committed to managing a broad group of digital content by working with other projects and organizations to provide a coherent service greater than the sum of its parts. To help achieve this goal *The Physics Front* collection will work to comply with the existing national and international projects/standards such as those created by the NSDL, Open Archives Initiative, or federal accessibility guidelines.

We aim to avoid duplication of activities by working with other organizations and projects in a standards-based distributed information environment. To this effect, where well-maintained current listings already exist elsewhere, *The Physics Front* collection will link to rather than duplicate existing efforts.

The Physics Front is committed to providing the most current resources and up-to-date materials possible in order to enhance physics and physical science teaching at all levels. We are dedicated to improving physics and physical science instruction by providing community-building through our collections. Future updates will include more standards alignment and concordance, links to special topics blogs and webinars as well as new contributions by our new assistant editors. A mentoring project for new teachers is planned as well as a new online mentor-training area.

Cathy Mariotti Ezrailson is an Assistant Professor of Science Education at the University of South Dakota. She received her B.S. in Geology and Comp. Science and Ashland University, her M.S. in Curriculum & Instruction: Science Education from the University of Houston. She received her Ph.D. in Curriculum & Instruction: Physics Education from Texas A&M University. She has taught physics, physical science and science methods courses at the precollege and university levels. She is a former PAEMST Award winner for Texas and a TAMU MALRC Fellow. She has been managing editor of The Physics Front*, the precollege collection of ComPADRE, since 2002*

PER-CENTRAL

H. Vincent Kuo

PER-CENTRAL–*The Physics Education Research–Community Enhancing Network for Teaching, Research and Learning* (http://per-central.org) is a ComPADRE collection designed specifically to serve as an informational touch-point and online community for "producers" and "consumers" of physics education research (PER). The collection contains information about and links to a wide range of materials and resources for the use of people conducting research on the teaching and learning of physics. Some of these materials are also useful to teachers and administrators interested in applying the findings of physics education research.

Collection Features

The resources in the collection are currently sorted in the following categories: News and Events, Research Work, Groups and People, Curriculum, and Bibliography.

- News and Events contains information on upcoming local and national PER events as well as news that is related to PER.

- Research Work contains links to PER Dissertations. Many of these dissertations are archived in the ComPADRE repository with the agreement of the authors and are available free of charge.

- Groups and People provides a listing of the PER groups and people around the country and world (see Figure 1). The listing is further divided by states, and each link will take you to a site that contains information about that particular research group or person. Each of these sites is maintained by an individual from that research group, and links exist to take you to the specific group site if it exists.

- Curriculum contains PER resources for use in research and the classroom, and links to research-based curricular material.

- Bibliography is a searchable database of PER references. Articles without use restrictions are linked to directly. For articles that have costs associated with them, the link will provide information on how to access copies. In the "details" page of each reference there is a way for any registered user to post a comment about its usefulness. These comments can be seen by any one accessing that reference.

Figure 1: Google Map of PER Groups and People

There is now a special series in the collection called *Reviews in Physics Education Research*. In the review articles published in this series, researchers help bridge research and practice, bringing the results of extended, multi-year research and development projects to the instructional community. The first volume is on research-based reform of university physics. Over the past two decades, the PER community has not only learned a great deal about how students learn and do not learn in the calculus-based (university) physics class, it has developed a number of effective instructional environments. The first issue contains four invited review articles where the developers of some of these curricula present an overview of their work. Additional editions are under development.

The collection also includes a direct link to the new digital *Physical Review Journal* devoted entirely to *Physics Education Research: PRST-PER*. This journal is free of charge, and contains peer-reviewed articles on the latest research results in physics education.

Collection Tools

A user can search and browse the reference database without joining PER-CENTRAL. However, membership–which is free – does have its benefits. Members of PER-CENTRAL have additional tools that improve their use of the site. These include individual search preferences, a personal filing cabinet to store resources found to be useful, access to discussion forums with other community members, the facility to create a personal group with restricted membership, and the ability to recommend resources for inclusion in the database.

Becoming a member of PER-CENTRAL is straightforward; click on the "create an account" link in the navigation bar–located on the left-hand side of the PER-CENTRAL site–and answer a few simple questions. Once a member, a user can begin to enjoy the following tools:

•Search Preferences: Searches can be specialized by Language, Results per Page, Education Level, User Type, and Resource Type.

•Filing Cabinet: this provides a user with his or her own personal storage system to create folders, name them, and then 'bookmark' items for later perusal. Folders and bookmarks will exist across all of the ComPADRE collections. To bookmark an item, find it using the search or browse functions, and check the box next to the item. At the top of the search page, choose the folder in which to save the selection and click "File." In addition, saved items can be viewed in multiple citation formats or exported to many popular reference editors. A personal synopsis can be added to each reference in the filing cabinet as a reminder for the future. The folders and the contents within a filing cabinet are a user's personal collection, and he or she alone has access to them. A user can, however, choose to "share" any part of the filing cabinet with any other user in the ComPADRE system.

•Discussion Forums: all members can read and post on any of the public discussion forums. All members can also create new forums on topics of their interest. The postings on these forums are monitored by the editors of the collection, and are open to all PER-CENTRAL members. If a user would like to have a closed forum that restricts general access, he or she can request a group be created under the Groups and People category. Each group site has built-in discussion tools and the editors can grant administrative access to a specific forum with which a user can privately invite certain members to join.

•Submit Resources: Any member can suggest a reference or a resource that does not already exist in the database via the "Submit Resources" link.

Things to come

Since the primary goal of the collection is to serve the users, we are currently in discussion with several members of the PER community on how to expand the collection to meet more of the community's needs. Here are just a couple of the features that will be implemented in the near future:

•Special topics of discussion: this can take the form of blogs or wikis, and will focus on topics such as General Research Methodology, Development of Assessment Tools, How to Conduct Interviews, Data Analysis, etc… We are looking for interested parties to serve as Topical Editors for these threads, as well as suggestions on other topics of interest.

•Applied PER: this new area inside the collection will contain annotated curricular material, more general practical uses of the findings from physics education research, and cross references with the relevant research articles. This area of the collection will become a detailed users' guide to PER.

The usefulness of this collection depends entirely on the participation of its users. The more comments, suggestions, and opinions we get, the better the collection becomes. I cordially invite you to access the site (http://per-central.org) and play around. If you find the collection to be beneficial, please join our community, and bring your friends and colleagues. Let me know how we can expand the collection to better serve your needs.

H. Vince Kuo is a lecturer with the Physics Department at Colorado School of Mines. He received his Ph.D. in Education at the University of Minnesota in 2004. Dr. Kuo's area of expertise is physics education research, with a concentration in problem solving in introductory calculus-based physics. He has helped develop several laboratory activities at UMN, and helped in the development of student activities that complemented the Matter and Interactions curriculum at NCSU in the SCALE-UP environment. As the editor for the PER-CENTRAL, Dr. Kuo is working to establish an electronic home base for the Physics Education Research *community.*

Pedagogy in Action: On-line resources for physics faculty and teachers

Cathryn A. Manduca and Bruce Mason

To be an effective teacher requires bringing together two fundamental bodies of knowledge: a deep understanding of the topic you are teaching and a practical knowledge of teaching methods and their application in your classroom. Nowhere is this more true than when you are teaching teachers who are trying to learn both physics and physics teaching.

In this context, it is interesting to consider how we make decisions in designing our courses. What expertise do we bring? What body of knowledge do we turn to for guidance? Faculty, who receive little education about teaching, have long been stereotyped as teaching only as they were taught. Of course this is an overstatement; at a minimum faculty draw upon both their experience as students and their experiences in their own teaching. Faculty focus groups indicate that they also draw extensively on conversations with their colleagues, often looking for examples of how a particular topic is taught (McMartin et al, 2006; Manduca et al., 2005). Teachers, who are educated about teaching as part of their credentialing, know that the fields of education and cognitive science have much to say about the design of effective learning experiences. Physics is a leader in recognizing the importance of discipline-based education research on physics teaching and learning. Ideally, when we put together our courses, we would draw on our own experiences as students and as teachers; on the experiences of our colleagues; and on the research addressing teaching and learning. This can be a daunting task for either a faculty member or a teacher.

ComPADRE, the physics education digital library of the AAPT, APS, AAS, and SPS, and the Science Education Resource Center (SERC) at Carleton College have joined forces to make it easier to access a rich body of expert teaching experience. The new pedagogic portal at ComPADRE brings together information about effective teaching methods and examples of ways in which teachers and faculty use these methods for specific physics concepts. Each teaching method is described in peer-reviewed websites that are written by faculty known for their teaching (in physics or other disciplines). Two critical aspects of these websites are a well-referenced discussion of why (and when) the method is useful in teaching and a practical guide to how to implement the method. Each method is linked to examples that capture the experience of faculty teaching physics in their own classroom. Each example both describes how the method is being used for a specific concept and provides practical information for educators wishing adapt or adopt the example for their own classroom. Where appropriate, these examples are linked to the resources provided by the ComPADRE collections. Teachers and faculty searching for help on ComPADRE (or the web) will find, all connected together, clearly cataloged learning resources, examples of using these resources from experienced colleagues, and background on the pedagogies that can help make those resources effective. This integration facilitates the sharing of physics and astronomy educational resources and experience through ComPADRE.

The physics pedagogic portal currently contains information on and examples of five teaching methods: Interactive Lectures (including ConcepTests), Just in Time Teaching, Teaching with Mathematical and Statistical Models, Teaching with Interactive Lectures, and Using Indoor labs. Based on a model developed for introductory geosciences (serc.carelton.edu/introgeo), the physics portal is part of a larger project (Pedagogy in Action: serc.carleton.edu/sp) that is creating and sharing effective pedagogies and practices across the STEM disciplines and beyond. Pedagogy in Action collaborators create a pedagogic portal by selecting methods and examples of high interest to their community (for example physics educators, or faculty at a specific college or university). They can also contribute methods and examples to the collection for use by others. In this way, physics can draw on the experiences of geoscience in teaching about seismic waves or geoscience can learn from mathematics about strategies for teaching unit conversions or derivatives. In addition to ComPADRE, current collaborators include digital libraries in statistics education, geoscience, biology, and mathematics, projects seeking to disseminate information on specific teaching methods, and on-campus centers of teaching and learning.

You can view the full collection of teaching methods at the Pedagogy in Action website (serc.carleton.edu/sp/pedagogies.html). Faculty and teachers use this collection to learn more about pedagogic methods and to teach courses about methods to future science teachers.

Generating a robust collection of examples which reflect the experience of faculty and teachers has been the most challenging aspect of the project to date. A culture of sharing information about teaching is just beginning to emerge in higher education (Huber and Hutchings 2005; Bok 2006). Fostering this culture is a high priority for the NSF program on Course, Curriculum, and Laboratory Improvement. This summer at a workshop in association with the Greensboro AAPT meeting, physics faculty authored about 30 new examples of their teaching experiences. You are invited to add to this collection via an on-line submission process that includes the peer review of the submitted examples.

The Pedagogy in Action project is one of several approaches that the Science Education Resource Center has taken to help improve teaching in the sciences. While much of their work has been in the geosciences, their collection of web resources (serc.carleton.edu) includes topics of interest to physics educators including teaching with data, visualizations, and models. There are also resources on observing and assessing student learning and collections of references on different aspects of research on learning.

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