



Forum on Education

American Physical Society

Summer 2009 Newsletter

Ernie Malamud and Carl E. Mungan, Editors

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Disclaimer—The articles and opinion pieces found in this issue of the APS Forum on Education Newsletter are not peer refereed and represent solely the views of the authors and not necessarily the views of the APS.

From the Chair

Peter Collings

According to the bylaws, the objective of the Forum on Education is the advancement and diffusion of knowledge regarding the inter-relation of physics, physicists, and education. In addition, the Forum provides opportunities for members to discuss and get involved with matters of physics education. From my perspective, the Forum does a good job on the “discussion” part by organizing high quality sessions at APS meetings and by producing an informative newsletter. But the Forum does not do as good a job on the “involvement” part. It is true that many APS members help organize sessions, a smaller number of APS members contribute to or help put together the Forum newsletter, but that’s about it. Therefore my priorities for the coming year are to maintain the quality of the sessions and newsletters, and to increase the involvement of APS members in physics education activities.

How might this be accomplished? We need to develop mechanisms to involve APS members in activities of



any of the professional organizations that are concerned with physics education (APS, AAPT, AIP, SPS, etc.). This might be a simple program that links local APS members with schools using PhysicsQuest curricular materials. Involving APS members with local AAPT activities like section meetings or teacher continuing education workshops is another possibility. In a slightly different direction, the results of physics education research grow each year. Perhaps the Forum can help provide easy access for APS members to both PER materials and PER physicists, including information on PER physicists who work close to interested APS members.

Given the volunteer nature of the Forum, it is going to be impossible to make major headway on all of these endeavors in one year. But if a few can be started in a way that their effectiveness grows over time, the Forum will be closer to fulfilling its objective.

Peter Collings is the Morris L. Clothier Professor of Physics in the Swarthmore College Department of Physics and Astronomy. His research specialties are liquid crystals, light scattering, self-assembly of biologically important molecules, and supramolecular chemistry. He is Chair of the Forum on Education and the APS Committee on Education.

Joint DPP/FEd Plenary Session at the Summer 2009 AAPT Meeting

The Symposium on Plasma Physics will take place from 10:30 to noon on Monday July 27 during the AAPT Summer meeting in Ann Arbor. The two plenary talks are “The Electrical Charge and Motion of Objects Inserted into a Plasma” by John Goree (Univ of Iowa) and “Turbulent Liquid Metal Dynamo Experiments” by Cary Forest (University of Wisconsin).

This session continues the tradition of having a session at AAPT national meetings jointly sponsored by an APS Division and the Forum on Education. Previous sessions in the series were DPB (Sacramento, 2004), DAMOP (Salt Lake City, 2005), DNP (Syracuse, 2006), and DPF (Baltimore, Winter 2008).

Workshops on Active Learning with Video Analysis

Robert Teese

Students find active learning with video capture and analysis both educational and compelling. Current video analysis tools are powerful as well as educationally effective for advanced physics majors as well as introductory physics students.

The LivePhoto Physics project is offering NSF-funded workshops for university and college faculty interested in using digital video analysis in student research, lectures, tutorials, homework assignments, and laborato-

ries. These 3-day and 5-day workshops will cover capture and analysis techniques for a range of topic areas such as mechanics, thermal physics, wave propagation, electricity, magnetism, and optics. In addition, the literature on the impact of digital video analysis on student learning will be reviewed. A collection of video-based curricular materials and video clips will be provided to participants. Follow-up activities and on-line communication will allow participants to share videos,

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activities and ideas for teaching.

There will be no tuition or fees. Room and board for faculty and instructional staff from US institutions will be provided, and those with demonstrated need who teach under-represented students may apply for partial travel stipends. The workshop leaders are Bob Teese (Rochester Institute of Technology), Priscilla Laws (Dickinson College), Pat Cooney (Millersville Univer-

sity) and Maxine Willis (Dickinson College).

A five-day workshop will be held June 8-12, 2009 in Rochester, NY. Three-day workshops will be held July 22-24, 2009 in Ann Arbor, MI and January 5-7, 2010 in Orlando, FL. For more information, visit <http://livephoto.rit.edu/workshops/>.

Robert Teese (Robert.Teese@rit.edu) is in the Department of Physics at the Rochester Institute of Technology.

Report from the Chair of the APS Committee on Education

Peter Collings

The Committee on Education (CoE) of the APS serves in an advisory role for the President, Executive Board, and APS Council for matters of physics education. It can suggest or supervise initiatives related to physics education, especially those that improve the cooperation between the educational community and other parts of the physics community. The Committee on Education and the Forum work together, with the Committee directing its attention toward policy and the Forum concentrating on activities designed for APS members. The Forum Past Chair, Chair, and Chair-Elect are members of the Committee on Education.

The Committee on Education has taken a couple of steps that are bound to be of interest to Forum members. The first has to do with the importance of a research experience in the undergraduate physics curriculum. While some time ago such experiences were rare, now a large number of physics majors have the opportunity to perform research. The benefits of such research experiences have been measured, and the Committee is convinced that the benefits can be so large that undergraduate research should be given a high priority across the nation. To that end, the Committee on Education adopted the following statement.

The Committee on Education of the American Physical Society calls upon this nation's physics and astronomy departments to provide, as an element of best practice, all undergraduate physics and astronomy majors a significant research experience.

The Committee put a substantial rationale together to further elaborate on the statement. This rationale can be found on the APS undergraduate education page <http://www.aps.org/programs/education/undergraduate.cfm>. A second step taken by the Committee concerns the publication of the results of physics education research

(PER) in APS journals. Already APS publishes papers in *Physical Review Special Topics – Physics Education Research*, which is sponsored jointly by the APS, AAPT, and Forum. This highly respected journal provides an excellent opportunity for physics education researchers to communicate the results of their work. So established and so important is some of this work that the question arises whether on rare occasions a PER manuscript might be significant enough for more widespread and more rapid dissemination. The journals *Science* and *Nature* have published such articles, and the Committee conferred with the APS Editor-in-Chief, Gene Sprouse, about the possibility of publishing a PER article in *Physical Review Letters* (PRL). The consensus was that it might be possible for an article describing the results of physics education research to reach the level of significance and importance required for publication in PRL. As a result, the Committee on Education adopted the following statement.

Research involving physics and education can rise to the level of importance expected for Physical Review Letters. The Committee on Education urges that such Letters be considered for review, and its members are willing to assist PRL editors in rendering preliminary judgment and identifying reviewers.

Since none of the PRL editors have been assigned the area of physics education research, PER manuscripts submitted to PRL should be sent to the APS Editor-in-Chief.

Peter Collings is the Morris L. Clothier Professor of Physics in the Swarthmore College Department of Physics and Astronomy. His research specialties are liquid crystals, light scattering, self-assembly of biologically important molecules, and supramolecular chemistry. He is Chair of the APS Committee on Education and Chair of the Forum on Education.

Letter to the Editor: College scientific literacy courses make a big difference

Art Hobson

Physics teachers, especially physics education researchers, need to know about the science education research of Jon Miller, Professor of Interdisciplinary Studies and Director of the International Center for Scientific Literacy at Michigan State University. He is probably the world's leading expert on the measurement of scientific literacy. This is profoundly important work, because most national and global problems cannot be solved without a scientifically literate populace.

Miller and his colleagues have developed a set of basic science knowledge (concepts such as molecule, laser, DNA, biological evolution) and scientific process (an understanding that science is based on evidence and reason) questions used to study adults in many nations. He has used these questions, periodically updated to reflect new knowledge, in adult scientific literacy tests since 1988. A person scoring above 70 on these tests probably has sufficient knowledge to understand science-related stories in the daily newspapers, and is thus considered to be scientifically literate. By giving his test to a representative sample in each nation, Miller can determine the scientifically literate fraction of that nation's population, called the "scientific literacy rate" (SLR).

The bad news is that global scientific literacy is shockingly low. Among the 34 nations tested in 2005, the SLR rose above 30% in only one nation, Sweden, whose SLR was 35%.

For the United States, the good news is that in all of Miller's results since the beginning of testing in 1988, the U.S. scored above nearly all other nations. In the 2005 tests, for example, the U.S. ranked second with an SLR of 28%; next-ranked were Netherlands, Norway, Finland, and Denmark at 20 to 25%; then 15 European nations including Germany, France, and the United Kingdom scoring between 10 and 19%; and finally 13 other nations including Ireland and Japan at under 10%. In light of American students' mediocre showings in international science tests at the primary and secondary school levels, this is surprising. What happens to Americans after secondary school that accounts for this result?

To investigate this question, Miller asked each U.S. participant in the 2005 tests their age, gender, highest level of education, number of college science courses,

number of children present in the household, their use of informal science learning resources (museums, magazines, etc.), and whether their adult occupation is science-related. He found that, over all these variables, the strongest predictor of adult scientific literacy was the number of college science courses taken; 75% of the variability in different people's scientific literacy scores could be predicted simply from this number. In assessing the effect of this variable, the number of college science courses was grouped into just three levels: (1) no courses, (2) one to three one-semester courses, and (3) four or more courses. People falling into the latter two groups were far more likely to be scientifically literate than those in the first group. Note that category (2) represents non-science students who are required to take a few science courses.

Thus the college experience is a strong determinant of scientific literacy in the U.S. The college experience is significantly different in nearly all other nations insofar as science education is concerned. Because other nations focus only on professional training at the college level, they don't require students outside of scientists and engineers to enroll in any science courses at all. Thus they have very few category (2) students. Miller concludes that "the college and university general education requirement to take at least a year of science courses makes a major contribution to the civic scientific literacy of [U.S.] citizens," and that the surprisingly high U.S. SLR is a result of the positive impact of these college-level science courses for non-science students.*

So it seems likely that all nations could increase their SLR by requiring science courses for non-science college students. Looking only at Europe, we might expect (in light of the superior performance of most European nations relative to the U.S. at the secondary level) such a requirement to raise the median European SLR to at least the 28% U.S. rate. In Miller's 2005 tests, the median European SLR was only 14%. Thus it's plausible that a science literacy course requirement for European non-science college students could double the median SLR in Europe!

But regardless of the precise effects on any nation's SLR, Miller's results certainly underline the importance of college scientific literacy courses. The U.S.

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should more strongly emphasize these courses, and all other nations should teach them.

I'd be delighted to discuss these ideas with anybody who is interested. Email me at ahobson@uark.edu.

Art Hobson is Professor Emeritus of Physics at the University of Arkansas in Fayetteville, and author of a scientific literacy textbook Physics: Concepts & Con-

2009 FEd Member Survey

Ernie Malamud

Brief History

Should the FEd take on more than its traditional role of organizing sessions at meetings and publishing a newsletter? Gay Stewart suggested a survey to address this question and perhaps also as a way to motivate and encourage the Forum membership numbering in the thousands to undertake new initiatives. Gay took the lead on creating a first draft of the survey. Subsequently many contributed and John Thompson produced the final version.

The email inviting our members to participate laid out the purpose:

“The Forum on Education is one of the largest Forums in the APS, an indication that science education is a critical issue for our members. Your opinions are needed to help identify the most important issues in science education that the APS faces. The FEd Executive Committee has created an online survey of the FEd membership to help identify these issues and set the goals for the Forum.

Currently, FEd activities include creating sessions and hosting events at APS meetings, providing workshops on educational issues and tools for APS members, helping support non-APS conferences and events focused on physics education, and publishing a newsletter three times a year highlighting educational activities in physics and beyond. The Executive Committee will use the results of this survey to focus the work of the Forum on those activities that best serve the members of the APS,

nections, now in its fourth edition. This letter is loosely based on the author's paper “The surprising effectiveness of college scientific literacy courses” appearing in *The Physics Teacher*, October, 2008.

* Jon D. Miller, “The impact of college science courses for non-science majors on adult scientific literacy,” paper presented to a symposium titled “The critical role of college science courses for non-majors” at the annual meeting of the AAAS, 18 Feb 2007, San Francisco.

whether this is strengthening its current efforts or starting new initiatives.”

Survey Details

The survey ran from March 26 through April 17, 2009 using the vehicle “Survey Monkey.” There were 8 questions. Questions 2, 5, 7, and 8 included the option of prose (text) responses. Question 6 is entirely open response.

Response and comparison with the 2007 survey which focused on the newsletter

There were 796 responses or 17.3% of our 2009 membership of 4595. Of the respondents, 91.3% (727) are FEd members. It is unclear how the other 69 got the survey and responded. (727 are 15.8% of our 2009 membership.)

This response is significantly higher than in our previous survey, in 2007, which focused on the newsletter. That survey had 14 questions plus a 15th one asking for comments. 504 people, 11.0% of our 4598 members at that time, responded.

After combining some categories (including a few entries in “other”) the table below indicates that 70% are employed in educational institutions (although they are not all necessarily teaching). That compares to the roughly 83% of all FEd members employed in educational institutions. Note: in the “other” category are 5 “unemployed.”

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Who responded? Question 2. Who is your current employer?

College or university with graduate program	46.70%	372
Undergraduate only college or university	20.70%	165
Junior or community college	2.50%	20
High School	1.60%	13
Industry	4.10%	33
Government	4.60%	37
Informal science education provider	0.10%	1
Retired	12.20%	97
Other (text response)	7.30%	58

The heart of the survey: Question 3. Do you feel the FEd should become engaged in more activities beyond its traditional role of organizing sessions at APS meetings and publishing a newsletter?

	Count	Percent
YES	550	69.1%
NO	198	24.9%
Skipped question	48	6.0%

So for what follows we have a somewhat biased sample, i.e., those who completed the survey were more likely to be those who would like to see the FEd take on more activities.

Question 4. To what extent should the FEd, as an APS unit, become more active in the following areas?

There were 8 areas and the respondents were asked to rate each on a scale of 1 to 5 where 1 meant that the FEd as an APS unit should not be active at all and 5 the FEd should be more active.

First, we list the 8 areas and examples for each one. The results are on the next page.

Undergraduate Capacity/Pipeline

Number of physics majors—recruitment and retention; the APS/AAPT Doubling Initiative (a joint APS/AAPT call to double the number of undergraduate physics majors over the next decade); recruitment and retention of majors from underrepresented groups

Graduate Education and Career Preparation

Number of physics graduate students—recruitment and retention; career skills and preparation for non-academic careers

Outreach

Demonstration shows, museums/science centers, school visits, media liaisons

K-12 Teacher Recruitment, Preparation, and Support

Recruitment of physics majors to become physics and physical science teachers; collaborations with teacher education programs; professional development workshops for K–12 teachers

University Physics Education

Development and/or dissemination of new courses, including interdisciplinary; issues in physics teaching at the introductory, advanced, or graduate levels.)

Dissemination of Results of Physics Education Research (PER)

Dissemination of PER-based practices, curricular materials, and results; promotion of PER in physics departments

Resources (non-financial)

Broader impacts assistance with NSF grants; electronic resources, e.g., ComPADRE

APS Policy Regarding Education

Recommendations for best-practice pedagogy; accreditation of physics programs; endorsement of teaching materials; K–12 physics teaching content (e.g., state or local standards)

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	Not Active At All				More Active	Rating	Response
						Average	Count
Undergraduate Capacity/Pipeline	3.3% (17)	7.9% (41)	25.0% (130)	37.4% (194)	26.4% (137)	3.76	519
Graduate Education and Career Preparation	3.1% (16)	10.3% (53)	31.3% (161)	32.1% (165)	23.2% (119)	3.62	514
Outreach	3.7% (19)	8.1% (42)	24.0% (125)	33.8% (176)	30.4% (158)	3.79	520
K-12 Teacher Recruitment, Preparation, and Support	2.3% (12)	4.4% (23)	17.2% (90)	35.5% (186)	40.6% (213)	4.08	524
University Physics Education	2.5% (13)	6.3% (33)	19.9% (104)	33.5% (175)	37.7% (197)	3.98	522
Dissemination of Results of Physics Education Research (PER)	3.3% (17)	5.6% (29)	18.6% (97)	35.1% (183)	37.4% (195)	3.98	521
Resources (non-financial)	4.3% (22)	11.4% (58)	32.1% (164)	32.9% (168)	19.4% (99)	3.52	511
APS Policy Regarding Education	3.3% (17)	4.6% (24)	15.6% (81)	33.1% (172)	43.5% (226)	4.09	520

Conclusion: About 2/3 of the respondents answered question 4. The average ratings are fairly similar for the 8 areas. They all are between 3.5 and a little over 4. The highest are for the FEd to be more active in APS policy regarding education and in K–12 teacher recruitment, preparation, and support. My understanding is that the first of these, APS policy, is more the purview of the CoE, whereas K–12 teacher recruitment, preparation, and support is certainly an area where the FEd could be more active (other than sessions at meetings and newsletters). So the question for discussion now is specifically what should we as a unit undertake, if anything?

Question 5. What are the most pressing areas the FEd should address? (choose up to three)

Since the respondent could choose up to three, the total does not equal 100%. Again, about 2/3 responded to this question. It is clear that the largest percentage of those who responded felt K–12 teacher recruitment, preparation and support was an area the FEd should address.

K-12 Teacher Recruitment, Preparation, and Support	59.60%	319
University physics education	45.20%	242
Dissemination of results of physics education research (PER)	38.10%	204
Outreach	33.50%	179
Undergraduate Capacity/Pipeline	30.10%	161
APS Policy Regarding Education	29.00%	155
Graduate Education and Career Preparation	21.90%	117
Resources (non-financial)	12.10%	65
Other (text response)	6.40%	34

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Question 6. What are the best ways to engage FEd members in pursuing these activities?

There were 213 prose responses to this question. There are a few common themes:

- Work locally with schools, universities, and APS sections
- Form subcommittees and task teams and give them well-defined charges and action items
- Improve dissemination of materials, PER materials, and public outreach materials
- Work more closely with AAPT and SPS

Question 7. What education-related activities are you currently involved in? (choose up to three)

This question (except for the first one asking if they were a FEd member) had the most response; 603 individuals responded.

	Percent	Count
University physics education	66.50%	401
Outreach	47.30%	285
Graduate Education and Career Preparation	29.20%	176
Undergraduate Capacity/Pipeline	28.70%	173
K-12 Teacher Recruitment, Preparation, and Support	27.40%	165
Dissemination of results of physics education research (PER)	15.40%	93
Resources (non-financial)	8.00%	48
APS Policy Regarding Education	2.20%	13
Other (text response)		67

Question 8: What would you personally like to become more involved in?

556 people answered this question.

	Percent	Count
University physics education	19.80%	110
K-12 Teacher Recruitment, Preparation, and Support	19.60%	109
Outreach	14.70%	82
Other (text response)	11.50%	64
APS Policy Regarding Education	9.20%	51
Dissemination of results of physics education research (PER)	8.50%	47
Undergraduate Capacity/Pipeline	7.00%	39
Graduate Education and Career Preparation	5.90%	33
Resources (non-financial)	3.80%	21

Another frequent reply in the “other” category was they were maxed out already.

I would be happy to provide detailed data upon request.

Ernie Malamud is the FEd Past-Chair and a member of the Adjunct Faculty at the University of Nevada, Reno.

Teaching K–12 fluid dynamics: The physics of flow

A FEd mini-grant report by Benjamin Blonder



Can you teach the basics of fluid mechanics at the middle school level? At the McCall Outdoor Science School, we're beginning to do it. Our program is operated as a partnership between the Palouse-Clearwater Environmental Institute and the University of Idaho, focusing on delivering inquiry-based science programs to public schools across Idaho. Every year we serve approximately 4000 K–12 students with weeklong programs delivered in schools or at our campus in the mountains.

Recently we received a \$500 mini-grant from the Forum on Education to help us implement a one-day program entitled 'The physics of flow'. We already have programs for river ecology, watersheds, and water quality monitoring, but we rarely address the physical properties of water or the nature of flow. Nevertheless those concepts are important and present in the state educational standards for middle and high school. Our new program can be delivered outdoors in the streams, rivers, and ditches near schools using natural flows as our laboratory. We can cover concepts concerning fluids such as speed, inertia, viscosity, drag, mass transfer, and turbulence in a hands-on fashion. APS has helped us purchase a large quantity of fluorescein, a yellow-green fluorescent dye that is suitable for tracer experiments in natural bodies of water. Students use it in syringes to explore movement in a fluid for themselves. APS has also helped us purchase a USGS Type AA current meter, an instrument that can directly measure speed in a stream. It has six conical cups mounted on a low-friction bearing that can be submerged to a desired depth; the rotations of the bearing are then transduced to a headset where they can be counted and timed by an operator. With an understanding of the rotation, the stream speed can be calculated. We use it to measure stream speed profiles and calculate total stream flow.

Thanks to the quick grant review process, we've already received the equipment and implemented the program. I trained our teaching team on the proper use of our new materials in the middle of March; now at the beginning of May we've delivered the program 6 times to 200 students, mostly in Title I schools. We've found that students respond very strongly to such exciting looking tools—not only does our program easily engage them, but they are also beginning to create an identity as a scientist. Fifth- and sixth-graders are able to understand our tools and begin to build their intuition for how fluids work. These initial successes mean we will continue to deliver the program this spring and fall, and will also use it with the 100 Upward Bound students hosted at our campus this summer.

As a recent physics graduate and new educator, I'm very enthusiastic about integrating real science tools and physics into all of our outdoor science programs. Seeing this program come into existence with the help of APS has been a wonderful experience for me—my first ever grant!

Benjamin Blonder received his BA in physics from Swarthmore College in 2008. He currently serves as an environmental educator in Idaho through AmeriCorps.

FEd Mini-grants of up to \$500 are available. Contact the FEd Chair, Peter Collings (pcollin1@swarthmore.edu) and the FEd Secretary-Treasurer, Bruce Mason (bmason@ou.edu) for additional information. Turn-around on these proposals is rapid.

LaserFest 2010: Celebrating 50 Years of the Laser

Nadia Ramlagan

Theodore Maiman developed the first working laser at Hughes Research Lab in 1960. Since then, the laser has affected our lives tremendously; it is responsible for technologies we couldn't do without, from barcode scanners to eye surgery. LaserFest is a celebration of the 50th anniversary of the laser that will emphasize its impact throughout history and highlight its future potential. Through a series of events and programs, LaserFest will help to showcase the prominence of the laser in today's world. LaserFest is organized by the APS and The Optical Society (OSA).

Anyone who is interested can find out about events and activities, and sign up to receive updates and program announcements from LaserFest by visiting our website at <http://www.laserfest.org>. There are also instructions for those individuals or corporations interested in being involved in LaserFest. All sponsors will be offered appropriate recognition on the website and in other LaserFest promotional materials.

LaserFest is designed as a public outreach activity. To successfully reach as wide an audience as possible, it will require broad participation from both scientific and local communities. We invite and strongly encourage the organization of independent LaserFest activities and events for the 2010 year, and their registration on the LaserFest website, so they can be incorporated in a comprehensive event calendar. Those with plans or event ideas are encouraged to submit them through our online event submission form. For questions, suggestions, or event ideas, please contact Nadia Ramlagan, LaserFest Project Coordinator at ramlagan@aps.org.

There are plenty of educational materials and resources available on the LaserFest website. Students can explore exciting laser innovations, watch laser videos, play an interactive laser challenge game, read about women in laser science, and browse a timeline of the milestones that paved the way for the experimental realization of the laser. There is also a step by step explanation and diagram of the first ruby laser. In 2010, the APS education department will produce a laser centered curriculum module for distribution to classes across the country. This module will focus on diffraction and interference. All of the instructions for these lessons will be available on the LaserFest website.

The site's laser history section provides information about the early history of the laser, from Einstein's the-

ory of stimulated emission to the invention of Maiman's laser in 1960. Specific contributions from key scientists whose work led to the invention of the laser is available, including Robert H. Dicke, Gordon Gould, Charles Townes, and Arthur Schawlow, as well as a list of Nobel laureates whose prize-winning research involved lasers.

In the coming months, PhysicsQuest 2010 will be featured on the LaserFest website and on <http://www.physicscentral.com>. PhysicsQuest is a middle school competition that consists of four physical science experiments centered on a mystery. The experiments are designed to be done by small groups in a classroom or after-school setting. Each of the experiments gives students a clue that they need to solve the mystery. Classes can submit their answers online and be entered into a random drawing for prizes. PhysicsQuest kits are provided free to registered classrooms.

In "Spectra's Power" PhysicsQuest 2010, students will follow the ordinary school girl Lucinda Hene, as she transforms into the powerful Spectra, a superhero with the powers of a laser. To unlock the mystery of her origin and her powers, Spectra must defeat the evil super villain, the beautiful yet deadly, Miss Alignment. As Spectra learns about her past, students will learn about why lasers are one of the most important inventions of the 20th century. They will do experiments that highlight why lasers are extraordinary tools for unlocking the mysteries of our world. All the while, students will be helping Spectra and her team save the world from the clutches of Miss Alignment.

New material is continually added, so visit <http://www.laserfest.org> frequently. Upcoming materials include a complete laser history timeline, a series of podcasts, ideas for outreach activities, and information on PhysicsQuest 2010. In the coming months, the site will show a calendar and interactive map of events, where you'll be able to find and participate in LaserFest in your local community. As events get underway, be sure to look out for a LaserFest blog featuring laser scientists profiles, fun articles, and highlights of events with weekly entries and photos.

Nadia Ramlagan is the LaserFest Coordinator at APS and a member of the team at APS that produces APS News.

Advice on Writing the Educational Component of an NSF Grant Proposal

Lincoln D. Carr

The following advice is based on a successful NSF career proposal in 2005. I have had a wonderful time carrying out that proposal, together with my close collaborator Prof. Sarah McKagan, a physics education researcher, and the results are publicly available for you to look at [1].

First, choose something you care about. Everyone has an educational issue that is particularly important to him or her. In my case, it was graduate quantum mechanics. I had taken graduate quantum mechanics at the University of Washington and written a thesis in many-body condensed matter theory. Yet when I arrived in Paris for my first postdoctoral position, I found that I knew almost nothing about quantum mechanics; from a French perspective I was forty years behind the state of the art. In the process of teaching myself what I needed to know, it struck me that many of these things I could have learned as a graduate student: for instance, that the density matrix is not just about finite temperature; what entanglement is; and what it means to make a measurement in a quantum system. So when I wrote my NSF career proposal I focused on bringing quantum mechanics up to date in the U.S., something I had direct experience with and cared about personally. Having reviewed for NSF many times now, I would say that this personal investment really shines through in a proposal. Don't write about something you don't believe in just because you think it sounds good. Find what you believe in and write about that.

Second, enlist help from the physics education research (PER) community. People in this discipline apply their scientific training towards improving teaching, something we should all be doing at least part time at universities. Prof. Noah Finkelstein aided me in my career grant application. Among other things he helped me develop a clear program of quantitative measurements I could make on my proposed teaching reform, and then put it in the context of ongoing research in physics education. A teaching experiment is not like a normal science experiment on human subjects, since there is no real double-blind experiment possible. Also, although there is extensive data showing that PER-inspired methods have a tremendous and measurable impact on course outcomes, the overall traditional research community is not always aware of this. Developing a good set of references to support the educational part of your proposal

shows that you are serious and understand the broader impact of your work. There are many aspects of education you can work on, and PER folks know them well: methodology, content, assessment, attitude, etc.

Third, always make sure that the faculty in your department is on board with your program. With their support and advice you can write a better proposal. And if you receive the grant, you will be better able to carry out the program and have something magnificent to report on when it comes time to apply for a renewal. Older faculty members have a great deal of teaching wisdom, which can be tapped during the proposal-writing process. Your department chair/head should also be invested in your ideas, which can have a real impact on key campus issues tied to actual department funds, like the number of undergraduates who major in physics. You may also need technical support for innovations like clickers or simulation-based in-class demonstrations.

Fourth, don't be over-ambitious. I have this tendency myself. In writing my own grant I initially wanted to create a viable terminal MS degree in physics at a national level as well as reform the teaching of graduate quantum mechanics, among other plans! This is far more than a new faculty member can do. You should be realistic about your time and provide a clear description of how your educational plan can be carried out while you make great strides in your traditional research. If possible, the two plans, research and education, should fit together nicely. For instance, in my case I was starting a many-body quantum research program at a fairly applied university. Therefore it was paramount to educate students in the proper understanding of quantum mechanics in order to eventually produce viable graduate students for my group.

Fifth, do something that stands out. For example, everyone creates a new course in their department at some point, so that is not really remarkable. On the other hand, creating a new course and then quantitatively studying its impact on depth of conceptual understanding in related courses would be novel. Does the new course create a better physicist, or just allow you to talk about what you like best? Similarly, speaking at the junior high or high school down the street and recruiting from there is something that already happens anyway on

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most university campuses. Instead, try going to a rural or poorer school where there is an underdeveloped science program and speak about science there, where it's really needed. The same is true for graduate recruiting—try going to a liberal arts school where there are talented science students who are being overlooked. Finally, it doesn't hurt to reach out educationally to the dominant under-represented group in your area. For instance, many western U.S. states have a high percentage of Hispanic Americans, many of whom struggle financially and languish in community colleges, despite a high level of talent.

To summarize, I suggest the following: write on something you care about; get advice from the experts in physics education research; make sure your fellow faculty are enthused about your ideas and get their input; stay focused and be realistic about your time; and step out of the ivory tower.

Reference

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Strategies for developing an educational component for an NSF proposal

John Cerne

The key questions that any proposal must answer are: What is the important problem that you are addressing? How will you contribute to resolving it? Why are you the one who should carry out this work? These same questions must be answered in the educational component of a proposal. I have addressed a number of challenges in teaching undergraduate and graduate students at the University at Buffalo (UB), and discuss three of them below.

Problem 1: Conceptual understanding of waves. I have been teaching a large (~200 students) introductory undergraduate course on waves, optics and modern physics every spring for the past decade and found that while most students could algebraically manipulate trig functions, their understanding was superficial. Few students knew what would happen when a phase constant was placed in the argument of a sine function. Waves represent one of the most important concepts in physics, playing a crucial role in topics ranging from acoustical phenomena, electricity and magnetism, optics, Fourier analysis, and quantum mechanics. However, since waves have both a temporal and spatial dependence (often in more than one dimension) that may be difficult to visualize, many undergraduate and graduate students have a poor understanding of even basic wave concepts. Many of my undergraduate students claimed to have never seen functions with more than one argument. This made visualizing waves that depend on space and time extremely challenging. Part of the problem is that waves are typically explained using static and non-interactive pictures or perhaps only mathematical equations. In collaboration with a local high

school teacher (Frank Nappo, Lockport NY) and two undergraduate students (Jaymee Minner and Michael Gerfin), we have attempted to explain many basic wave concepts using interactive graphical simulations, Conceptual Learning Approach to Waves [1] There are many excellent web sites using similar graphical interactive tools, but they tend to focus on mechanics, electrostatics, and magnetism. My initial work was focused on polarized light, and I wrote several Java applets to allow students to manipulate the polarization of light, either linear or circular (Fig. 1). Since my research involves probing the polarization of light, these applets have been very useful in explaining my work. CLAW has been expanded to cover a much wider range of wave phenomena, ranging from basic phase concepts to Fourier analysis (Fig. 2). These simulations have become an important part of my lectures for calculus-based physics courses as well as my magneto-polarimetry teaching lab.

Problem 2: Designing appropriate and stimulating research projects for undergraduate students. Every semester, several motivated undergraduate students ask me to supervise them in an independent research project. These projects last one semester and it can be very challenging to design a project that is interesting and worthwhile for students who may have very limited experimental physics backgrounds. Many times I have had to turn down motivated students because I did not have suitable projects available. I have created a magneto-polarimetry teaching lab for our Advanced Lab course, and also am using this lab regularly for inde-

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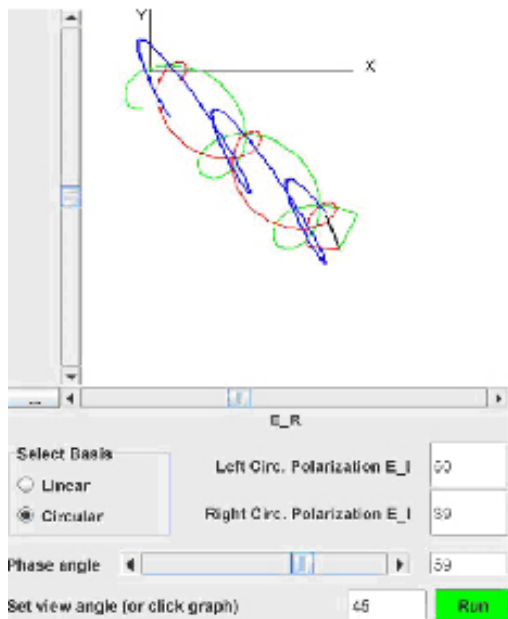


Fig. 1. Interactive graphical Java applet shows how to create various states of polarization.

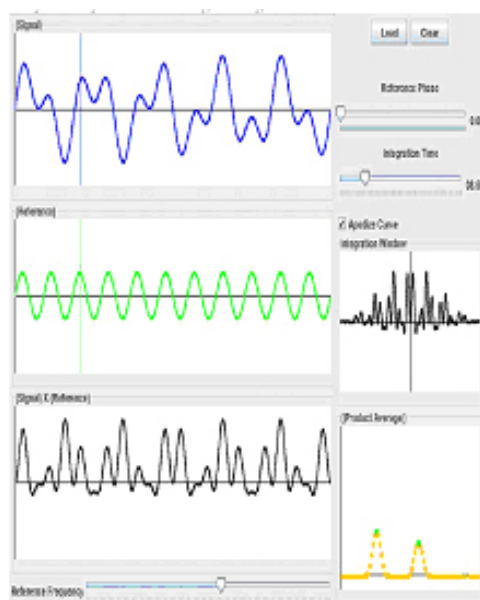


Fig. 2 Interactive simulation that allows users to visualize how and why Fourier analysis works.

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pendent research projects. The students use this system to characterize the latest magnetic semiconductor samples grown by Hong Luo’s molecular beam epitaxy group at UB, so that they become part of and contribute to the latest research that is being carried out at UB.

Problem 3: Traditional (monologue) lectures to passive students in large introductory courses. I have found that monologue lectures make poor use of the limited time that instructors have with their students and basically repeat material that is already covered in the textbooks. Many students leave physics courses intimidated and unenlightened. I was shocked to learn that one study (Redish et al., *AJP* **66**, 212-224, 1998) found that university students’ understanding of what physics is about decreased after they finished their first semester of traditional introductory physics. This surprising result may not be so incredible when one realizes that most introductory courses teach physics as an encyclopedic discipline where one simply needs to memorize formulas that are written in large books. In my experience, traditional monologue lectures almost completely eliminate interactions between the instructor and the students (or among students), and probably could be replaced with videotaped lectures with little loss in effectiveness. Although, motivated students may actually ask questions and actively try to understand the content of monologue lectures, I have found that most of my students only learn and make critical conceptual connections in lecture when they are forced to think and respond actively. I also involve them in lecture demonstrations as much as possible, including one demonstration that I developed where all the students (~100) participate to explore radioactive decay. Each student is given a penny and all the pennies begin with the head side up, representing undecayed unstable atoms. Then the students toss their pennies and the number of remaining heads is recorded and projected on a semilog plot on the lecture screen. The toss is repeated for the coins that are still heads, and the new number of remaining heads (undecayed atoms) is plotted. The data are then fitted to an exponential function that is used to determine the decay time of the tossed pennies. The atmosphere is quite gripping as the number of “contestants” is reduced from a hundred to a handful in several tosses.

Although I have always tried to get students involved by asking them questions (and waiting the unendurably long period of silence for them to break down and actually answer the questions) and taking polls by asking for a show of hands, since 2007 I have been using clickers. I have based my lectures on Eric Mazur’s Peer Instruction [2] and found the lectures to be much more interesting and varied. Polling the students has greatly helped me check the students’ understanding and has allowed me to adjust my lectures to address real, rather than perceived, problems in their understanding. Thanks to the clickers, I can give up to 5% extra credit for attendance/participation. Whereas I was lucky to get 50% attendance before the clickers, the average attendance now is around 70%. The extra points are certainly part of the increase in at-

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tendance, but I also think that students are finding the lectures more stimulating and useful, realizing that actively figuring out the material in lecture will save them time later.

In addition to identifying and addressing educational challenges, I have found a number of strategies that can help in writing effective teaching components for proposals:

1. Base the teaching components on your actual experiences and interests. There are many exciting new teaching techniques being developed and it is tempting to simply use educational buzzwords to make a proposal seem more credible. As a reviewer, I am much more impressed by proposals where the author shows genuine interests and real actions in teaching.
2. Get in touch with people involved in physics education research. I have been fortunate to have been helped by and worked with many excellent people involved in physics education research. Thanks to Dan MacIsaac (Buffalo State College), I have established contacts with local high school teachers (for example, Frank Nappo, my collaborator on CLAW), while David Henry (Buffalo State College) and Chandralekha Singh (University of Pittsburgh) have given me a greater appreciation of the challenges and subtleties in assessing how (and how much) students learn.
3. Participate in conferences and workshops that deal with education. In my first semester at UB, I was sent to the AAPT/APS New Faculty Workshop [3]. This workshop opened my eyes to new teaching techniques and introduced me to people like Eric Mazur (Harvard), Evelyn Patterson (US Air Force Academy), Ken and Patricia Heller (University of Minnesota, Minneapolis), and Lillian McDermott (University of Washington, Seattle). I have greatly benefited from attending two Cottrell Scholar Conferences, which focus on the challenges of improving education at research universities.
4. Apply for grants that emphasize teaching. My best teaching proposals were developed for grants which value teaching. For example, the Research Corporation [4] typically weeds out 50% of its grant applications based solely on the educational component. This greatly helps applicants with strong interests in teaching, encouraging them to spend more time and energy on their teaching proposals. My proposal for the Research Corporation's Cottrell Scholar Award provided excellent preparation for my NSF CAREER proposal.
5. Take advantage of your institution's educational resources. Some teaching proposals that are well suited for one institution may not work as well at another. For example, I am very impressed by the studio learning approaches such as the SCALE-UP Project [5] and Tutorials in Introductory Physics [6], but currently we do not have lecture space that could accommodate such an approach for our large introductory courses. On the other hand, all the large lecture halls at UB have excellent LCD projectors with internet access, so online simulations such as CLAW are readily implemented.
6. High school teachers are a great resource for educational and outreach ideas. Almost all the simulations in CLAW were written in Flash by high school teacher Frank Nappo. Furthermore, Frank is great at bringing high school students to our outreach events. For example, when we had an open house and public lecture a few months ago, Frank brought 70 students to the Department.
7. Work with your University's programs for minorities. I have found UB's Cora Maloney College [7] to be extremely useful in finding highly qualified and motivated students (e.g., Jaymee Minner who worked on CLAW) from under-represented groups to work on my educational projects. For example, Daniel Crowe, an Undergraduate Louis Stokes Alliance for Minority Participation summer intern, made a kicker circuit to drive the Foucault pendulum at the Buffalo Museum of Science [8]. Having real contacts and experience with people and programs that support minorities strongly bolsters proposals that target minorities.
8. Design education projects that will help, not hinder, your research. Not all proposed educational components interfere with research. I have found that my magneto-polarimetry teaching lab [9] has helped my research and allowed me to start new research projects. The lab has provided a method to recruit and train students; has given me new experimental tools to start new research collaborations, and has provided a test bed for new experimental techniques that could not be attempted in my research

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lab due to lack of space and/or equipment availability. As an example, we are currently developing a polarization-sensitive confocal microscope using the magneto-polarimetry lab.

Writing proposals is one of the most challenging and stressful parts of academic life. For many faculty, the

teaching component of a proposal only adds to the burden, or is relegated to boilerplate material that is only included to satisfy minimum administrative requirements. Instead, investigators can use this component of the proposal as an opportunity to explore creative ways to enrich the experiences of both the students and the instructor.

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Using Cases in Introductory Physics

Debora M. Katz

If you teach physics to non-physics majors for a long enough time, you are bound to be asked, “Why do I need to know this?” This question may seem hostile, and so we appeal to the student’s most selfish interest and answer, “Because it is on the test,” or “Because you need to know it for the next required class.” Perhaps the student’s question is born out of a genuine curiosity. It seems likely that students may want to know how the physics that they learn in our classroom fits into their experience of the world. In fact, being able to answer that question may be the single most important thing you do for your students. Many students cannot learn physics without knowing why they are required to do so.

For the moment, imagine that you are a student who hopes to become a medical doctor, an electrical engineer, or a United States senator. You are in a physics class either in high school or college, and you have just spent three hours in a laboratory measuring the kinematics of a cart. A bright, curious student is likely to wonder why such a laboratory is important. Think of the sort of answers that might satisfy you.

For example:

1. Studying the motion of a cart may seem trivial and perhaps boring. However, we work with the cart because it is simple, and this allows us to focus on the mathematical description of motion. This is the foundation for studying more complicated motion.
2. Since so many things (our hearts, particles in a conductor, people on public trains) are in motion, the description of motion is the beginning of understanding a wide variety of phenomena. So whether you want to be a doctor, an engineer or a legislator, understanding motion is an important part of your preparation.
3. The laboratory helps to develop your skills. You practice making quantitative measurements and estimating the error in those measurements. You learn the difference between experimental errors and mistakes.
4. For over 1500 years, people did not understand the nature of motion. One of the great achievements of science is developing a mathematical description of motion. It was an important step in our understanding of nature. Understanding nature allows us to know ourselves better, and determines how human-

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ity works together. All educated people should understand nature in general, and motion in particular.

I think you would be more satisfied with one of these answers than with just knowing that you will be tested on the laboratory.

These are terrific answers, but what is the best way to persuade your students that these claims are true? You have probably seen the ancient Chinese proverb:

*I hear and I forget
I see and I remember
I do and I understand*

The proverb tells us that when our students listen to a lecture or watch us demonstrate a concept, they don't learn as much as when they are actively engaged. You probably use some active learning techniques in your classroom, in the hope that your students will better understand important concepts such as Newton's laws or Maxwell's equations. But while a laboratory measuring the kinematics of a cart is likely to deepen students' understanding of motion, such experiences do not answer your students' most fundamental question of why they should learn these physics concepts in the first place.

Just as lecturing is not an effective way to teach physics concepts, it is not an effective way to address this fundamental question either. Case studies are active learning projects that address not only particular physics concepts, but also the importance of physics. In general a case study has two parts: a motivating or exciting setup and a challenge to be solved by the students. A student working on a case study is like Sherlock Holmes solving a mystery. The student sees the importance of the challenge and is excited to find the solution.

A case study may be used to draw a connection between the concepts learned in the classroom and challenges faced in the outside world. For example, suppose a trucking company is being sued because one of its drivers collided with a car. Based on data taken at the scene and reported in a newspaper article, students can determine whether the truck driver was exceeding the speed limit. The motivation is making sure that justice is done. The challenge is for students to find the driver's speed. Such a case study shows students that the basic (and sometimes boring) concepts they learn in our laboratories make a difference in people's lives.

(Will the trucking company lose the suit?)

A case study may also be used to show the importance and the process of scientific discovery. For example, a case may include an imaginary dialogue between historic figures such as Galileo and Aristotle. Aristotle would argue that a force is required to keep an object in motion. Galileo would disagree; he would argue that a net force will cause the object to accelerate. The debate is exciting. Students are challenged to evaluate each figure's argument. Working through the same struggle that took people more than a millennium to sort out helps students to see the important place of science in human understanding.

This particular case study works nicely as an introduction to a kinematics (or dynamics) laboratory. In order to understand the difference between Aristotle's and Galileo's theories, students learn to take friction into account as a source of error. Then they are better able to distinguish between laboratory errors and human mistakes.

There is another benefit to using a case study that involves fictional dialogue; it allows students to address their own preconceptions. It is possible to include many common preconceptions in a fictional dialogue. When students work through such a case study, they learn how their preconceptions are connected to their formal study of physics. This process of connecting their preconceptions to physics concepts helps to break down the notion that there is one sort of physics used in the classroom, and another sort of physics used in the more complicated outside world.

My students wrote some of the best case studies I have seen. Whenever I teach non-physics majors, I always include a term project in which students ask and answer a question using the physics covered on our syllabus. Students are willing to tackle complicated and interesting problems when they choose the problem for themselves. The problems they choose to solve are generally more involved than any homework problem, and there is no doubt that in solving them, students see the importance of physics in their lives. Here are some examples:

1. One runner wanted to know if she should buy a new type of running shoe. She borrowed a piece of the track from the coach and a new shoe from another runner. She used these to measure the co-

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- efficients of static friction between the new shoe and the track, and also between the old shoe and the track. She used techniques similar to ones she used in one of our boring laboratory exercises. She found that the old shoes had a slightly higher coefficient of static friction.
2. A movie fan wanted to know why we haven't built a light saber as featured in the *Star Wars* movies. He learned to isolate a single answerable question, "How many batteries would it take to power a light saber?" Based on particular scenes in the movies, he estimated the number of batteries that would be required. He applied principles from thermodynamics and electricity and magnetism. He found that great number of batteries required would make the

light saber too heavy to be practical.

3. A student interested in the classics learned that in ancient Greece, self-propelling carts were used to move scenery around in theatrical productions. He wanted to know if such a cart could be used to move the actors. His analysis involved free-body diagrams, rotational kinematics and conservation principles. While he had done more than enough work to complete the assignment, he also decided to build a scale model of the device. It looked something like the carts we use in our laboratories.

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START WITH A STORY: The Teacher as Storyteller

Clyde Freeman Herreid

Teachers are inveterate storytellers. Today around the world in science classrooms, faculty are taking this skill to new heights; they are using case studies to present basic concepts. Imagine the possibilities: teaching astronomy, chemistry, physics, or geology using stories. That is what case studies are, "stories with an educational message."

Case study teaching has a long hoary history in law and business schools, having been started at Harvard in the early days of the 20th century. Of course, that makes sense. Law professors use previous criminal or civic cases as precedents for today's courtroom dramas. Business profs do the same, as they look at the 1930's depression to help evaluate today's fiscal crisis. In medicine, patient cases serve as exemplars for students as they struggle to earn their right to wear a stethoscope, and McMaster University in Canada uses case study teaching in their problem-based learning approach to instruct physician wannabes.

But can case study teaching be used to teach the basic sciences? Chemist James Conant of Harvard University thought so. He returned from his World War II stint as science advisor to President Franklin Roosevelt convinced that US citizens didn't understand how science was done. He believed that the only way to change this was by telling his Harvard students stories of how the great discoveries in science were pulled off. He created a novel approach developing the Case Histories in Experimental Science course. He regaled his students with the rivalry of Priestly and Lavoisier in their overthrow

of the phlogiston theory, the discovery of the laws of thermodynamics, and the motions of the planets—one engaging story after another. This innovative approach has not survived him; nonetheless it was surely a more dynamic way to get at basic science than most of our current lecture mavens have dared.

But it was still a lecture course. As current educational research has revealed, lectures are a poor substitute for active learning in the classroom. Recall the famous study by Richard Hake who followed 6000 students in physical science classrooms and found striking improvements in learning whenever active involvement of students occurred. Educational researchers, the Johnson brothers and engineer Karl Smith reinforce this conclusion with their publication of a meta-analysis of over a thousand studies indicating the superiority of small group work over lectures in learning virtually any subject.

Twenty years ago, I began exploring different ways of teaching, starting with the notion that people love to hear stories and might learn better when information is delivered that way rather than by the dreary recitation of facts that often represents a typical lecture. After all, native peoples the world over use oral traditions for instruction. Homer's stories of the *Iliad* and the *Odyssey* have been used for millennia to teach the foibles of the human condition. Jesus told parables to illustrate his message, as did Mr. Rogers on public television and

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Dr. Seuss in the pages of children's books. There is a prestigious pedigree for storytelling for educational purposes.

But there are many ways to tell a story and to teach with cases. The classical Harvard approach emulated by business and law schools is where the professor assigns her students long descriptions of situations, perhaps 15 pages in length. In the following class, the professor runs a discussion about the topic even in classes of 70 students. In contrast, the medical school approach uses problem-based-learning, where small groups of students work through short cases with a faculty facilitator. They receive the case in stages. As more and more information is revealed like a detective story, the students must decide what they know and what they need to find out in order to solve the mystery of an illness. The students do research to find the answers, return to their classmates and share the information. After three cycles of this, where more and more information is provided, they make their conclusion and receive another case. Imagine this: the entire medical school training is provided this way. No lectures.

The Harvard discussion method and the McMaster PBL approach are not the only ways to teach a case. Other approaches include debate, symposia, trials, public hearings with role-playing, and so forth (see the book *Start with a Story* published by the National Science Teachers Association, 2007).

Recently we have started using audience response systems ("clickers") to teach with cases in classrooms of several hundred students. Using remote radio frequency clickers, the students send in their answers to a classroom computer and the results are summarized on an overhead screen. The instructor uses PowerPoint slides

Mining Your Research

Jonathan F. Reichert

I have been a regular attendee at the March APS meeting for more years than I care to count—most recently as a vendor of advanced laboratory equipment, not as a contributor to the invited or contributed sessions (although I once did that). I have witnessed over these many years the explosion of papers and posters presented which has always left me with the same two strong feelings. First of all, I am so glad that my research efforts were carried out many years ago, when the physics community was much smaller and I actu-

ally knew most of the people working in my field. I cannot imagine how today's scientist deals with a meeting which has 30 simultaneous sessions every day for five days, but I certainly admire the outburst of creative research.

However, I often find myself wondering what recently discovered physics phenomena could also be observed in an undergraduate advanced physics laboratory?

Some disciplines find case study teaching more attractive than others. Physiologists and ecologists have little trouble finding or writing cases. Physicists and chemists have more difficulty finding the story lines that might engage students. Yet even here the creative teacher will find opportunities in global warming, space travel, industrial discoveries, and the origin of life.

For the past decade, we at the University at Buffalo have developed an extensive website dedicated to publishing cases in all science and engineering fields. Supported by NSF, the National Center for Case Study Teaching in Science now has over 350 cases and teaching notes at [1]. Teachers from across the world download these cases and customize them for their classrooms. We have an average of 4000 visitors per day; over a third are high school teachers. Clearly this sort of teaching is resonating with teachers who have stories to tell.

Link [1]:

<http://ublib.buffalo.edu/libraries/projects/cases/case.html>.

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Surely something being discussed in one or two of the papers being presented at a meeting could become a new advanced lab experiment, possibly even a new “classic.” Do any of the contributing physicists ever think about that possibility? Do they ever ask themselves that question? Do they think about ways to simplify, modify or re-engineer an experiment, which led to their discovery so that it might be accessible to the undergraduate physics major? Does the idea of any kind of “crossover” to the teaching lab ever enter their minds?

After WWII, there was an enormous surge in the development of new and modern advanced laboratory experiments in this country, creating some of the most innovative, challenging, and exciting instructional laboratories in the world. That surge, led by faculty such as Robert Pound at Harvard, lasted about 25 years. In the last 15–20 years, it has died off. How old are the experiments we offer our students in the advanced lab? Who last took the time to bring experiments from the research lab into the teaching lab? I believe that those cutting edge undergraduate labs helped the United States become strong in experimental physics very quickly. Now, while other countries are building world-class facilities, we are showing signs of falling behind. Physics is still an experimental science! This generation of experimental physicists has an obligation to maintain our excellence, even our pre-eminence in this basic science.

No, the sky is not falling “Chicken Little,” but it is time for the physics community to pay attention to these concerns. What is the last new advanced lab experiment *you* can think of that has come from new research and has now become a standard in the teaching lab? There is always concern about technological transfer from the research lab to industrial applications and new products, but hardly a peep about transfer to experimental pedagogy. That must change! I have a proposal to help encourage, even possibly enhance, that transfer.

Every year at the March, and possibly the April APS meeting, the FEd should sponsor an invited/contributed session (or sessions) called “Mining Your Research for New Advanced Lab Experiments.” Faculty, and even industrial physicists, should be invited to submit papers that:

- a) Propose experiments that could be transferred from the research lab to the teaching lab.
- b) Explain experiments they have already in

place at their own institutions that were inspired by current research.

- c) Discuss the equipment and facilities needed to bring these new research experiments into the teaching lab.
- d) Explain the kind of special samples needed for these new experiments and the possibility of their labs supplying them to other schools.
- e) Discuss possible collaborations with colleagues and industry to facilitate bringing new experiments into the curriculum.

Such a session might include both invited and contributed papers. I would suggest that the time allotted for contributed papers be double that of a standard talk. For real communication about experimental pedagogy to take place, the presenter needs to go into the details of instrumentation and student response as well as the basic science. I don’t suspect there will be a flood of participants, so time constraints should not be a problem. If we can find the small but dedicated minority willing to undertake this challenge, we need to give them both exposure and a realistic chance to convince others of the worth of these new experiments.

I want to share one of several examples of such a “transfer” that our company has participated in. Dr. Kenneth Libbrecht of Caltech approached us several years ago with an apparatus and a set of experiments that he had developed for a junior level optics lab at Caltech. Stabilized diode lasers had become an important research tool and he had developed his own homemade version with a set of wonderful experiments. At that time, we had no in-house expert in optics, but with Dr. Libbrecht’s help, we were confident we could develop a robust and rugged teaching apparatus. The photograph shows Dr. Libbrecht’s students using the apparatus, which resulted from that collaboration. And now, one might say the “transfer” has passed from Caltech to TeachSpin to seventy-five colleges and universities all over the world.

In this case, the transfer had an intermediate step of going through a commercial development. Certainly, that won’t be necessary all the time. What is important is the transfer—from research lab to teaching lab. For that to happen, the research community must be conscious of the ongoing need. They must at least think about it some of the time. TeachSpin wants to support this effort and to encourage professional recognition for those who make this a part of their life as physicists. We are

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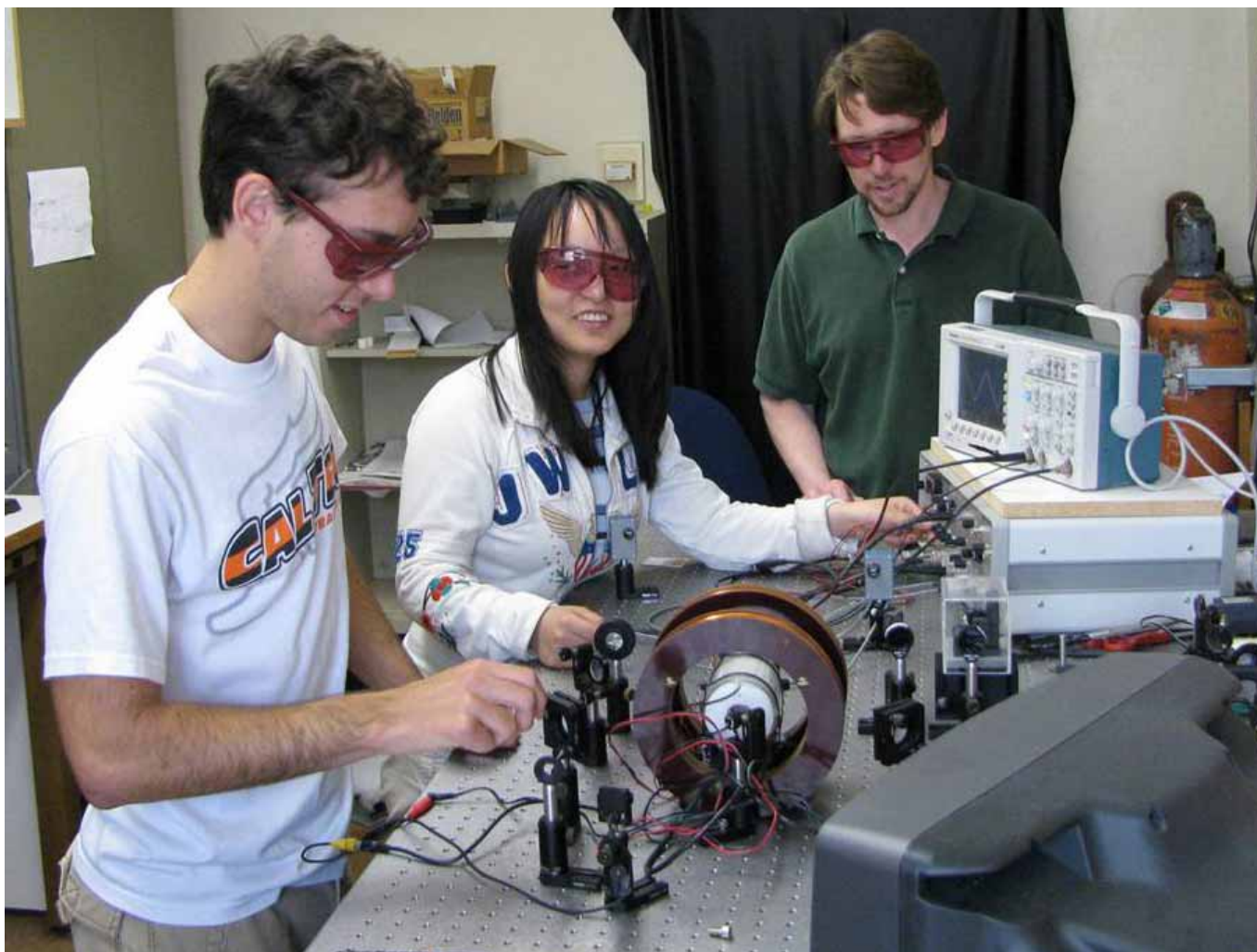
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willing, in fact eager, to fund an APS prize, which recognizes excellence in the development of new advanced laboratory experiments. We propose that the FED provide judges for the award. This award would be given every year in which the judges agree that a worthy candidate had made a recent contribution to the advanced teaching laboratory. The awardee would present an invited talk at the special session of the March (or April) meeting in addition to being presented with a cash honorarium. The APS awards some 45 prizes, none of which recognize what some of us would call the most difficult and time-consuming part of teaching: lab development.

Maybe these few steps will help generate new activity within the physics community, activity that focuses on advanced experimental instruction. It might even encourage the NSF to put more resources into this part of their educational program. It is certainly in the interest of industry, as well as academia, to have students well trained in experimental physics, with real hands-on experience. I even hope that some of the major corporations would come forward with their own support for these efforts. It is certainly in their self-interest.

Let's begin again!

Jonathan Reichert is President of TeachSpin, Inc. in Buffalo, NY, which he began in 1992.



Caltech students using the "Diode Laser Spectroscopy" apparatus in their advanced laboratory

Educating Engineers for the 21st Century

Charles M. Vest and Norman L. Fortenberry

In 2008, the National Academy of Engineering unveiled fourteen Grand Challenges for Engineering. <http://www.engineeringchallenges.org>

These challenges were established by a committee of highly innovative and accomplished engineers and scientists, intended to be a set of important challenges that if met would improve the quality of life on earth. Indeed, some of these challenges must be met if human life is to survive. Furthermore, the committee believes that these challenges can actually be met on a time scale of a few decades if we set our minds and resources to the task. Broadly grouped, these Grand Challenges are to

1. Address key elements of energy, global climate change, and sustainability;
2. Apply engineering and informatics advances to improve medicine and healthcare delivery;
3. Reduce our vulnerability to human and natural threats; and
4. Expand Human Capability and Understanding.

Addressing these challenges will require a scientifically and technologically educated citizenry as well as a dedicated workforce of engineering professionals with not only exemplary technical skills, but the intellectual agility to cope with uncertainty and integrate disciplines, cultures, and evolving technologies. Addressing many of these challenges requires serious educational and research integration among engineering and the life, physical, and information sciences. We have barely started down that path in education, although it is increasingly the norm in forefront research.

The Grand Challenges for Engineering have been articulated and presented in a variety of ways, with emphasis on attracting young men and women to pursue relevant studies. In this vein, a NAE Grand Challenges Summit held last March at Duke University attracted almost 1000 faculty, students, and representatives of industry and government (<http://summit-grand-challenges.pratt.duke.edu>). These challenges appear to strike a resonant chord with the pragmatic idealism of this generation of young people. The National Academy of Engineering working in conjunction with professional film makers is producing a modular video titled "Imagine It: Grand Challenges for a New Generation" that conveys the message of engineering challenge and service to human kind in a dramatic and appealing manner. A sample of this video, still being developed, is found at

<http://www.imagineitproject.com/naepreview/>

What must universities do to prepare engineering students to address these challenges, and to perform well in many domains that engage the power of science and engineering to build strong economies and keep us healthy and secure? In 2004 and 2005, the National Academy of Engineering released two reports [1–2] that (a) identified the professional and technological as well as the global and professional contexts for engineers in the year 2020, (b) identified the desired attributes of professionals best positioned to operate within those contexts, and (c) gave suggestions for how to best prepare future professionals to acquire the desired attributes through formal education and lifelong learning. One key lesson is the need to move from "cycles of reform" to "continuous improvement" in engineering education. In essence this is a call to apply the engineering cycle of research, development, and innovation to the process of engineering education. Much of this will build on the foundation of discipline-based education research pioneered within the physics community.

Most are now familiar with the elegance and significance of the force concept inventory developed by Hestenes and his associates [3–4] as well as other seminal work in the physics education research community [5]. Some in engineering have built upon this base in order to develop concept inventories in a wide array of engineering-related topics: computer science, strength of materials, heat transfer, dynamics, and waves [6].

Our next step is to engage in the process of knowledge transfer from research to practice. We're familiar with doing this in traditional research domains, but less so in the area of education.

Here is a short list of things that we think engineering graduates should experience or know. They should:

- Be excited by their freshman year experience
- Understanding what engineers actually do
- Write and communicate well
- Appreciate and draw upon the richness of American and global diversity
- Think clearly about ethics and social responsibility
- Be adept at product development and high-quality manufacturing
- Know how to merge the physical, life, and information sciences while working at the micro- and nanoscales
- Know how to conceive, design, and operate engineering

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systems of great scale and complexity

- Work within a framework of sustainable development
- Be creative and innovative
- Understand business and organizations
- And ... Be prepared to live and work as world citizens.

This is a tall order, so faculty must properly devote much thought to what their curriculum should be, and what pedagogical styles they will develop and employ.

But having said this, our philosophy of Engineering Education is simple: *Making universities and engi-*

neering schools exciting, creative, adventurous, rigorous, demanding, and empowering environments is more important than specifying curricular details.

This means that students should be engaged in the full range of their institution's intellectual life—engaged as partners in research, design, projects, and industry interaction as well as in formal classroom settings. A key question is how do we transfer the findings of education research in order to achieve the desired outcome. This is an area where engineers and physicists can work together to our mutual benefit.

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Professor of Mechanical Engineering at the Massachusetts Institute of Technology. Norman L. Fortenberry is Director of the Center for the Advancement of Scholarship on Engineering Education of the National Academy of Engineering

What is ABET and What does it have to do with physics?

Keryl Cryer and M. Dayne Aldridge

As a physics professional, you may be familiar with some institutions related to STEM fields. Here is an overview of one organization in this area and how it relates to physics.

What is ABET?

ABET is a nonprofit organization of 30 professional and technical societies that collaborate to accredit post-secondary degree programs in applied science, computing, engineering, and technology in the United States and abroad. ABET currently accredits 2800 programs at more than 600 colleges and universities, primarily in the United States but increasingly abroad also.

ABET has a long history, dating back more than 75 years. In 1932, seven professional engineering societies banded together to found ABET's predecessor organization, the Engineers' Council for Professional Development. Its original focuses included supplying infor-

mation to engineering students and potential students, developing plans for personal and professional development, appraising engineering curricula and maintaining a list of accredited curricula, and developing methods whereby individuals could achieve recognition by the profession and general public. Eventually this organization began to expand into related areas, including engineering technology and applied science fields. By the 1980s, the original charges were too large for a single organization to handle, and the body that retained the charge of appraising engineering curricula and maintaining a list of accredited curricula became the Accreditation Board for Engineering and Technology, or ABET for short. A few years later, ABET helped establish the Computing Sciences Accreditation Board (now CSAB) and in 2001, CSAB merged with ABET. Today CSAB is one of ABET's largest member

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societies, with more than 300 accredited programs. In 2005, ABET formally changed its name from the Accreditation Board for Engineering and Technology to ABET, Inc. This allowed the organization to continue its activities under a recognized name in accreditation while reflecting its broadening into additional areas of technical education.

What is ABET Accreditation?

ABET accreditation is assurance that each program in applied science, computing, engineering, or technology at a college or university meets the quality standards established by the profession for which it prepares its students. For example, an accredited engineering program must meet the quality standards set by the engineering profession. An accredited computer science program must meet the quality standards set by the computing profession. ABET accredits programs only, not degrees, departments, colleges, or institutions.

The ABET professions themselves set the quality standards that the programs must meet to be ABET-accredited. The professional and technical societies collaborate and work together through ABET to develop the standards, and they provide the professionals who volunteer to evaluate the programs and ensure that they meet those standards.

The first step to ABET accreditation is that an institution requests an evaluation of its program(s). Then, each program conducts an internal evaluation and completes a self-study questionnaire. The self-study documents whether students, curriculum, faculty, administration, facilities, and institutional support meet the established criteria.

While the program conducts its self-examination, ABET forms an evaluation team to visit the campus. A team chair and one or more program evaluators make up the evaluation team. Team members are volunteers from academe, government, and industry, as well as private practice. During the on-campus visit, the evaluation team reviews course materials, student projects, and sample assignments and interviews students, faculty, and administrators. The team investigates whether the criteria are met and tackles any questions not adequately covered in the self-study. Following the campus visit, the team provides the school with a written report of the evaluation. Then, at a large annual meeting, the final evaluation report is presented by the evaluation team, along with its recommended accreditation actions. Based on the findings of the report, the commission members vote on each action, and the

school is notified of the decisions. The information the school receives identifies strengths, concerns, weaknesses, deficiencies, and recommendations for improvements. Accreditation is granted for a maximum of six years. To renew accreditation, the institution must request another evaluation.

Outcomes Assessment & Continuous Improvement

More than a decade ago, ABET adopted Engineering Criteria 2000 (EC2000), considered at the time a revolutionary approach to accreditation criteria. The revolution was its focus on what is learned rather than what is taught. At its core was the call for a continuous improvement process informed by the specific mission and goals of individual institutions and programs. EC2000 meant that ABET could enable program innovation, as well as encourage new assessment processes and subsequent program improvement. Today the spirit of continuous improvement can be found in the evaluation criteria of all ABET disciplines.

How Physics fits into ABET Accreditation

Physics coursework is a requirement for the vast majority of ABET-accredited programs, including engineering, technology, and some applied science fields such as health physics.

Not only is physics considered an important basic science for programs that ABET accredits, but it is also fundamental to the applied topics covered in most programs. For example, engineering programs have traditionally designed their introductory engineering courses around calculus-based physics courses that include significant laboratory experiences.

ABET evaluators look closely at the quality of the physics courses because experience shows that both physics and engineering programs benefit from healthy relationships that engage the basic and applied perspectives. Evaluators usually expect to review course materials and examples of student work for both recitation and laboratory classes. Efforts to maintain active and productive communication among the physics faculties and applied science, engineering, and/or technology faculties pay off on a continuing basis, not just at the time of an accreditation evaluation.

More information about ABET and its accreditation of postsecondary applied science, computing, engineering, and technology programs is available at <http://www.abet.org>.

Keryl Cryer is a Communications Specialist and M. Dayne Aldridge is Adjunct Accreditation Director for Engineering at ABET.

March 2009 APS Meeting in Pittsburgh

The FEd sponsored or co-sponsored with other APS units 26 invited talks at the Pittsburgh meeting. These talks in invited sessions or leading off a focus session were exciting, informative, and challenging to hear but only reached a fraction of our FEd members and the APS membership as a whole. Yet there is much to learn from these talks. In order that they do not disappear into a “black hole” they are being archived on an APS server. Below are summaries of the sessions with links to the talks, mostly in pdf. There are also animations and movie clips. I hope these will be useful, especially to those who did not attend the meeting, who were at the meeting and missed a particular talk or session, or heard the talk and want a reminder of some of the key points presented. The 5-day meeting, March 16–20, was held in the David L. Lawrence Convention Center.



Session A6: Computational Physics in Research and Teaching: GRC Topics and Themes
Session Chair and Summary: Wolfgang Christian, Davidson College

Focus Session L29: Incorporating Computational Physics into Teaching
Session Chair: James Belak, Lawrence Livermore National Laboratory

The FEd co-sponsored a number of computational physics education activities with the Division of Computational Physics (DCOMP). Wolfgang Christian, Anne Cox, Harvey Gould, Jan Tobochnik, and Chandralekha Singh led a workshop on “Incorporating Simulations and Computer Modeling into Upper Level Physics Courses” on Sunday March 15. This workshop presented recently developed computer-based curricular materials that improve student understanding of upper-level physics topics and that make many previously inaccessible topics available to undergraduate and graduate students. Participants received a CD containing curricular material from the Open Source Physics (OSP) project and the Quantum Interactive Learning Tutorials (QuILT) project, as well as the Easy Java Simulations (EJS) modeling and authoring tool.

On Monday, the FEd/DCOMP collaboration sponsored invited session A6 on the expanding and deepening role of computers in physics research and instruction, with particular emphasis on undergraduate education. The session was based on the 2008 Physics Research and Education Gordon Research Conference and highlighted current efforts to incorporate computational physics and other computer-based methods (such as simulations and visualizations) into the physics classroom.

“Unstable Periodic Orbits as a Unifying Principle in the Presentation of Dynamical Systems in the Undergraduate Physics Curriculum” by Bruce Boghosian

<http://apps3.aps.org/aps/meetings/march09/presentations/A6Boghosian.pdf>

Simulations from Boghosian’s talk:

MagnetsGeneric

MagnetsUPO

“Innovations in Teaching with Computers: What Works, What Doesn’t, and How We Can Tell” by Bradley Ambrose

http://apps3.aps.org/aps/meetings/march09/presentations/A6_Ambrose.pdf

“Molecular Dynamics Simulation: A Tool for Exploration and Discovery” by Dennis C. Rapaport

<http://apps3.aps.org/aps/meetings/march09/presentations/GranularDynamicsExamples.htm>

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“Computation in the Classroom: Open Source Physics Resources” by Anne Cox

<http://apps3.aps.org/aps/meetings/march09/presentations/A6Cox.pdf>

“Astrophysical Computation in Research, the Classroom, and Beyond” by Adam Frank

<http://apps3.aps.org/aps/meetings/march09/presentations/A6Frank/A6Frank.ppt>

On Tuesday afternoon, the FED co-sponsored focus session L29. This session was devoted to the teaching of computational physics at all levels and to current efforts to incorporate computational physics and other computer-based methods (such as simulations and visualizations) into the physics classroom. The session began with an invited talk by **Steven Gottlieb** titled **“One Lattice Gauge Theorist’s Perspective on Important Skills and Concepts for Computational Physics Courses.”**

<http://apps3.aps.org/aps/meetings/march09/presentations/L29Gottlieb.pdf>

Twelve contributed talks described the bridge between our framework of understanding for how nature works and experiments or problems that can be subject to experimental examination. Issues concerning textbooks, coverage (both physics and programming), software, and hardware were also addressed.

***Session B3: 10,000 Undergraduate Physics Majors: Progress on Doubling
Session Chair and Summary: Robert Hilborn, University of Texas at Dallas***

Why Do We Need 10,000 Physics Majors? Theodore Hodapp, American Physical Society

<http://apps3.aps.org/aps/meetings/march09/presentations/B3Hodapp.pdf>

Hodapp, APS’s Director of Education and Diversity provided statistical and policy background that underpins the physics community’s effort to increase significantly the number of undergraduate students receiving degrees in physics. The talk also outlined strategies such as the

- SPIN-UP report; <http://www.aapt.org/Projects/upload/SPIN-UP-Final-Report.pdf>
- PhysTEC project; <http://www.phystec.org/>
- Recommended best practices <http://www.aps.org/programs/women/reports/bestpractices/index.cfm> from APS’ Committee on the Status of Women in Physics for addressing some of these issues.

Successful Minority PhD Producing Programs—Bell Laboratories and the Meyerhoff Scholarship Program at UMBC, Anthony Johnson, University of Maryland Baltimore County

<http://apps3.aps.org/aps/meetings/march09/presentations/B3Johnson.pdf>

Johnson described the successful Bell Labs program for producing more minority Ph.D.s and the Meyerhoff Scholarship program at the University of Maryland Baltimore County that has led to significant increases in the number of minority students majoring in STEM fields at UMBC.

Best Practices for Recruiting and Retaining Women in Physics, Margaret Murnane, University of Colorado

<http://apps3.aps.org/aps/meetings/march09/presentations/B3Murnane.pdf>

Murnane (University of Colorado) spoke of a list of best practices for recruiting and retaining women in physics.

Doubling the Number of Physics Majors who Teach, Michael Marder, University of Texas at Austin

<http://apps3.aps.org/aps/meetings/march09/presentations/B3Marder.pdf>

Marder talked about the UTeach program, which has been successful in increasing the number of undergraduate STEM majors who go into K–12 teaching. That program, started at UT Austin, is now being replicated at 13 colleges and universities across the country. For more details see the UTeach web page.

Integrating Research Experiences into the Undergraduate Education, Wolfgang Bauer, Michigan St Univ

<http://apps3.aps.org/aps/meetings/march09/presentations/B3Bauer.pdf>

Bauer described the successful undergraduate research program in physics at Michigan State University and its role in increasing the number of undergraduate physics majors at MSU.

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Focus Sessions D29 and H29: The Physics and Astronomy New Faculty Workshops
Session Chair: Robert Hilborn, University of Texas at Dallas

This highly successful program yielded a “flood” of contributions, 21 all told between the two sessions. Session D29 began with an invited paper by Ken Krane of the Department of Physics at Oregon State University:

A Dozen Years and a Thousand Participants:
The Workshops for Preparing New Faculty in Physics and Astronomy

<http://apps3.aps.org/aps/meetings/march09/presentations/D29Krane.pdf>

Beginning in 1996, an annual workshop for newly hired faculty in physics and astronomy has been held under the organizational leadership of AAPT, APS, and AAS. To date more than 1000 faculty have participated in this workshop, representing approximately 25% of the new hires at all U. S. institutions that award a baccalaureate in physics or astronomy, from 4-year colleges through research universities. The original motivation for the workshops was to improve physics teaching by introducing new faculty to instructional strategies and innovations that had been shown to be effective in a variety of contexts. The need for such a program was suggested in part by the belief that a national mentoring workshop could effectively address a commonality of physics and astronomy teaching challenges that transcended institutional characters and types, and also in part by the reaction to a significant decrease in the number of baccalaureate physics degrees awarded in the U. S. in the 1990s, which many believed was due to ineffective and uninspiring teaching at the undergraduate level and especially in introductory courses. Surveys of the participants (and their department chairs) have shown that a large fraction of the participants have become adopters of innovative teaching techniques and that they rate the workshops as the most significant cause of the improvements in their teaching.

Session J8: Preparing Physics Students for Careers in Industry
Jointly sponsored by the FEd and FIAP

Session Chair and Summary: Larry Wolf, General Atomics

The Physics Workforce: The Latest Data on Supply and Demand, Roman Czujko, Amer Inst of Physics

<http://apps3.aps.org/aps/meetings/march09/presentations/J8Czujko.pdf>

Czujko began the session with an overflow crowd consisting of a large number of graduate students, clearly indicating their interest in their future employment possibilities. Statistical data were presented on the number of physics degrees awarded each year at the BS, MS, and PhD levels. Also discussed were career paths pursued by physicists at different degree levels, including comparative salaries with other fields. Czujko described the professional master’s degree program in physics departments and skills that employers value, concluding with recommendations for departments.

Industrial Physics Careers: A Large Company Perspective, Stephan Zollner, IBM

<http://apps3.aps.org/aps/meetings/march09/presentations/J8Zollner.pdf>

Zollner’s talk began with some interesting statistics on where industrial physicists work and how universities should prepare students for industrial careers. He next discussed different aspects of industrial careers including issues of goals (both organizational and personal), performance, rewards, leadership, results, and behaviors. Based on the NIST Baldrige criteria of Performance Excellence, he then concluded with how to achieve and measure organizational success through a focus on products and customers.

The Rutgers Undergraduate Physics Program: Preparing Students for Varied Careers, Mohan Kalelkar, Rutgers University

<http://apps3.aps.org/aps/meetings/march09/presentations/J8Kalelkar.pdf>

Kalelkar described the characteristics of the Rutgers University undergraduate physics program, which offers five main physics major tracks for different careers. The Professional Option is for students planning to go to graduate school in physics, while the Astrophysics Option is for those intent on graduate work in astronomy or astrophysics. The Applied Option focuses on students who desire technical jobs in industry or patent law, or who are engineering double majors. For students with a general interest in physics, there is the General Option. Most recently created is an Ocean Physics Option.

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Training PhD Physicists for Industrial Careers: The Industrial Leadership in Physics Program at Georgetown University, Edward Van Keuren, Georgetown University

<http://apps3.aps.org/aps/meetings/march09/presentations/J8VanKeuren.pdf>

Van Keuren discussed the unique graduate program designed at Georgetown University to prepare PhD physicists for positions in high-tech businesses. The Industrial Leadership in Physics (ILP) graduate program combines training in technical and business areas with group learning, communication skills, and practical work experience. The ILP program includes a modular curriculum in fundamental physics, centered on solid-state physics, instrumentation, problem solving and computer modeling, a yearlong apprenticeship at an industrial partner, and coursework in the McDonough School of Business at Georgetown. He concluded with a discussion of both program challenges and successes.

Session P7: Forging Effective Partnerships with your Local Science Center: Outcomes from the Workshop on University/Science Center Collaborations

Session Chair: Philip Hammer, AIP

Lessons Learned from the APS/TFI Workshop on University/Science Center Collaborations: Outreach Strategies for Faculty Working with their Local Science Museum, David Statman, Allegheny College

<http://apps3.aps.org/aps/meetings/march09/presentations/P7Statman.pdf>

On May 31–June 1, 2008, The Franklin Institute hosted the APS/Franklin Institute Workshop on University/Science Center Collaborations. This Workshop brought together leaders from science centers, universities, and federal funding agencies to explore what works and what doesn't work in university–science center collaborations. The goal was to explore the outreach motivations of academic institutions, their scientists and students, the characteristics and needs of small versus large science centers, and the goals for and outcomes expected from reaching out to the general public from the perspectives of universities and science centers. The result was a convergence of viewpoints on how a good collaboration is established, built upon, sustained, and evaluated.

University Perspectives on Science Center/University Interactions, Leo Kadanoff, University of Chicago

<http://apps3.aps.org/aps/meetings/march09/presentations/P7Kadanoff.pdf>

A program bringing graduate students into science museums was described. Practical nuts-and-bolts methods for making the program work were outlined. Questions were asked about the somewhat uncomfortable relation between graduate education, research, and informal science education.

University/Science Center Collaborations (A Science Center Perspective): Developing an Infrastructure of Partnerships with Science Centers to Support the Engagement of Scientists and Engineers in Education and Outreach for Broad Impact, Eric Marshall, Strategic Partnerships and Innovation,

Director of TryScience.org and Volts (Volunteers TryScience) <http://tryscience.org/>

Science centers, professional associations, corporations, and university research centers share the same mission of education and outreach, yet come from “different worlds.” This gap may be bridged by working together to leverage unique strengths in partnership. Successful partnerships stem from clearly defined roles and responsibilities. The need for a supportive infrastructure becomes evident. Marshall described examples that exemplify some of the pieces of this evolving infrastructure.

Perspective of NSF-MPS Program Directors on Educational Outreach, Daniele Finotello, NSF

<http://apps3.aps.org/aps/meetings/march09/presentations/P7Finotello.pdf>

The National Science Foundation Broader Impacts review criterion (often known as Criterion 2) has been subject to much discussion since it was first implemented by NSF. The broader impact of different proposals can vary widely, based on different factors such as the particular research activities proposed, the interests of the PI(s), the type of institution involved in the proposal, and the different opportunities available in the local area, to name just a few. In this talk the Broader Impacts review criterion was discussed from the viewpoint of the NSF Program Officers and included different examples of potential Broader Impact activities.

Session Q6: Physics Demonstrations and Strategies for Teaching and Public Outreach

Session Chair and Summary: Ernest Malamud, University of Nevada, Reno

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A major focus of the Forum on Education is to improve the teaching of physics at all levels by connecting researchers and educators. Leading educators from both the formal and informal science education communities showed the audience effective techniques and a variety of strategies for presenting science to both classroom and public audiences. This diverse group of speakers drawn from the wealth of talent in the Pittsburgh area offered March meeting attendees insights into innovative ways of teaching physics.

So, You Want to be a Science Communicator?,

John G. Radzilowicz, Director of Visitor Services, Carnegie Science Center

<http://apps3.aps.org/aps/meetings/march09/presentations/Q6Radzilowicz.pdf>

The late Carl Sagan opined that somehow we have managed to create a global civilization dependent on science and technology in which almost no one understands science and technology. This is an unacceptable recipe for disaster with social, political, and financial implications for the future of scientific research. And so, like it or not, popular science communication, more than ever before, is an important and necessary part of the scientific enterprise. What does it take to be a good science communicator? What is needed to develop and deliver meaningful public outreach programs? How do you handle non-technical presentations? And what help is available in developing the necessary skills? The presentation described the essential components of effective science communication aimed at a broad public audience. Radzilowicz paid specific attention to how university-museum partnerships can expand the reach and enhance the quality of public outreach programs.

Public Outreach for the International Year of Astronomy Through Faculty and Science Center Partnerships, Andrew Zentner, University of Pittsburgh.

Zentner's web page. <http://www.phyast.pitt.edu/people/fprofile.php?id=373>

The International Year of Astronomy 2009 provides an opportunity to jump-start public education and outreach programs and to engage the community in a fascinating field. In his talk, Zentner discussed a diverse program of education and outreach designed and implemented as a collaborative effort between the Astronomy faculty at the University of Pittsburgh and the Carnegie Science Center and highlighted some of the unique benefits of such a partnership and some of the unique events such a partnership enables.

Public Education and Outreach Through Full-Dome Video Technology,

John Pollock, Duquesne University

<http://apps3.aps.org/aps/meetings/march09/presentations/Q6Pollock.pdf>

Pollock began his talk with the long-term goal of enhancing public understanding of complex systems through richly detailed computer graphic animations displayed with full-dome video technology. His current focus is on health science advances in regenerative medicine and he used that to illustrate available technologies and approaches. Visually rich, accurate 3D computer graphic environments are created. A suite of films have been produced, and evaluated. While the images are rich and detailed, the language is accessible and appropriate to the audience. The digital, high-definition video is also re-edited for presentation in other "flat screen" formats, increasing the distribution potential. Show content is also presented in an interactive web space (<http://www.sepa.duq.edu/>) with complementing teacher resource guides and student workbooks and companion video games.

A New Approach to A Science Magnet School—Classroom and Museum Integration,

Samuel Franklin, Pittsburgh Science and Technology Academy

<http://apps3.aps.org/aps/meetings/march09/presentations/Q6Franklin.pdf>

The Pittsburgh Science and Technology Academy, a new school, is a place where any student with an interest in science, technology, engineering, or math can develop skills for a career in life sciences, environmental sciences, computing, or engineering. The curriculum is tailored to students who have a passion for science, technology, engineering, or math. This talk explained the unique features of the Pittsburgh Science and Technology Academy, (<http://www.pps.k12.pa.us/pst/site/default.asp>) lessons learned from its two-year design process, and the role that the Carnegie Museums have played and will continue to play as the school opens and then grows.

Fractured Physics and the Great Color Caper: Large Scale Physics Outreach,

Mike Hennessey, Carnegie Science Center <http://carnegiesciencecenter.org/>

<http://apps3.aps.org/aps/meetings/march09/presentations/Q6Hennessey.pdf>

Hennessey described the successful Carnegie Science Center's Science on the road program and then presented several interesting demonstrations illustrating basic physics concepts.

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***Session T29: NSF's Research Experiences for Undergraduates (REU) Program: Overview and Perspectives
Session Chair and Summary: Cathy Mader, Hope College***

This focus session concerned the National Science Foundation's Research Experiences for Undergraduates Program. The perspectives of directors of REU programs, faculty who supervised undergraduates in REU programs, and students who participated in REU programs were presented. An overview of the program and a description of the recent REU Directors Workshop were also included.

Physics NSF-REU Site Director Workshop: What did we learn and what questions remain?

Mario Affatigato, Coe College, Cedar Rapids, Iowa

<http://apps3.aps.org/aps/meetings/march09/presentations/T29Affatigato.pdf>

Session T29 began with a presentation by Dr. Mario Affatigato, the PI of the Coe College Physics REU Site and a member of the steering committee for the NSF Physics REU Site Director Workshop. Dr. Affatigato spoke on the 2008 workshop, which was attended by representatives from 36 of the over 50 NSF Physics REU sites as well as representatives from several national professional societies for Physicists. The workshop format allowed participants to discuss both effective practices in the current REU programs as well as to learn more about effective practices in programs outside of the NSF REU Physics Sites. In particular, the participants learned about current results in assessment of undergraduate research experiences and programs that have increased the diversity in undergraduate research programs from other disciplines and discussed how to adapt/adopt these ideas for Physics REU sites.

Link to a more complete summary of this interesting and important session by Cathy Mader.

<http://apps3.aps.org/aps/meetings/march09/presentations/T29Mader.pdf>

2009 APS Meeting in Denver

The FED sponsored or co-sponsored with other APS units 19 invited talks at the Denver meeting. These talks were exciting, informative, and challenging to hear but only reached a fraction of our FED members and the APS membership as a whole. Yet there is much to learn from these talks. In order that they do not disappear into a "black hole" they are being archived on an APS server. Below are summaries of the sessions with links to the talks you can follow to those that whet your curiosity. I hope these will be useful to those who did not attend the meeting, missed a particular talk or session, or heard the talk and want a reminder of key points presented. The 4-day meeting on May 2–5 was held in the Denver Sheraton Hotel.



Session C7. Teaching the Physics of Energy

Jointly sponsored by the FED and DNP

Session Chair and Summary: Lawrence Cardman, Thomas Jefferson National Accelerator Facility

The physics of energy is of great relevance to a broad variety of issues facing society today. As a consequence, teaching the physics of energy is an increasingly popular topic for physics courses aimed at non-majors at the undergraduate level; it has also proved useful to excite students in K–12 education about science in general. This session included presentations on three aspects of the teaching of energy: a highly technical course recently developed at MIT for a sophisticated audience; a course that utilizes the *Second Life* simulation capabilities available on the web to provide interactive learning of nuclear energy and nuclear physics; and a discussion of the experiences of a group of scientists and engineers in Santa Fe working to enhance K–12 education both locally and at the state level, including lessons to be learned from that effort to date.

(Continued on page 30)

Teaching the Physics of Energy at MIT, Robert Jaffe, MIT

<http://apps3.aps.org/aps/meetings/april09/presentations/C7Jaffe.pdf>

Course web page: <http://physicsofenergy.mit.edu/about.php>

Robert Jaffe and Washington Taylor have developed a unique new course at MIT on the “Physics of Energy.” It is unusual in its high technical level, and is open to *all* MIT students who have taken MIT’s common core of university-level calculus, physics, and chemistry but avoids higher level prerequisites in order to make the subject relevant to students in the life sciences, economics, etc. as well as physical scientists and engineers. The course interweaves the teaching of fundamental physics principles on the foundations of energy science with the applications of those principles to energy systems, and presents the basics of statistical, quantum, and fluid mechanics at a fairly sophisticated level while applying those concepts to the study of energy sources, conversion, transport, losses, storage, conservation, and end use. Almost all of the material for the course was developed from scratch. The course debuted this past fall. The talk describes the course and presents what the authors learned from the experience of teaching it for the first time, providing information for others contemplating a course aimed at teaching energy physics to a technically sophisticated audience.

Use of Second Life for Interactive Instruction and Distance Learning in Nuclear Physics and Technology, Robert C. Amme, University of Denver

<http://apps3.aps.org/aps/meetings/april09/presentations/C7Amme.pdf>

The developing nuclear power renaissance, coupled with related environmental consequences, the stagnant growth of nuclear physics and nuclear technology instruction for the past 20 years, and the broad public ignorance of the relevant issues, has resulted in a need for new approaches to the teaching in these areas. In particular, it is essential that students be prepared to deal with the regulatory environment and safety standards that must be addressed prior to new plant certification. Regrettably, too few individuals who are trained in environmental science are adequately prepared in the basic concepts of nuclear physics to deal with such issues as radioactive waste storage and transportation, biological effects of ionizing radiation, geological repositories, nuclear fuel reprocessing, etc. which are of great concern to the Nuclear Regulatory Commission.

To address these needs, the author and his colleagues are developing a master’s degree, to be taught online, in the area of environmental impact assessment as it relates to these and other issues. The associated laboratory exercises have been developed within the virtual world developed by Linden Laboratory entitled *Second Life*; it is here that the student, as an avatar, will gain knowledge of the nature of ionizing radiation, radioactive half-lives, gamma and beta ray spectroscopy, neutron activation, and radiation shielding, using virtual apparatus and virtual radiation sources. Additionally, a virtual Generation III+ power reactor has been constructed on an adjoining Second Life island <http://scienceschool.wordpress.com/>, which provides the visitor with a realistic impression of its inner workings. This presentation provides the details of this construct and how it is incorporated into the distance-learning curriculum. The presentation included a YouTube clip of the Virtual Area Nuclear Power Plant in Second Life.

K-12 Math and Science Education: A Physicist Meets Reality,

Robert Eisenstein, Santa Fe Alliance for Science <http://www.sfafs.org/>

<http://apps3.aps.org/aps/meetings/april09/presentations/C7Eisenstein.pdf>

Can professional engineers, mathematicians, and scientists have a positive impact on K–12 math and science education? The experience of the Santa Fe Alliance for Science, and several other like-minded organizations, indicates that they can indeed. But success is by no means assured. Good scientists are not automatically good educators, but they can learn enough about pedagogy, classroom, and community to do well. For example, their experiences working on research topics of great societal interest (e.g., the energy supply or global warming) can be a great attraction to young people. Robert Eisenstein’s talk reviewed three major points: lessons learned, prospects for the future, and how our effort fits into state-wide plans for re-inventing K-12 math and science education in New Mexico.

Session D7 Teaching the Physics of Energy

Jointly sponsored by the FEd and DPB

Session Chair: Thomas Rossing, Stanford University

A Conspectus on US Energy,

Howard Hayden, Editor and Publisher of The Energy Advocate <http://www.energyadvocate.com/>

<http://apps3.aps.org/aps/meetings/april09/presentations/D7Hayden.pdf>

Hayden summarized US energy use beginning in 1850. Compared to our ancestors in 1850, we use over 40 times as much energy. Hayden discussed prospects for various alternative sources, including nuclear fission and T. Boone Pickens' plan to displace imported petroleum indirectly by substituting wind for natural gas.

**Teaching Photovoltaics: From Grammar School to Graduate School,
Richard Ahrenkiel, Colorado School of Mines**

Photovoltaics (PV) have certainly become the topic of the times in economic and political circles. In his talk Ahrenkiel described and illustrated various presentations on the topic to audiences ranging from grammar school to high school. Each audience presents a different set of challenges and requires a different type of presentation.

Session G6: Physics on the Road Conference: A Follow-Up to the World Year of Physics 2005

Session Chair: Ernest Malamud, University of Nevada, Reno

Session Summary: David Bennum, University of Nevada, Reno

If you were not able to attend the "Taking Physics on the Road" session (G6) sponsored by the FED at the APS April meeting in Denver this year, you missed some fun. The three invited talks were follow-ups to the "Taking Physics on the Road" workshop held at Colorado State University in 2003 in preparation for the World Year of Physics (2005). The first speaker, Brian Jones, was the CSU host of the 2003 event, Steve Shropshire from Idaho State University was the second speaker, and myself, David Bennum from University of Nevada-Reno, was the third. Each brought different programs to showcase and all three brought fun demonstrations or movie clips and pictures. The CSU program is one of the "grandfathers" of the genre, the ISU program is mature and diverse, and the UNR program is fairly new and diversifying into "Physics and Stars on the Road" in response to the Year of Astronomy interests. To view the presentations of each, connect to the links below. Soon to follow will be some movie links to demonstrations on YouTube from UNR, which are currently in production.

**Half a Million Hands: On the Road with the Little Shop of Physics,
Brian Jones, University of Colorado**

<http://apps3.aps.org/aps/meetings/april09/presentations/G6Jones.pdf>

**Idaho State University Physics Road Show,
Steve Shropshire, Idaho State University**

<http://apps3.aps.org/aps/meetings/april09/presentations/G6Shropshire.pdf>

**Taking Physics and Now the Stars on the Road With the Magic Physics Bus,
David Bennum, University of Nevada, Reno**

<http://apps3.aps.org/aps/meetings/april09/presentations/G6Bennum.pdf>

University of Nevada, Reno Physics on the Road web page: <http://physics.unr.edu/Outreach.html>

Session H13: Focus Session: Professional Preparation of Teachers of Physics

Session Chair: David Haase, North Carolina State University

Task Force on Teacher Education in Physics: Preliminary Results, Stamatis Vokos, Seattle Pacific Univ

Web page: <http://www.ptec.org/webdocs/TaskForce.cfm>

The nation currently produces a significantly smaller number of well-prepared teachers of physics than it needs. The AAPT, APS and AIP have instituted the Task Force on Teacher Education in Physics, which seeks to study exemplary teacher preparation programs and identify generalizable characteristics of them. The Task Force will author a report of its findings, which will be distributed to all physics departments and schools of education in the US. In addition, the Task Force will disseminate its findings through presentations, workshops, and other mechanisms, under the auspices of the sponsoring professional organizations. In this talk, preliminary results from site visits and other data collection means will be presented.

Vokos' introductory invited talk was followed by 6 contributed papers.

Session L8: Excellence in Physics Education Award
Session Chair: Arthur Bienenstock, Stanford University
Session Summary: Peter Collings, Swarthmore College

The 2009 Excellence in Physics Education Award was given to the Two-Year College Workshop Team “for leadership in introducing physicists in two-year colleges to new instructional methods, in developing new materials based on physics education research, and in fostering faculty networking, particularly in two-year colleges.” This session was a summary and celebration of the work of the group and included presentations by Curtis Hieggelke, Thomas O’Kuma, and David Maloney, who represented the group (<http://tycphysics.org/>).

Physics at the Community College, Thomas L. O’Kuma, Lee College

<http://apps3.aps.org/aps/meetings/april09/presentations/L8OKuma.pdf>

After describing community colleges in general and physics programs at community colleges specifically, the presentation outlined two projects of the Two-Year College Workshop Team. These included the microcomputer-based laboratory (MBL) project and the conceptual survey of electricity and magnetism (CSEM) project.

Revitalizing Introductory Physics at Community Colleges and More, Curtis J. Hieggelke, Joliet Junior College

<http://apps3.aps.org/aps/meetings/april09/presentations/L8Hieggelke.pdf>

The main activities of the Two Year Community College Workshop were described, including (1) new microcomputer-based materials in rotation, work-energy, sound, and magnetism (MBL), (2) the conceptual survey of electricity and magnetism (CSEM), (3) tasks inspired by physics education research (TIPERs), and (4) the physics workshop project (PWP).

Promoting Incremental Research-Based Instructional Innovation, David P. Maloney, Indiana University – Purdue University Fort Wayne

<http://apps3.aps.org/aps/meetings/april09/presentations/L8Maloney.pdf>

Three areas in which physics education research can provide insight are students’ initial knowledge state, student epistemologies, and problem solving. Interactive engagement is a technique that grew out of some of these insights, and workshops were designed to provide instructors with the resources and experiences to implement some interactive engagement techniques. Also, among the many tasks inspired by physics education research (TIPERs) are conflicting contentions tasks, qualitative reasoning tasks, working backwards tasks, and troubleshooting tasks.

Session Q6: Introductory Physics for Pre-Health and Biological Science Students
Session Chair: Robert Hilborn, University of Texas at Dallas
Session Summary: Ken Heller, University of Minnesota

This session sponsored by the FEd featured three speakers addressing the teaching of introductory physics to pre-medical and biological science students. Both biology and medicine are rapidly progressing fields, which have engendered a great deal of discussion about the need to modernize the academic preparation of these students. Robert Hilborn is the physicist in the group formed by the Association of American Medical Colleges and the Howard Hughes Medical Institute to propose major revisions to the entry requirements for medical school. Students majoring in biological science represent one of the fastest growing populations at many universities and thus directly impact physics departments. Although the number of pre-medical students has not grown as rapidly, there is a great deal of overlap in the populations since most pre-med students have a biological science major.

Pre-Medical Education in the Physical Sciences for Tomorrow’s Physicians, Sharon Long, Stanford Univ

<http://apps3.aps.org/aps/meetings/april09/presentations/Q6Long.pdf>

Sharon Long, professor of biological sciences and former dean at Stanford, gave a preview of the soon-to-be-released study dramatically revising the science requirements for entry into medical school. Professor Long is currently co-chair of this

study, the Scientific Foundations for Future Physicians (SFFP) project sponsored by the Association of American Medical Colleges and the Howard Hughes Medical Institute. Professor Long was also a member of the National Academy of Sciences study, BIO2010, that outlined the needs of students majoring in the biological sciences, and her talk reflected that study. Her message was that medical schools will eliminate course requirements, such as one year of physics, and change to competency based requirements, such as “apply quantitative reasoning and appropriate mathematics to describe or explain phenomena in the natural world.” This is similar to the changes instituted several years ago by engineering, ABET accreditation requirements that also eliminated course requirements in favor of specified competencies. It is not yet clear how students will demonstrate that they have acquired the necessary competencies since there is no pre-medical school accrediting body such as ABET for undergraduate programs. One direct consequence of this report will be substantial changes in the exam that students take for medical school entry, the MCAT. It is clear that if physics departments are to retain their population of pre-medical students in the future, they will need to be aware of these competencies and make sure they are addressed in their courses.

Designing an Introductory Physics Course for Biological Science Students, Kenneth Heller, University of Minnesota

<http://apps3.aps.org/aps/meetings/april09/presentations/Q6Heller.pdf>

Ken Heller, professor of physics at the University of Minnesota, gave a review of the process and results of an ongoing effort to revise the introductory physics course taught to biology and pre-medical students. The course is based on the recommendations of the BIO2010 study, a survey of biological sciences faculty, and the input of physics faculty teaching the course. It seems to conform to the SFFP competencies reported by Professor Long. This course emphasizes the fundamental principles of physics and analytical problem solving in the context of biology. It is taught with the standard pedagogy of Cognitive Apprenticeship, used throughout the University of Minnesota physics curriculum. The course uses much of the traditional framework of an introductory physics course but emphasizes addressing complex systems using fundamental physics. This requires more emphasis on topics such as conservation of energy, thermodynamics (including a statistical treatment of entropy), fluids, optics, and circuits with the consequent reduction of emphasis on constant-acceleration kinematics, rotational motion, and electrostatics. Some important topics such as momentum, angular momentum, and Gauss' law have been eliminated. Although the course emphasizes analytical problem solving, the students show very good conceptual gains on standard tests such as the Force Concept Inventory (FCI) and Brief Electro-Magnetism Assessment (BEMA).

The Care and Feeding of Pre-Meds, Stephanie Magleby, Brigham Young University

<http://apps3.aps.org/aps/meetings/april09/presentations/Q6Magleby.pdf>

Stephanie Magleby from Brigham Young University reviewed the characteristics of pre-medical students taking an introductory physics class and gave suggestions for reducing the friction caused by the mismatch of expectations between the student and the professor. She pointed out that these students have been brought up to have a positive self-image. They feel entitled to succeed and yet are desperately competitive. They do not recognize the contradiction between competition and the expectation that each student feels entitled to win. This leads to behavior that can be antithetical to the learning process. Every student expects to be the best, expects to be able to choose their own path, and regards requirements as not applying to them. To bridge the gap between student and instructor expectations, she recommends giving students as many choices as possible, making it obvious to students that you listen to them as individuals, giving students a lot of praise, having a thick skin to not take students' inappropriate comments personally, and constantly reminding the students that a class is not a democracy. Because they expect perfection from themselves and from the instructor, they will do any assignments required to get an A, but will hold the instructor responsible if they do not. This is a wired generation that expects immediate responses from the instructor. It is useful to post everything on the web, return grades for tests and assignments promptly, and answer email quickly. It is also important to have an airtight syllabus that clearly explains what is required of the student and exactly how their grade will be determined.

Focus Session R13: Adopting PER-Based Teaching Methods and Materials

Chair: Noah Finkelstein, University of Colorado

Sustaining Educational Transformations: Evidence and Approaches at CU Boulder, Steven Pollock, University of Colorado

<http://apps3.aps.org/aps/meetings/april09/presentations/R13Pollock.pdf>

Research in educational innovations provides mechanisms to systematically improve education in large introductory physics classes. But what is involved in adopting, and then adapting, research-based transformations to suit local constraints? How do we assess the impact of the curricula, and how do we promote and sustain changes across time, with a broad variety of faculty? Pollock reported on local efforts to implement two well-studied PER-based innovations: Peer Instruction and Washington Tutorials. Our course transformations are facilitated through our local model of undergraduate Learning Assistants, promoting reforms while recruiting and supporting future K–12 teachers.

Pollock's invited talk was followed by 6 contributed talks.

Session W7: Teaching Physics and the Arts

Session Chair: Thomas Rossing, Stanford University

Teaching Physics of Music, Thomas D. Rossing, Stanford University

<http://apps3.aps.org/aps/meetings/april09/presentations/W7Rossing.pdf>

Courses in musical acoustics (physics of music) are an especially appealing way to introduce physics to students who are interested in music and entertainment but do not think they are interested in science, as well as students who are preparing to be performing musicians. Musical acoustics includes: the study of sound production by musical instruments; the transmission of sound from performer to listener (via the concert hall or via recorded media); and the perception of sound and music by the listener (psychoacoustics). Rossing reviewed some of the materials available for such courses, including textbooks, videotapes and DVDs, simple apparatus for demonstration experiments, and materials for laboratory experiments.

Communicating Science with the Arts, Christopher Chiaverina, New Trier High School

<http://apps3.aps.org/aps/meetings/april09/presentations/W7Chris.pdf>

Chris Chiaverina followed with a discussion of the connections between the seemingly disparate disciplines of art and science. Three approaches to incorporating the arts in physics instruction were examined. Each approach was accompanied by concrete examples of interdisciplinary classroom activities.

Dance as a Road to Science, Kenneth Laws, Dickinson College

One of the challenges facing the science community is finding ways of demonstrating for non-scientists the logic and appeal of understanding how science applies to familiar phenomena. Dance movement involves many examples of physical principles that allow dancers and observers of dance to deepen their understanding of the natural world. To demonstrate the connection between science and art, we observed a ballet dancer performing several movements, which were then analyzed to illustrate why the movements are shaped the way they are and how dancers can improve their effectiveness through such analysis. This was a great show!

Some links:

http://physics.dickinson.edu/dept_web/research/podance.html

http://www.hep.uiuc.edu/home/g-gollin/dance/dance_physics.html

Teacher Preparation Section

John Stewart, Editor

In this issue, we look at two examples of projects designed to reach out to working teachers and provide meaningful, research-based professional development. Jim Nelson, the leader of the Physics Teaching Resource Agent (PTRA) program since 1984, discusses that very successful, longstanding program. The University of Arkansas Physics and Mathematical Sciences departments have recently received a seven million dollar MSP grant to improve the college outcomes of students in Oklahoma and Arkansas by improving the professional development of science teachers in 38 school districts. The partnership cuts across all demographic boundaries from rural to urban and from underprivileged to affluent. The PI, Gay Stewart, provides an outline of the program.

The Physics Teacher Education Coalition (PTEC) held its annual meeting in Pittsburg on March 13th and 14th. The meeting featured many workshops presented by leaders in physics education reform including Lillian McDermott, Gay Stewart, Michael Marder, Valerie Otero, Paul Hickman, and many others. At the right, Valerie Otero from the University of Colorado- Boulder talks with Rob Thorne of Cornell during a break. The presentations for all workshops at the conference are available at <http://PTEC.org>.



John Stewart(johns@uark.edu) is a Visiting Assistant Professor of physics at the University of Arkansas. He is a long-time participant in the Arkansas PhysTEC project and editor of PTEC.org, the National Science Digital Library's collection on physics and astronomy teacher preparation and the home of the Physics Teacher Education Coalition (PTEC).

AAPT/PTRA Professional Development Program: A Model For Successful Teacher Professional Development

Jim Nelson

With the help of National Science Foundation (NSF) and the American Physical Society (APS) funding, the American Association of Physics Teachers (AAPT) has developed the Physics Teaching Resource Agent (PTRA) model for successful physical science and physics teacher professional development. This model includes development of peer mentors and professional development leaders, systemic infrastructure, assessment instruments, and a curriculum based on experienced mentors and physics education research.

Components of AAPT/PTRA Professional Development Program

The features included in the AAPT/PTRA Professional Development Model are:

- A consistent and known curriculum for Professional Development consisting of the sequence of Kinematics, Newton's Laws, Energy, Momentum, Electricity (DC Circuits and Electrostatics), Waves, Optics, and Sound. A consistent and logical sequence of professional development events over a period of time has a much better rate of success than a random collection of events.
- Each AAPT/PTRA curriculum Teacher Resource Guide has been developed by experienced and knowledgeable high school physics teacher(s). This assures that the activities and instructional techniques in the Teacher Resource Guide are effective both during the professional learning experience and when teachers

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use the activities in their classrooms. Each AAPT/PTRA Teacher Resource undergoes rigorous review by the Publication Committee of the AAPT. The review process assures that the content and pedagogy of the AAPT/PTRA Teacher Resource Guides are world class. Consistent curriculum at all sites is based on AAPT/PTRA Teacher Resources Guides and leadership training in order to facilitate system wide AAPT/PTRA evaluation.

- AAPT/PTRA mentors and leaders undergo yearly training in researched-based pedagogy, including guided inquiry, instructional use of technology, in addition to AAPT/PTRA curriculum and content so they are better prepared as role models for new and crossover science teachers. This approach takes advantage of the old adage, “... teachers teach the way they were taught.”
- The AAPT/PTRA leadership selects Regional Sites (RS), usually on a college campus, to host AAPT/PTRA Summer Institutes and follow-up sessions. A college or university professor is selected to be the Regional Coordinator (RC) for this site. Although the AAPT/PTRA professional development model does not use the college or university professor(s) as teachers within the program, the college or university professor is an important component of the collaborative support structure for the program.
- The AAPT/PTRA Program is committed to provide over 100 hours of consistent professional development for participants.
- The AAPT/PTRA Program has developed formative and summative content assessment instruments for use with second-tier participants.
- Full commitment for three summers and two follow-up sessions per year is expected of participants who attend AAPT/PTRA Summer Institutes.
- For more information about the AAPT/PTRA Program see <http://www.aapt.org/PTRA>

AAPT/PTRA - Goals & Activities

The AAPT/PTRA Program goals include providing an opportunity for upper elementary, middle, and high school teachers to experience professional growth in the areas of physics and physical science content (e.g., Kinematics, Energy, Newton's Laws, etc.), use of technology (e.g., electronic measurements, graphic calculators, simulations, etc.), and teaching techniques based on physics education research.

Teachers identified as outstanding in the four areas listed below have been designated and trained by the AAPT as AAPT/PTRAs. These first tier AAPT/PTRAs attend annual AAPT/PTRA professional development sessions on workshop leadership, organization, and delivery of content topics. These teachers continue to be provided with experiences during the annual AAPT/PTRA National Summer Institutes to grow as workshop leaders. The four areas used to critique applicants for AAPT/PTRA status are:

1. Evidence of Content Knowledge
2. Evidence of Creativity in Teaching
3. Evidence of Interest in Personal Professional Growth
4. Evidence of Leadership Potential



A Boston College study, **TIMSS (Third International Mathematics and Science Study) Physics Achievement Comparison Study**, published in April 2000 shows that students of teachers who have attended NSF funded projects, such as AAPT/PTRA Professional Development Program, performed significantly better on the TIMSS physics assessment. See <http://www.timss.org>. The USA overall mean is 423 while the mean for students of teachers who have attended NSF sponsored professional development is 475. In addition Horizon Research, Inc has documented the success of the AAPT/PTRA Program. This study shows that teachers who attend AAPT/PTRA workshops are more confident in their own physics content knowledge and thus are more likely to make a commitment not only to use technology, but also to use the results of successful and research-based teaching strategies (e.g., modeling, directed guided inquiry, self-directed learning, ranking tasks, etc.)

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The AAPT/PTRA workshops are of two types: content specific and teaching strategies specific. Content specific subjects include (e.g., Kinematics, Energy, Geometric Optics, Momentum, Newton's Laws, and the Electromagnetic Spectrum. etc.). Workshops dealing with teaching strategies include (e.g., Role of the Laboratory, Use of TI-84 in Teaching Physics, Role of Demonstrations, Guided Inquiry, etc.)

OUTLINE OF A TYPICAL AAPT/PTRA WEEKLONG INSTITUTE: KINEMATICS/MOTION

Compare/Contrast/Measurement: Time as an Instant, Frequency, Time as an Interval, and Period Using Pendulum and/or Flashing Light.

- Measurement of Time Intervals
- One Second Timer Challenge
- Pendulums on Parade
- Period of a Pendulum using a Photogate
- Frequency versus Period using a Flashing Light

Compare/Contrast/Measurement: Position, Distance Traveled, and Displacement

- Traveling Washer in One Dimension
- Traveling Washer in Two Dimensions
- Where am I?

Compare/Contrast/Measurement: Speed and Velocity

- Toy Car moving with Uniform Linear Motion
- Toy Car moving with Uniform Circular Motion
- Movement of Waves (Wave Equation compared to Speed Equation)
- Instantaneous Speed, Average Speed, Initial Speed and Final Speed Using a Toy Car Coasting Down an Inclined Plane using a Photogate Timer.
- Analysis of Motion Using Graphs Made from a Ticker Tape Timer.

Compare/Contrast/Measurement: Acceleration Using Toy Cars and Toy Airplanes

- Speeding Up
- Speeding (Slowing) Down
- Changing Directions
- Measuring acceleration with a Liquid Level Accelerometer.
- Linear Acceleration and Circular Motion Acceleration

Calculations using basic kinematics definitions, graphs, and equations

- Position versus Time Graphs (Motion Probe)
- Velocity versus Time Graphs (Motion Probe)
- Acceleration versus Time Graphs
- Basic Linear Kinematics Equations
- Freely Falling Objects (Free Fall Timing)
- Basic Uniform Circular Kinematics Equations

All of these topics are developed with inquiry based laboratory activities.

Jim Nelson has been leader of the Physics Teaching Resource Agent (PTRA) program since 1984. Jim currently teaches at Santa Fe College in Gainesville. He received the Presidential Award for Excellence in Science Teaching (1985), the Distinguished Service Award from the American Association of Physics Teachers (AAPT), the AAPT Award for Excellence in Pre-College Physics Teaching (2000), and numerous other national awards for educational excellence.



Teachers enjoying learning during an AAPT/PTRA summer institute

College Ready in Mathematics and Science Partnership: University and School District Partners working together to improve student success and teacher preparation

Gay Stewart

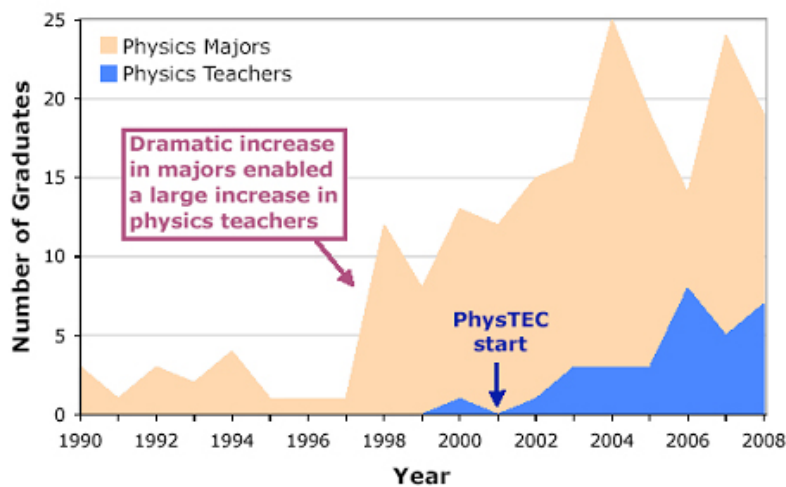
The College Ready in Mathematics and Science Partnership is a five-year, \$7M, targeted Math Science Partnership funded by the National Science Foundation to enhance mathematics and physics learning for all students in its partner districts and teacher-preparation programs in partner institutions, closing achievement gaps, and preparing students for success in mathematics, science, and teaching careers. *College Ready* will build vertical and horizontal learning communities among school and college faculty in order to improve major issues that impact the successful transition of students from high school to college, targeting physics. *College Ready* focuses its work on the school-college critical juncture and therefore is centered on articulation issues between school and college—teacher preparation in college for work in schools and student preparation in school for college mathematics and science, as well as among colleges and disciplines.

Successfully building partnerships is central to any effort to enhance K–12 teacher education. K–12 faculty work within a much different structure with many more constraints than college faculty. We started out working with teachers who had come to us with various questions or suggestions. We got to know them and earned their respect, and the respect was mutual. These teachers reciprocate by serving as our experts on teacher needs and teaching. Building these relationships with individual teachers eased forming collaborations with district-level personnel. Working with some schools

gave us better entrées into other districts. Opening these collaboration discussions with money ideas helped. Our first partnership request to a district was to work together on a state Teacher Quality Enhancement proposal, the year before the Physics Teacher Education Coalition (PhysTEC) was officially formed. Actually producing teachers, and placing them into area schools, further strengthened our partnerships, opening more dialogue with building-level administrators.

College Ready's core partners include 38 school districts in Arkansas and Oklahoma, University of Arkansas, Fort Smith, and University of Arkansas, Fayetteville (UAF), which serves as the lead. The supporting partners are APS, AAPT, College Board, Mathematical Association of America, Maplesoft, and Northwest Arkansas Community College. *College Ready* will carry out a series of interconnected activities including vertical alignment of high school and college expectations, intensive content-driven workshops, university course and program revisions, the creation of professional learning communities, and the opportunity for teachers to earn advanced degrees and endorsements. The physics workshops utilize materials and master teachers from the Physics Resource Teaching Agent (PTRA) program. *College Ready* builds on and looks to establish synergy between established efforts of PhysTEC and Preparing Mathematicians to Educate Teachers (PMET).

The University of Arkansas Success Story



There is a strong desire nationally to increase the number of students preparing to teach in STEM fields. The UAF physics department has been significantly engaged in the preparation of pre-service teachers for eight years, building on major efforts to reform their undergraduate program, which received NSF support in 1995. UAF has seen a dramatic increase in both the number of physics majors and of physics teachers produced, as shown in the figure, distributed by the American Physical Society as an exemplar of both the new “Doubling Initiative” and PhysTEC. UA’s PhysTEC philosophy is that there are reasons you want teachers to teach in certain ways, and

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so you should model this pedagogy for all students, improving their learning and providing future teachers with good models of instruction. Many of the changes that have made these dramatic increases possible would be transportable to the mathematical sciences. Like physics, mathematics has the goal of improving its service to all students, with a significant impact on those who will later teach. Not only will this program have a significant effect on the number of future teachers, but on student success at the university, particularly in STEM fields. Mathematics and physics are typically “gatekeeper courses” for other STEM majors. Reforming introductory physics courses into experiences that not only provide significant student learning, but also develop skills necessary for success in subsequent STEM courses, has increased graduation rates in engineering markedly. Physics is the most successful course in the new freshman engineering program, built at UAF to enhance the retention of engineering majors.

Mathematics is already working with PhysTEC faculty on how to bring some of the successful course policies to the calculus sequence, which remains a barrier for many students. Additionally, improvement of the calculus sequence, increasing student engagement in the ma-



Undergraduate Learning Assistant Shane Carey, a Noyce scholarship recipient and future high school physics teacher, works with two University Physics I (UPI) students at UAF, Stephen Brinson, left, and Mark Blanco. UPI is one of the courses strongly reformed under the PhysTEC project. It serves as a core course in the Freshman Engineering program, as well as providing an excellent early teaching experience.

terial, will positively impact physics majors, especially teachers, most of whom go on to certify in both physics and mathematics. Having a major impact on other departments was not a primary goal of PhysTEC. But establishing a successful preservice teacher program in another STEM department would be a positive model to institutions nationwide.

The physics department’s MA in physics teaching has been carefully adjusted over a twelve-year period to become a degree that serves teachers well. While mathematics has a similar degree, it has not been informed by the same sort of close work with practicing teachers as the physics degree. Mathematics has a long history of teacher education, including major professional development programs in the 1960–80 period, and NSF summer and academic-year institutes. During that period the MA degree program was structured. Recently the degree program has been modified but further modifications are needed. The same is true of the



Gay Stewart (right) works with undergraduate learning assistants on developing grading rubrics to encourage students to demonstrate conceptual understanding. (Left to right) Marshall Scott, Noyce Scholar and future high school physics teacher, and Christopher Jackson, high school physics teacher, are just joining in the discussion. Belinda Hendley, new Noyce graduate, still looking for a physics teaching position, and Elaine Christman, high school physics teacher and Amgen Fellow in Teach for America, are already at work. In the fall of 2007, when this photo was taken, the students were all still undergraduates, and Marshall had not yet expressed an interest in high school teaching.

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bachelor's degree in mathematics that serves future teachers. Reforming both programs to make them more responsive to the needs of high school teachers is a major goal of *College Ready*, and physics' experiences can be very informative. Time spent between the two departments on the differences will allow more teachers to have a valid and meaningful degree path to increase their content and pedagogy. As part of this project, it is planned that both degrees will incorporate important features that physics has introduced, helping the students in the MA program work toward National Board Certification.

Over 600 grade 7–12 teachers of mathematics and science currently teach at the partner schools, and the school districts are in the process of expanding, with a new high school just opened. Most of these teachers have at least an endorsement for their area of teaching, although few have degrees in their field. (For instance, eight that are currently teaching physics in partner schools have degrees in physics or physics teaching.) Because of the integration of the sciences in the Arkansas standards (over 500 of these teachers are in Arkansas school districts), teachers prepared to teach earth or life science are also finding themselves required to address physics strands. Licensure can be obtained in the area required for teaching high school physics with *as little as two introductory algebra-based physics courses* and a physical science content exam. State-wide, approximately 80% of physics teachers have a biology background. This is improving slowly. Similarly, licensure can be obtained in the area required for teaching high school mathematics with *as little as Survey of Calculus* as the most advanced mathematics course taken.

The master teachers will participate in three years of continuous, content-based professional development, which will reach approximately 50% of the mathematics and science teachers in the partner districts. There are also quantitative literacy and vertical teaming workshops, where master teacher candidates will be working with other teachers from their school districts to achieve the horizontal and vertical teaming goals. There are also content-specific workshops. For instance high school physics teachers preparing to teach an AP calculus course will be able to attend just the AP calculus portion of a mathematics workshop series. The project expects to have worked with at least 500 mathematics and science teachers directly, and to have impacted all of them, over the course of the project.

This project dovetails directly into the long-range plans

of all partners. All partners seek to increase the overall achievement of their students. Increasing students' abilities in literacy and math skills is essential to overall performance, not only because these content areas are measured regularly on standardized tests, but also because these areas are fundamental to further learning in all content areas.

The school districts become partners because they are deeply committed to the success of their students in mathematics and physics and in the preparation of those students to enter college with a realistic expectation that they can and will succeed in STEM fields. They believe that the key components to achieving these two goals are (1) providing rigorous, successful high school courses and curricula, (2) building the capacity of teachers to offer such courses, and (3) working with universities to a) identify areas where students need extra support, and b) provide placement mechanisms so that students are likely to succeed in colleges that are better informed of students' progress on the educational continuum. These efforts are most seriously impeded by the inability of school districts to provide high-quality, discipline-specific professional development to teachers of mathematics and physics. This is directly addressed by the partnership by providing significant training over the funding period to a large cadre of teachers within these school districts to become resources to the districts. These master teachers will then form the nuclei of professional learning communities in their schools that will allow them to direct peer-led professional development into areas of greatest need. This will allow the achievement of these goals to be sustained beyond the end of the funding. The school districts are committed to providing the necessary infrastructure support for this in-service professional development, reaching teachers that do not participate directly during the project, as well as beyond the funding period. The schools will nurture these professional learning communities that are, frankly, needed to support the learning of all students in mathematics and science. It is envisioned that if these teachers change schools in the future, they will be seen as valuable resources to their new schools as well.

Gay Stewart is an Associate Professor of Physics at the University of Arkansas – Fayetteville. She received her PhD in experimental high energy physics from the University of Illinois Urbana-Champaign in 1994. Since then she has been actively engaged in physics education reform, and, since 2000, in physics teacher preparation.

Browsing the Journals

Carl E. Mungan



- In the May 2009 issue of *The Physics Teacher*, Vincent Toal and Emilia Mihaylova present a two-page article entitled “Double-Glazing Interferometry.” They explain how one can easily see white-light fringes by looking at the full moon against a black night sky through a double-paned window at an angle. A secondary image of the moon with interference fringes appears beside the moon. I found it also worked to look at a large street lamp, so there’s no need to wait for a full moon. I must admit I have often seen such secondary images previously through my house windows at night but had not taken any notice of them, a demonstration of the fact that “discovery activities” need to be guided to be truly effective.
- An article entitled “On the stability of electrostatic orbits” in the May 2009 issue of *American Journal of Physics* discusses the stability of two charged conducting spheres orbiting each other in free space. Effects of charge polarization and dependence on the orbital angular momentum are analyzed. The first two references in the paper are to the actual demonstrations of such orbits using graphite-coated styrofoam spheres aboard the “Vomit Comet” aircraft by undergraduate students.
- In the featured paper “A simple demonstration of a general rule for the variation of magnetic field with distance” in the May 2009 issue of *Physics Education*, a Japanese geophysicist discusses a simple method to measure the variation in magnitude of the field with distance along the axis of a small permanent magnet using only an ordinary compass. The idea is to position the magnet’s axis to be perpendicular to earth’s magnetic field so that the tangent of the compass needle’s deflection angle gives the ratio of the magnet’s field strength to that of the earth. The connection to the magnet’s dipole moment is analyzed.
- “A simple derivation of Kepler’s laws without solving differential equations” in the May 2009 issue of *European Journal of Physics* presents an elegant geometrical derivation of Kepler’s three laws where the force of gravity is approximated as a succession of impulses (so that the orbit is an elliptically shaped polygon). The key step is to introduce the Runge-Lenz (“eccentricity”) vector to obtain the equation of an ellipse in polar coordinates.
- A fairly new journal, featuring pedagogical physics articles in both English and Spanish, is the *Latin-American Journal of Physics Education* (freely available on the web at <http://www.journal.lapen.org.mx/>), published in January, May, and September. For example, the May 2009 issue includes articles about laboratory determinations of Malus’s law, properties of a pendulum, and Planck’s constant.
- The International Commission on Physics Education puts out a Newsletter twice a year (available at <http://web.phys.ksu.edu/icpe/Newsletters/news.htm>). As might be expected, it features articles and advertises conferences that promote physics education in different geographical areas of the world.
- From time to time, the *Journal of Chemical Education* has articles of interest to physics educators, particularly in the areas of thermodynamics and statistical mechanics. A notable example is the January 2009 issue whose “Research: Science and Education” section focuses on articles discussing entropy, the Clausius-Clapeyron equation, and the virial expansion.

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Web Watch

Carl E. Mungan



- My favorite physics blog is “Built on Facts” (<http://scienceblogs.com/builtonfacts/>) written by graduate student Matt Springer at Texas A&M. I like it because I share the author’s interest in statistical mechanics, mathematical physics, and science fiction. It helps too that his posts are only a few paragraphs long, stick to a single topic at a time, and occur about 5 times a week. (Who has time for rambling posts several times a day?)
- I also highly recommend the News & Advice columns (<http://chronicle.com/jobs/news/>) and the blogs (<http://chronicle.com/blogs/>) of the Chronicle of Higher Education. I make it a point to read them once a week, typically on Fridays. They are loaded with excellent commentary and opinions about all topics academic.
- Speaking of Fridays, that’s the day that the weekly issue of Bob Park’s column “What’s New” comes out. (You can subscribe at <http://bobpark.physics.umd.edu/>.) Always provocative and often humorous, it usually consists of about 5 news items at the intersection of science and politics that I don’t hear about anywhere else. Not recommended for the thin-skinned.
- While none of us wants to subscribe to too many email listservers (you do have a life beyond the internet, don’t you?) I strongly recommend the PHYS-L digest (make sure you sign up for the digest version, unless you want to receive 20 or more individual postings per day) at <http://physicsd.buffalostate.edu/phys-l/>. It’s a good source for asking about and discussing issues related to physics teaching. For academics in general, two other excellent resources are Tomorrow’s Professor (subscribe at <http://ctl.stanford.edu/Tomprof/index.shtml>) and The Irascible Professor (<http://irascibleprofessor.com/>), each of which emails out articles a couple of times of week related to the life of a professor.
- A good site for readable summaries of recent scientific research can be found at Spotlight (<http://physics.aps.org/>), which highlights important new articles in APS’s physics journals.
- Did you know you can solve indefinite integrals online at <http://integrals.wolfram.com/> using Mathematica?
- Useful online columns in *The Physics Teacher* include the monthly Physics Challenge (http://scitation.aip.org/tpt/past_answers.jsp) and Fermi Questions (http://scitation.aip.org/tpt/past_fermi.jsp), as well as Figuring Physics (archived as Next-Time Questions at http://www.arborsci.com/Labs/CP_NTQ.aspx). Note that there’s an underscore after “past” and “CP” in the preceding three URLs.
- Project Galileo at Harvard (<http://galileo.harvard.edu/>) is a repository of materials based on *Peer Instruction* and *Just-in-Time Teaching*. A broader collection of online resources supporting teaching and learning in physics and astronomy is comPADRE (<http://www.compadre.org/>).
- You have signed up for free Educator Access to Cramster (<http://www.cramster.com/>), haven’t you? Many of your students are probably paying \$9.95/month to get access to detailed solutions to textbook problems at this site. Have you looked to see what they can see?
- Finally, there are some great physics movies on the web (other than on YouTube). Try the classic “Frames of Reference” at http://www.archive.org/details/frames_of_reference (those are underscores before and after “of” in the URL), the complete 52-program set of “The Mechanical Universe and Beyond” at <http://www.learner.org/resources/series42.html>, and “The Video Encyclopedia of Physics Demonstrations” at <http://www.physicsdemos.com/>.

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