APS physics

Forum on Education

American Physical Society

Fall 2009 Newsletter

Paula Heron and Chandralekha Singh, Editors

IN THIS ISSUE

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 J. Collings

As you can see from contributions to this newsletter, Forum on Education (FEd) members have been busy organizing sessions at the February (April) and March meetings of the American Physical Society. The February meeting is a joint meeting with the American Association of Physics Teachers (AAPT), so FEd members have been collaborating with AAPT members in organizing sessions. In some sense, this joint meeting is an experiment. If it works out well for both APS and AAPT, it may become an annual joint meeting, although that cannot happen for a while as both organizations have meetings planned for a few years to come.

In an effort to increase the participation of members in FEd activities, annual events that are organized with cooperation from AAPT were examined in hopes of making them as productive and successful as possible. To that end, a joint meeting of the FEd Executive Committee and the AAPT Executive Board was held during the AAPT Summer Meeting in Ann Arbor, MI. At this meeting, the plenary sessions annually organized by the FEd and one other APS unit at AAPT Summer Meetings were praised by everyone for the quality of the presentations and the high degree of interest in the topics. There was unanimous agreement that these sessions should continue to be organized as they have been in the past, with the FEd being the prime mover in the planning.

The second topic concerned the FEd sessions at the April APS meeting that are supposed to be organized jointly with AAPT. Although this arrangement has been on the books for a while (put there when the joint APS/AAPT Winter meeting ceased), the involvement of AAPT has been largely through the participation of FEd/AAPT members on the FEd Program Committee. The discussion in Ann Arbor therefore centered on how the AAPT Program Committee might play a larger role. Some general ideas were outlined, and after the meeting the AAPT Executive Board discussed it further, putting its ideas on paper. Soon the FEd Executive Committee will discuss these ideas and propose a way to plan for these sessions that is agreeable to both the FEd and AAPT. The hope is to have this planning agreement in force soon enough to affect planning for the 2011 April meeting.

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.

FEd Sessions at the 2010 "April" and March APS Meetings

Larry Woolf, FEd Program Chair

The Forum on Education program committee and the session organizers have worked very hard to put together the exciting and varied educational program that is described below.

"April" Meeting–February 13-16–Washington DC, jointly held with the AAPT Winter Meeting

Invited Sessions organized by the FEd

1. Developing Exemplary Undergraduate Physics Programs: The SPIN-UP Regional Workshops, organized by Ruth Howes (Ball State University)
2. Taxonomies as Tools for Enhancing Physics Learning– joint with the Division of Nuclear Physics, organized by Gay Stewart (University of Arkansas)
3. Strategies for Improving Climate and Diversity in Physics Departments, joint with the Committee on the Status of Women in Physics, organized by Chandralekha Singh (University of Pittsburgh)
4. Panel Discussion: Benefits of Undergraduate Research Experiences, organized by Cathy Mader (Hope College)
5. Excellence in Physics Education Award Session, organized by Richard Peterson (Bethel University)

Invited Sessions co-sponsored by the FEd

1. Origins of Research and Teaching at Selected Physics Departments, organized by the Forum on the History of Physics
2. What Can We Learn from Physics Teachers in High Scoring Countries on the TIMSS and PISA International Assessments? organized by the Forum on International Physics
3. Energy Education, organized by the Forum on Physics and Society

In addition, various AAPT committees are co-sponsoring many of the above sessions, and the Forum on Education is co-sponsoring numerous AAPT sessions. There will also be an education related workshop on TA Preparation: Challenges and Successes led by Ken Heller, University of Minnesota.

March Meeting – March 15-19, 2010 – Portland, Oregon

Invited Sessions organized by the Forum on Education

1. LaserFest: Laser Education and Outreach, organized by Becky Thompson-Flagg (APS)
2. How to Interest Middle School Children in Physical Science– joint with the Forum on Physics and Society, organized by Ernie Malamud (University of Nevada-Reno)

3. Graduate Education in Physics: Which Way Forward? - joint with the Forum on Graduate Student Affairs, organized by Chandralekha Singh (University of Pittsburgh)
4. Renewable Energy Education – joint with the Forum on Physics and Society, organized by Robert Ehrlich (George Mason University)
5. Science Literacy, the Nature of Science and Religion, organized by Larry Woolf (General Atomics)

Invited Sessions co-sponsored by the FEd

1. Educational Challenges in Biological Physics, organized by the Division of Biological Physics

March Meeting Focus Sessions:

1. Research in Mathematics Education and Mathematics in Physics Education, organized by John Thompson (University of Maine)
2. Physics Teacher Preparation: Effective Strategies, National Models, and Challenging Issues, organized by Stamatis Vokos (Seattle Pacific University)

There will also be an education related workshop on Strategies for High-Quality, Effective Educational Materials and Efforts led by Greta Zenner, University of Wisconsin, Madison. An education related tutorial on Physics Careers in Industry and Government will be presented by Kate Kirby (APS), David Seiler (NIST), Larry Woolf (General Atomics), Stefan Zollner (IBM), and Alex Panchula (First Solar).

FEd Program Committee

Peter Collings (Swarthmore College), Noah Finkelstein (University of Colorado), Ted Hodapp (APS), Ruth Howes (Ball State University), Catherine Mader (Hope College), Ernie Malamud (University of Nevada-Reno), Bruce Mason (University of Oklahoma), Mel Sabella (Chicago State University), Chandralekha Singh (University of Pittsburgh), David Sokoloff (University of Oregon), Amber Stuver (California Institute of Technology-LIGO), John Thompson (University of Maine), Larry Woolf, Chair (General Atomics)

Acknowledgment: The FEd program committee would like to thank Gary White (Director SPS & Sigma Pi Sigma) for representing the FEd at the "April" 2010 sorters meeting and Thomas Olsen (Assistant Director SPS & Sigma Pi Sigma) for representing the FEd at the March 2010 sorters meeting.

Larry Woolf is principal optical scientist and senior program manager at General Atomics, where he has been active in education activities since 1992. He is chair-elect of the Forum on Education.

Book Review of *Unscientific America: How Scientific Illiteracy Threatens Our Future*

by Chris Mooney and Sheril Kirshenbaum (Basic Books, New York, NY, 2009); 132 pages of text plus 66 pages of notes, ISBN 978-0-465001305-0.

Reviewed by Art Hobson

The rift between science and mainstream American culture is growing ever wider, says this book. Chris Mooney should know; his 2005 book *The Republican War on Science* analyzed an important and blatant example of this rift. The opening pages of Unscientific America note the nation's historical disdain of intellect as documented in Richard Hofstadter's classic 1962 book *Anti-Intellectualism in American Life*, a problem that's especially acute when it comes to science. The book notes the science-society rift in politics, the media, entertainment, and, most importantly, religion.

The authors largely blame scientists themselves for this rift, and look to scientists to lead us out of it. But scientists today tend to step out of their labs only long enough to blame the problem on others such as education or the media. The authors share C. P. Snow's concern, as expressed in Snow's much-quoted essay *The Two Cultures*, that science isn't being translated broadly into relevant social and cultural terms, and that this stems from compartmentalization of knowledge in science and in other fields. Today, science is walled off not only from the humanities (Snow's chief concern) but also from politics, the media, entertainment, and religion.

Unscientific America offers Carl Sagan as a foremost example of the kind of scientist that's needed. A successful researcher early in his career, Sagan quickly turned to broader issues of public education and scientific literacy. One of Sagan's more successful projects, for example, was the PBS television series *Cosmos*, called by Sagan's friend Stephen Jay Gould "the greatest media work in popular science of all time." Although Sagan won a goodly share of praise from scientists, the authors fault the scientific and academic community for failing to award him tenure at Harvard and failing to admit him to the National Academy of Sciences after he was nominated for membership in 1992. He was criticized for "oversimplification" in his scientific writings. Speaking as one who has read a lot of Sagan's writings, I find that he wrote with skillful and powerful accuracy, using non-technical language without mathematics. Unfortunately, for some scientists this kind of writing is synonymous with "oversimplification," and therein lies

much of the cause of the science-society rift of which *Unscientific America* speaks.

One of Sagan's best known warnings comes from his final published book, *The Demon-Haunted World:*

> We've arranged a global civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner of later this combustible mixture of ignorance and power is going to blow up in our faces.

In fact, what with global warming, superstition-driven terrorism, etc., it's blowing up now.

The book wisely remains focused on the dumbing down of American culture by anti-intellectual, conservative, and religious forces. As evidence, the authors cite their experience as participants in "ScienceDebate2008," a nonpartisan grassroots call for presidential candidates to debate science and technology policy on national television. But the project found its invitation declined by Clinton and Obama and ignored entirely by McCain. Meanwhile, political journalists nearly ignored science throughout the campaign, and the candidates managed to debate religious issues in religious forums.

The demise of the congressional Office of Technology Assessment at the hands of the partisan Gingrich Congress in 1995 is another example. In the words of a 2008 report on how members of Congress think about science, "most members seem to have little care about, interest in, or attention to technical and scientific matters, and to credible sources of information to guide Congress on [scientific] issues."

Another tragically important example is how the media bungled the most important science-related story of our time: global warming. The media mostly ignored the story until 2005, although scientists had been sounding the alarm since at least the first Intergovernmental Panel on Climate Change report in 1990. When the media did report on global warming, it was always in the "he said, she said" mode that bowed to industry and media interests by maintaining the fiction that science was seriously divided on this issue. It remains true today that, on global warming science, "the press is AWOL."

In Chapter 8, "Bruising Their Religion," the authors criticize the actions of the "new atheists," i.e. those such as Sam Harris, Richard Dawkins, and Christopher Hitchens who forthrightly criticize religion for maintaining America's superstitions and anti-intellectual attitudes. The authors argue that "America is a very religious nation, and if forced to choose between faith and science, vast numbers of Americans will select the former." Furthermore, "Atheism is not the logically inevitable outcome of scientific reasoning." Although I agree with these two quotations, I part company with the book on this issue. It seems to me that religion, or at least fundamentalist religion, is a major cause of the science-society split. This isn't the place for me to debate this point, but I don't see how the problem with fundamentalist religion can be resolved without direct confrontation.

The 2005 National Academy of Sciences report *Rising Above the Gathering Storm* noted a U.S. failure to produce enough scientists and engineers to keep us competitive for the long haul, and recommended dramatically bulking up K-12 science education. But *Unscientific America* notes that this recommendation is narrowly rooted. "Simply producing more scientists won't solve our cultural problems." The book laments the equations and formulas that public school students memorize, while these science students don't look at how science will transform the future world they will inhabit, never learning that science's most profound implications reach far beyond the scientific technicalities that science students are required to master, never becoming *scientifically literate*.

The solution, says this book, is that scientific and educational institutions, including universities, must redefine the scientists' role by rewarding endeavors that these institutions have long undervalued: public outreach, education of non-scientists, communication, and interdisciplinary education.

The authors document the trials and tribulations of U.S. science students in traversing undergraduate school, graduate school, and post-doc labor, only to find that, contrary to what one would expect from *Gathering Storm's* analysis, they are overeducated and have few job prospects. The proposed solution to both this "pipeline" problem and the scientific illiteracy problem is obvious: broaden the scientific mandate to include scientific literacy for all. Arm all science students with the skills to teach and otherwise communicate publicly relevant science, broaden public school science to emphasize scientific literacy for all non-scientists and all scientists (since scientists are not really scientifically literate today), and encourage public policy makers to create public-interest fellowships and jobs whose purpose is to connect science with society. In other words, instill in scientists the notion of *public service*.

Summarizing its prescription, the book's final chapter states "We must fundamentally change the way we think and talk about science education," and this means rethinking the education of *scientists* as well as the public school and college education of non-scientists. "We don't simply need a bigger scientific workforce: We need a more cultured one, capable of bridging the divides that have led to science's declining influence. …We must invest in a sweeping project to make science relevant to the whole of America's citizenry." I couldn't agree more.

Art Hobson is Professor Emeritus of Physics at the University of Arkansas in Fayetteville, and author of a scientific literacy textbook Physics: Concepts & Connections*, now in its fourth edition. This review is loosely based on the author's paper "The surprising effectiveness of college scientific literacy courses" appearing in* The Physics Teacher*, October, 2008.*

Outsourcing in Higher Education – will physics be the first to go?

Robert Ehrlich

Outsourcing components of higher education is a complex issue. Here we discuss a number of forms of outsourcing, and speculate about the impact on physics programs. Although it is not usually considered outsourcing, the increasing reliance on part-time faculty by many schools, in effect is just that. When a university chooses to hire inexpensive part-time faculty rather than fill full-time slots, we understand it to be an administrative prerogative, and a way to cope with budgetary stringency. Nevertheless, in such cases most faculty and administrators probably would acknowledge that part-timers will not fulfill the many non-teaching duties taken on by full-time faculty, including curriculum development and research, which cannot be so easily outsourced. The question of compromising teaching quality is somewhat less clear however, since some part-time faculty may be highly qualified, and possess expertise that is absent among the full-timers. On the other hand, what is acceptable on the part of the institution and its administration is certainly not acceptable on the part of individual faculty. Thus, "outsourcing" by full-time faculty members of their teaching duties is not permitted–they are not free to pay someone out of their own pocket to teach their classes, apart from covering perhaps one or two classes when they are out of town.

There are, however, other forms of outsourcing of teaching-related duties, where complex issues arise that are often overlooked. For example, consider the issue of computerized grading of homework –a service that is increasingly available by both textbook publishers and other companies–especially in physics. Many faculty members believe that this innovation is highly desirable, because of its many advantages–routine grading of all student homework (not just a random sample), allowing students to do the homework on their own schedule, get prompt feedback, and be permitted multiple tries to get the "right" answer. Other faculty members are less impressed with such systems, precisely because rewarding student's finding the right answer does not measure their understanding very well. Some faculty may use such systems as a labor-saving device, but fear that it represents a quality compromise.

Most institutions are quite content to defer to the judgment of individual academic departments on such matters. But suppose there is a division of opinion within the unit,–should some faculty members be allowed to use such systems, which are often provided free by publishers, whatever their colleagues think? I suspect that most faculty would answer "yes" on grounds of academic freedom, even though the individuals who use the service are in effect outsourcing a time-consuming teaching-related duty entirely on their own, and hence reducing their workload. Now let's take this grading outsourcing example a step further.

If the online homework grading is not provided free, is there any problem with faculty members paying for it on their own, and would the department have the right to forbid such a practice? Again, most faculty would probably regard the matter as one of academic freedom, and side with the individual faculty member. The tricky further extension is whether faculty members have the right to privately contract not with companies providing online grading of homework, but rather with private individuals to grade their student's homework–assuming student identities are kept confidential. It seems likely, for example, that one could easily locate highly-qualified persons in developing nations that would be eager to do this for a very small fee. One could argue that this should be disallowed, because individual faculty have a strong self-interest (and hence a possible ethical conflict) in making the judgment that the individuals doing the grading are in fact highly qualified, and doing a proper job. (I assume this was the basis for my dean venturing the opinion that the hypothetical hiring of individuals by faculty seemed to him to be unethical.) However, exactly the same kind of self-interest criticism can be made about those choosing to use a computerized grading system. This hiring of graders by faculty for the moment remains hypothetical, although I am sorely tempted to look into the possibilities–especially for the grading of lab reports, one of the least pleasant chores for many science faculty.

Outsourcing of individual components of teaching duties, such as grading, is just the tip of the iceberg, of course, with many schools outsourcing whole courses, and degree programs. Online education is now well over 20% of all post-secondary education, and growing rapidly. In fact, a law dean at the University of California at Berkeley recently publicly advocated online universities as a partial solution to the State's fiscal problems (July 23, 2007 *Chronicle of Higher Education*). Elite campuses in states facing less of a budget crunch can continue to justify the traditional mode of higher education, based on their research mission. But how long will it be until many less-prestigious four-year institutions than Berkeley conclude that in an era of budgetary stringency most of their under-enrolled majors can just as well be done entirely online, making use of the creative talents of highly-educated citizens in English-speaking developing nations?

I suspect that for a variety of reasons physics degrees might be among the first programs to be outsourced by some schools to other online degree-granting institutions. These reasons include:

- The low enrollment (and high cost) of many physics programs
- The extent to which much grading in physics is already done online–far more than other subjects
- The willingness of many institutions, including some very

prestigious ones, to boost their own course enrollments in physics by offering an online supplement

- The wide availability of online resources, including applets, demonstrations, course notes, and indeed whole courses in physics

Robert Ehrlich chairs the physics and astronomy department at George Mason University. In 2009 he had his own venture into the world of outsourcing, when he contracted with a company in India to build the rev-up.org web site. Rev-up stands for renewable energy valuation and understanding project, and the acronym reminds us of the need to rev-up our efforts in this important area.

A TIME FOR ACTION, NOT ANOTHER REPORT

Physics and Astronomy Communities Call for All Physics and Astronomy Undergraduates to have a Research Experience

John Mateja

Over the past year, the physics and astronomy communities took a decisive step to enhance retention and to increase the number of undergraduates pursuing advanced degrees in these disciplines. The American Physical Society's Committee on Education, Society of Physics Students, American Astronomical Society and the Council on Undergraduate Research's Physics and Astronomy Division called on physics and astronomy departments nationwide to provide ALL undergraduate majors in these disciplines with a research experience. [1]

For over a quarter of a century, the education community has been called upon to strengthen science, technology, engineering and mathematics (STEM) education in the U.S. Starting with the Department of Education's report *A Nation at Risk* [2] in 1983 and the National Science Board's *Neal Report* [3] in 1986, the community has been "called to action" every few years by another major report[4-7]. The latest of these, *Rising Above the Gathering Storm–Energizing and Employing America for a Brighter Economic Future,* argues the need for action in terms of a rapidly changing global economy.[8]

Of all of the STEM disciplines, the U.S. physics community, because of its relatively small size and its current workforce demographics, may be one of the most vulnerable to rapid and significant global marketplace changes. According to the National Science Board's 2008 Science and Engineering Indicators[9], 26% of the U.S. science and engineering labor force is older than 50. For physics, the percentage of the workforce with their highest degree in physics that is older than age 50 is 38%, the highest percentage of any STEM area! In addition to a "graying" workforce, significant percentages of the U.S. physics workforce–27%, 34% and 40% at the bachelor's, masters, and doctoral levels, respectively–are foreign born.[10] While the strategy to import whatever physics talent was needed has worked well for the physics community and the U.S. for over a half a century, the changing global marketplace and the demand that is developing in other countries for this expertise may, in simple terms, cause the well to go dry.

This picture is even more troubling when one considers the production of new physics talent in the U.S. At the bachelor's level, the 2007 August issue of *APS News* noted that "the proportion of bachelor's degrees in physics to total degrees awarded was twice as high the year before Sputnik, deemed a time of dangerous education neglect, than it was in 2004."[11] While the number of physics and astronomy majors has been increasing over the past 5 years[12], it is still not at a point to support future workforce needs. Troubling pictures can also be painted at the precollege and graduate levels.[13, 14]

Recognizing the seriousness of this situation, a number of physics and astronomy societies decided it was time to act rather than to simply generate another study. The research literature on "what works," clearly identifies the involvement of undergraduates in research as having a positive impact on many factors, including undergraduate STEM retention and the number of undergraduates who pursue advanced degrees.[15-27] The 2002 SPIN-UP study[28] of 21 "thriving" undergraduate physics programs with large physics major enrollments done by the American Association of Physics Teachers, American Institute of Physics and American Physical Society found that these departments all had very active undergraduate research programs and that about half of them required participation for the major. Taking this into account, the community is now calling on departments to provide ALL physics and astronomy majors with an undergraduate research experience.

Considering that the number of physics and astronomy majors is small (nationally ~6,000 in a class year)[12] and AIP survey statistics indicate that approximately 70% of graduating physics majors already have participated in some type of undergraduate research experience[29], the task is not as daunting as it may first appear. To provide all physics and astronomy undergraduate majors with a research experience, departments should consider a variety of strategies. Where possible, students should be encouraged to join on-campus faculty-mentored research projects. When such opportunities do not exist or the numbers of students exceed the number of available on-campus opportunities, departments should

proactively help students find research opportunities at NSF REU sites, at the national laboratories, and at corporate research facilities. A list of REU sites can be found on NSF's web site at http://www.nsf.gov/crssprgm/reu/reu_search.cfm. The Society of Physics Students populates a site called "The Nucleus" with a wide variety of summer opportunities, including those at NSF REU sites (http://www.the-nucleus.org/research)[30]. Rather than simply posting summer research announcements on a bulletin board, departments should work with their students to help them prepare competitive applications for these opportunities. For still other departments, undergraduate research might be provided through the existing course and laboratory curricular structure. For this type of curricular experience, research questions could be developed, experiments designed, data collected and analyzed, error analysis performed, inferences and conclusions drawn, and written and oral reports prepared and delivered. Support for changing the current curriculum to a more research-like or to include even authentic research experiences may be available through, for example, the NSF's Course, Curriculum and Laboratory Improvement program.

Will this recommendation require departments to change? For some, like those highly successful departments found in the SPIN-UP study, the answer is no as they are already encouraging and requiring their students to have an undergraduate research experience. For other departments, change will be required. However, for all departments, enrollments matter and if those physics and astronomy departments that have small enrollments can increase their numbers, both the departments and the physics community will benefit.

References

1. All statements are posted on the Society of Physics Student web site and can be viewed at http://www.spsnational.org/governance/statements/2008undergraduate_research.htm.
2. The National Commission on Excellence in Education, D. P. Gardner (Chair), *A Nation at Risk: The Imperative for Educational Reform,* **1983**, Report to the Secretary of Education, US Department of Education (www.ed.gov/pubs/NatAtRisk/title.html)
3. National Science Board (Neal Report), **1986** (NSB-86-100)
4. Boyer Commission on Educating Undergraduates in the Research University, S.S. Kenny (chair), *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*, **1998**, State University of New York at Stony Brook
5. Boyer Commission on Educating Undergraduates in the Research University, S.S. Kenny (chair), *Reinventing Undergraduate Education: Three Years after the Boyer Report*, **2002**, State University of New York at Stony Brook
6. National Science Board, Washington, W.M. (chair), *The Science and Engineering Workforce–Realizing America's Potential,* **2003** (NSB 03-69)
7. National Panel Report, Ramaley, J. (chair), *Greater Expectations: A New Vision for Learning as a Nation Goes to College,* **2002**, Association of American Colleges and Universities (ISBN 0-911696-92-x).
8. Committee on Science, Engineering and Public Policy, N.R. Augustine (Chair), National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies report titled *Rising Above the Gathering Storm – Energizing and Employing America for a Brighter Economic Future,* **2007**, National Academies Press (ISBN: 978-0-309-65442-5).
9. Science and Engineering Indicators (S&EI), National Science Board, **2008**, page 3:44.
10. Science and Engineering Indicators (S&EI), National Science Board, **2008**, page 3:51.
11. American Physical Society, **2007**, *APS News*. August/September
12. Mulvey, P., Enrollments and Degrees Report, 2006, Statistical Research Center, American Institute of Physics (September, **2008**).
13. Education at a Glance **2009**, Organization for Economic Co-operation and Development (www.oecd.org/dataoecd/41/25/43636332.pdf).
14. Graduate Science and Engineering enrollment, by status and sex, and postdocs in science and engineering fields: 1993-2003. National Science Foundation, Division of Science Resource Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering. http://www.nsf.gov/statistics/infbrief/nsf05317
15. Nagda, B.A., Gregerman, S.R., Jonides, J., von Hippel, W., and Lerner, J.S., Undergraduate student-faculty Research Partnerships Affect Student Retention, *The Review of Higher Education* **1998**, 22, 55-72.
16. Gregerman, S., Improving the Academic Success of Diverse Students through Undergraduate Research, C*ouncil on Undergraduate Research Quarterly* **1999**, 2, 52-59.
17. Hathaway, R.S., Nagda, B.A. and Gregerman, S.R.,The Relationship of Undergraduate Research Participation to Graduate and Professional Education Pursuit: An Empirical Study. *Journal of College Student Development* **2002**, 43, 614-631.
18. Hutchinson, A.R., and Atwood, D.A., Research with First- and Second-year Undergraduates: A Model for Undergraduate Inquiry at Research Universities, *J. Chem. Education* **2002**, 79, 125-12
19. Bauer, K.W.; Bennett, J.S., Alumni Perceptions Used to Assess Undergraduate Research Experiences, *Journal of Higher Education* **2003**, 74, 210-230.
20. Seymour, E., Hunter, A.B., Laursen, S.L., Deantoni,T. Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-year Study. *Science Education* **2004**, 88, 493-534.
21. Rauckhorst, W.H., Czaia, J.A. and Baxter Magolda, M., Measuring the Impact of the Undergraduate Research Experience on Student Intellectual Development. (July, **2001** July) Paper presented at

Project Kaleidoscope Summer Institute, Snowbird, UT.

22. Hunter, A.B., Laursen, S.L., Seymour E., Becoming a Scientist: The Role of Undergraduate Research in Students' Congnitive, Personal, and Professional Development, Science Education **2007**, 91, 36-74
23. Russell, S.J., Hancock, M.P. and McCullough, J., Benefits of Undergraduate Research Experiences, *Science Education* **2007**, 316, 548- 549
24. Karukstis, K., The Impact of Undergraduate Research on America's Global Competitiveness, *Journal of Chemical Education* **2007**, 84, 912, and references therein.
25. Lindsay, H.A., McIntosh, M.C., Early Exposure of Undergraduates to the Chemistry Research Environment; A new Model for Research Universities, *Journal of Chemical Education* **2000**, 77, 1174.
26. Hurtado, S., Eagan, M.K., Cabrera, N.L., Monica, H.L., Park, J., and Lopez, M., Training Future Scientists: Predicting First-year Minority Student Participation in Health Science, *Research in Higher Education* 2008, 49, 126-152.
27. Taraban, R; and Blanton, R.L., Creating Effective Undergraduate Research Programs in Science: The Transformation from Student to Scientist, Teachers College Press **2008**, ISBN 978-0-8077-4877-0
28. Hilborn, R.C., Howes, R.H., Krane, K.S., Strategic Programs for Innovations in Undergraduate Physics: Project Report (SPIN-UP), **2003**, American Association of Physics Teachers.
29. Mulvey, P. Survey of Physics Seniors, Physics Trends, Statistical Research Center, American Institute of Physics (Spring **2005**).
30. *The Nucleus* is part of the physics digital library ComPADRE (Committee of Physics and Astronomy Digital Resources in Education), a joint effort led by AAPT, with contributions from APS and AIP/SPS, and funded by the NSF as a pathway project of the National STEM Education Distributed Learning (NSDL) program.

John Mateja (john.mateja@murraystate.edu) is the Director of the Undergraduate Research and Scholarly Activity Office at Murray State University. He is a Fellow and past president of the Council on Undergraduate Research and serves on the Board of Governors of the National Conference on Undergraduate Research.

Peer Instruction For Quantum Mechanics

Guangtian Zhu and Chandralekha Singh

Quantum Mechanics is one of the most widely taught topics at the college/university level in the physical sciences. Undergraduates see aspects of quantum mechanics in their introductory physics, modern physics, physical chemistry, statistical and thermal physics, and quantum mechanics courses. However, the subject matter makes instruction in quantum mechanics quite challenging—able students constantly struggle to master basic concepts. Effective teaching of quantum mechanics to undergraduate students is an intellectually important task; if it is not done well, students will be handicapped in their later careers.

One way to immerse students actively in the learning process is to have them interact with each other. In introductory physics instruction, integration of peer interaction (PI) with lectures has been popularized by Mazur from Harvard University [1]. In this PI approach, the instructor poses conceptual problems in the form of multiple-choice questions (ConcepTests) to students periodically during the lecture [1]. The students reflect with their peers about the answers to the conceptual multiple-choice questions. After the students discuss their reasoning with peers, they are polled about their choices on the ConcepTests. The focal point of the PI method is the discussion among students, which is based on conceptual questions; the lecture component is limited and intended to supplement the self-directed learning.

To help students develop a solid grasp of the fundamental principles of quantum mechanics, we have been developing and evaluating resource material for "Peer Instruction" in quantum mechanics. The resource material includes ConcepTests for formative assessment, standardized assessment tools for summative assessment and "Reflective Homework" problems for Just-In-Time Teaching (JITT) [2]. Instant feedback on ConcepTests from students provides a "reality check" to the instructors about the extent to which students have actually learned to apply the concepts discussed. This can help instructors adjust the pace of the class appropriately. Peer interaction also keeps students alert during the lectures because they know they must discuss the questions with peers, and it also helps students organize and extend their knowledge. Articulating one's opinion requires attention to logic and organization of thought process. Moreover, there is often a mismatch between the instructor and students' expectations about the level of understanding that is desired related to a concept. Peer instruction helps convey the instructor's expectations explicitly and concretely to the students so that they are on the same wavelength.

The following features of the Peer Instruction material and approach make it particularly suited for the challenging task of teaching quantum mechanics: (1) Formative assessment by polling students about their responses provides feedback to the instructors which is critical for bridging the gap between teaching and learning. (2) The material is being developed based upon prior research by us and others on student difficulties and misconceptions related to quantum mechanics (for example see [3-5]). (3) The material strives to bridge the gap between the abstract quantitative formal-

ism of quantum mechanics and the qualitative understanding necessary to explain and predict diverse physical phenomena. (4) The method consistently keeps students actively engaged in the learning process because not only must the students answer the questions, they must also discuss it with their peers. (5) The method provides a mechanism to convey the goals of the course and the level of understanding that is desired of students. It can also help students monitor their own learning.

The development of ConcepTests goes through an iterative process to ensure that they are pedagogically valuable. Several ConcepTests being developed are related to each other to help students build a robust knowledge structure. Similar to the introductory physics courses, ConcepTests for quantum mechanics can be integrated with lecture after every 10-15 minutes or at the beginning of a lecture to reinforce material from the previous lecture. Posing research-based review questions at the beginning of the lectures ensures that students are the ones who do the thinking, organizing, repairing and extending their knowledge structure.

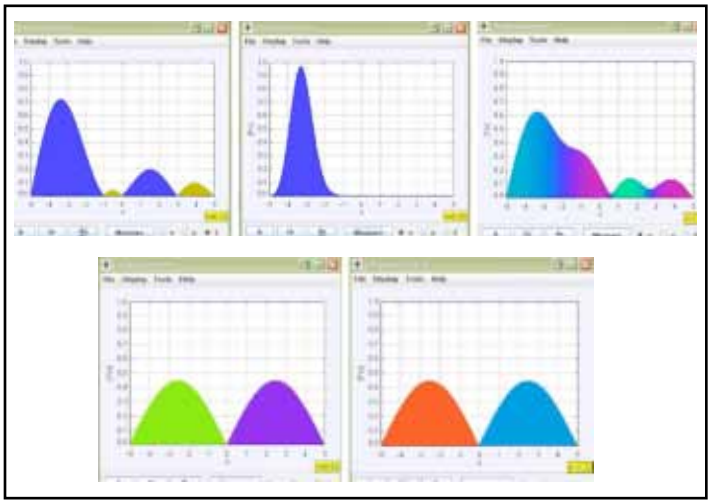


Figure 1. Simulation following ConcepTests related to time evolution of wavefunction after the measurement of position or energy.

Students are also given ConcepTests in which they discuss with their peers what should happen in a given situation and then they observe simulations to help them visualize the situation [6]. For example, students are asked a sequence of four ConcepTests dealing with the evolution of a wave function after the measurement of different physical observables. These ConcepTests also help students understand the difference between stationary state wave functions and position eigenfunctions, a topic about which students have many common misconceptions [3]. One ConcepTest asks about what happens when we start with a general wave function for a system and perform a measurement of position. The next question asks about the time-development of the wave function after the measurement of position. The next two ConcepTests in the set ask similar questions about the stationary state wave functions. After discussion with the peers, students observe the corresponding simulations and a class discussion ensues. For example, the top row in Figure 1 shows that starting with a general wave function, measurement of position makes the wave function very peaked (theoretically a delta function but in the simulation this collapsed wave function has a width) but then the system evolves with time and the wave function does not remain peaked for all future times (contrary to a common misconception that if the system is in an eigenstate of the position operator, it will remain in that state for all future times). The second row of Figure 1 shows that if the measurement of energy is made and the system "collapses" to an energy eigenstate, the isolated system remains in the same energy eigenstate (the only change is the overall phase that is represented by colors in the plots shown).

Just-in-Time Teaching (JITT) is a strategy for keeping students actively engaged in the learning process via web-based assignments which are typically conceptual [2]. The web-based conceptual assignments are carefully developed and can be submitted by students via course website and the instructor can browse over the student submissions just-in-time to incorporate the needs of the students and adjust the classroom lessons accordingly. Thus, students' responses can be fed back into the in-class discussions. As part of the JITT material, we have been developing "Reflective Homework" problems that strive to bridge the gap between conceptual and quantitative learning. These "Reflective homework" assignments can be effective tools for classroom discussions after students turn them in via the course website.

For example, one set of Reflective Homework questions asks students to compare a stationary state wave function with a non-stationary state wave function which is an equal superposition of the ground state and the first excited state wave functions. Students are asked to compare the probability density, wave function after a time t, the expectation value of position and momentum at the initial time and as a function of time. They are asked to perform these comparisons for a one dimensional infinite square well and a simple harmonic oscillator. Students can later discuss in the class why the probability density should not depend on time for the stationary state wave function but it should depend on time for the non-stationary state wave function. Students can also discuss why the same formalism is applicable whether these questions are

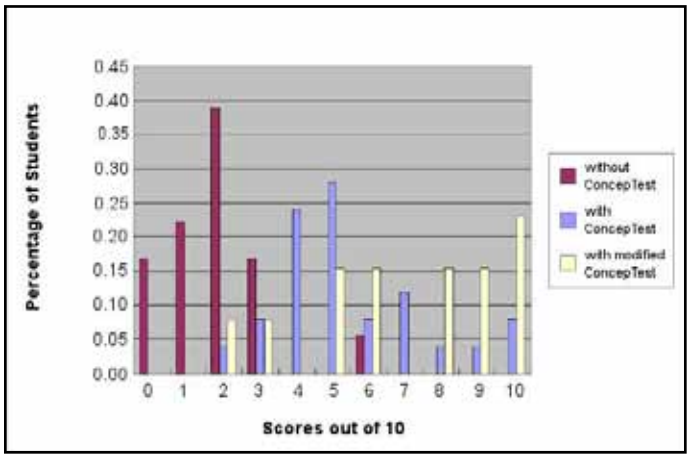


Figure 2: Post test results for the infinite square well.

about the infinite square well or simple harmonic oscillator.
Our preliminary evaluation suggests that the Peer Instruction tools developed so far are helping students, but further development and refinement is necessary. For example, Figure 2 shows students' performance on a study in which one class did not use ConcepTests related to the time-development of wave function whereas two classes did. One of the two classes that used the ConcepTests used the modified version that took into account the feedback from prior year's administration. The performance of the classes that used the ConcepTests is better than the class that covered the same material using more traditional methods. We have been refining the tools based upon the feedback obtained from the students. Surveys administered to students about the effectiveness of Peer Instruction tools suggest that students themselves value these tools.

This work is supported in part by the National Science Foundation.

References

1. E. Mazur, *Peer Instruction: A User's Manual*, Series title: Prentice Hall series in educational innovation. Upper Saddle River, Prentice Hall, N.J., 1997.
2. G. Novak, A. Garvin, W. Christian, E. Patterson, *Just-in-time teaching: Blending active learning with web technology*, Prentice hall, 2001.
3. C. Singh, Student understanding of quantum mechanics at the beginning of graduate instruction, *Am. J. Phys*., **76(3)**, 277-287, (2008); C. Singh, M. Belloni, W. Christian, Improving student's understanding of quantum mechanics, *Physics Today,* 8, 43-49, August (2006); C. Singh, Student understanding of quantum mechanics, Am. J. Phys., **69(8)**, 885-896, (2001).
4. M. Wittmann, R. Steinberg, E. Redish, Investigating student understanding of quantum physics: spontaneous models of conductivity, *Am. J. Phys.* **70(3)**, 218-226, (2002).
5. P. Jolly, D. Zollman, S. Rebello, A. Dimitrova, Visualizing potential energy diagrams, *Am. J. Phys.*, **66(1)**, 57, (1998).
6. For example, see http://www.opensourcephsyics.org, M. Belloni, W. Christian and A. Cox, *Physlet Quantum Physics,* Pearson Prentice Hall, Upper Saddle River, NJ, 2006.

Guangtian Zhu is a graduate student and Chandralekha Singh is an Associate Professor in the Department of Physics and Astronomy at the University of Pittsburgh.

Overview of the Foundations and Frontiers in Physics Education Research Conference

Michael Wittmann, Paula Heron, and Rachel Scherr

The third Foundations and Frontiers in Physics Education Research conference was held June 15–19, 2009, in Bar Harbor, Maine. As with the 2005 and 2007 conferences, about 60 active researchers in the field of physics education spent the week on the campus of the College of the Atlantic examining and articulating the current state of the field, exploring future directions, and discussing ways to pursue the most promising avenues for future research.

The conference featured a series of plenary lectures given by established and emerging leaders in PER: Fred Goldberg (San Diego State University), Priscilla Laws (Dickinson College), Andrew Boudreaux (Western Washington University), Danielle Harlow (University of California, Santa Barbara), Stamatis Vokos (Seattle Pacific University), Leslie Atkins (California State University, Chico), Noah Finkelstein (University of Colorado), Andrew Heckler (the Ohio State University), Bruce Sherin (Northwestern University), Olivia Levrini (University of Bologna, Italy) and John Thompson (University of Maine). Each addressed the theme of "Foundations and Frontiers" by synthesizing major accomplishments in the field and/or speculating on the directions they consider especially important and promising. Afternoons were unscheduled, and were variously spent exploring issues raised by the plenaries, developing collaborations, or enjoying the superb weather and natural beauty of Bar Harbor. Evening sessions included topical sessions devoted to specific research issues, a contributed poster session, and working groups on subjects of community-wide interest. Reports from two of the working groups appear on the pages that follow. They address issues facing physics education researchers collaborating across institutions and the requirements for a textbook on PER. A full set of working group reports can be found on the conference website and on Compadre.

Conference participants came from Argentina, Canada, Finland, Italy, South Africa, Sweden and throughout the U.S. Among them were 12 PhD students, whose participation was supported by a grant from the APS Forum on Education. The conference organizers would like to thank the Forum for their continued support of this conference series. The 2009 conference was also supported by a grant from the National Science Foundation, for which the organizers would like to express their gratitude. Additional thanks are due to the staff of the College of the Atlantic in Bar Harbor and the Center for Science and Mathematics Education Research at the University of Maine.

More information regarding past and future Foundations and Frontiers in Physics Education Research conferences can be found at http://perlnet.umaine.edu/~ffper/.

Michael Wittmann, Paula Heron and Rachel Scherr are co-organizers of the Foundations and Frontiers in Physics Education Research Conference. Michael Wittmann is Associate Professor of Physics and Cooperating Associate Professor of Education at the University of Maine. Rachel Scherr is Research Assistant Professor of Physics at the University of Maryland. Paula Heron is Professor of Physics at the University of Washington.

Working Group Report: Collaborations in PER

MacKenzie Stetzer and Michael Loverude

The Working Group on Collaborations in Physics Education Research (PER) was given an initial charge of identifying broad types of collaborations that are possible as well as systemic issues that discourage researchers from collaborating and hinder the productivity and effectiveness of existing collaborative projects. At its first meeting, the Working Group discussed this charge but felt that it was of greater importance to take this opportunity to identify the needs of PER community members regarding collaboration. In particular, many researchers have positions in which they are the only PER faculty member at an institution. For these 'singletons,' collaboration is an essential means of maintaining a productive research effort. We therefore discussed specific recommendations for fostering PER collaborations in order to provide additional support for singletons and any other researchers looking for collaborators. As a result, our report includes several items we plan to propose to the Physics Education Research Leadership and Organizing Committee (PERLOC) for its consideration, as well as other suggestions for future action on the part of the Working Group and the PER community.

The general strategy of the Working Group was to begin by identifying the benefits and costs associated with collaborations (in general) and then deciding how to divide up the types of possible collaborations in a meaningful way. The Working Group considered establishing several sub-groups that would investigate, in detail, different type of collaborations. However, given the increased emphasis on efforts to foster collaboration, we decided that certain sub-groups would focus exclusively on formulating broader recommendations while other sub-groups would focus on characterizing specific types of collaborations and identifying their unique needs.

In order to make this document most useful to the larger PER community and to best capture the general consensus of the Working Group, the authors have decided to focus much of the report on outlining steps the community can take to facilitate PER collaborations–at the expense of documenting in detail some of the other efforts of the Group. Therefore, in this report, we only briefly discuss some general advantages and challenges of collaborative PER and outline four broad categories of collaborations. We then describe, in detail, several specific proposals for fostering increased collaboration by members of the PER community.

Benefits and costs of collaborations

During the first meeting of the Working Group, much of the discussion focused on identifying the benefits and costs of collaboration. While the following lists are not exhaustive, they highlight common reasons why a researcher might wish to collaborate as well as potentially problematic aspects of collaboration with which researchers should be familiar.

Benefits of collaboration

The advantages of collaborating with other researchers include:

- Access to a larger number of students and to diverse student populations (important for generalizing findings)
- Institutional, cultural, and national diversity of researchers and research subjects
- Expansion of professional network
- Fresh ideas and different researcher perspectives (e.g., diverse views about the nature of PER)
- Expertise with multiple research techniques
- Broadening of research language
- Increased opportunities for feedback and discussion throughout project
- Higher quality of work due to issues of accountability, deadlines, and additional reviewing
- Opportunity to learn how to deal with situations beyond your control (i.e., "roll with the punches")
- Greater potential for funding.

Costs of collaboration

Some of the disadvantages of collaboration identified by the Working Group include:

- Differences in Institutional Review Board (IRB) requirements
- Costs (in terms of money, time, and effort) of travel and communication
- Possibility of poor matches (due to different research standards and ethics or different beliefs about the nature of PER)
- Differences in academic calendars, course sequencing, and institutional types
- Collaboration between a junior faculty member and a senior faculty member may be viewed as a lack of independence on the part of the junior member
- Multiple author papers may be perceived negatively in tenure and promotion cases
- Compromise on specific research goals may be necessary in order to accommodate all collaborators
- Poorly-defined collaborator roles and difficulty in achieving an appropriate and agreed-upon balance among different researchers' roles in a project (e.g., certain collaborators may feel "used")
- Possibility of collaborators failing to stay on schedule, thereby holding up the project
- Learning curve for successful collaboration
- Cultural, national, and linguistic differences associated with international collaborations; analogous differences associated with interdisciplinary collaborations

- Additional time required when investigators lack experience or background in PER or discipline-based education research
- Different (and possibly conflicting) expectations from different departments and faculty for graduate students involved in collaborations (particularly when they are interdisciplinary).

Types of collaborations

The Working Group also sought to identify, in a meaningful way, the different types of collaborations that exist in PER. While many classification schemes are possible, the one presented here represents an effort to highlight the role of collaborations in assisting junior researchers who may be singletons at their institutions. In addition, although large-scale collaborations (modeled on those employed by high-energy physicists) might be particularly well suited for exploring larger questions (e.g., research-based improvement of the K-12 education, which would include collaborative efforts in teacher preparation, curriculum development, and in-depth investigations of several different populations), the Working Group felt that, in the absence of either a well-defined vision for such a collaboration or the existence of a collaboration of this type, the discussion would be limited to collaborations that are small to average in size. For this reason, we came up with four categories of collaborations:

1. *Collaborations designed to foster the professional development of junior researchers*

   In these collaborations, a junior researcher (possibly a singleton) or graduate student works with established PER faculty at a different institution. Such collaborations help junior faculty become involved in new areas of research, gain familiarity with new techniques, receive detailed constructive feedback on their work, and conduct investigations that extend beyond the limitations of their independently secured grants.

2. *Collaborations in which collaborators employ similar techniques*

   In this type of collaboration, researchers typically share a common background, similar expertise, and a shared perspective on PER. By collaborating in this manner, researchers are more easily able to generalize on the basis of their findings due to larger data sets that reflect more diverse student populations. Since common techniques are used, collaborators can be deeply involved in all aspects of the project, thereby improving the overall quality of the work.

3. *Collaborations in which collaborators specialize in different techniques*

   The strength of this type of collaboration lies in the fact that a single research question (or set of questions) may be approached using multiple techniques. As a result, investigators are able to explore questions in PER that cannot be adequately probed using a single technique. Similarly, a researcher with a primarily theoretical focus might collaborate with another whose expertise is primarily experimental, as is often the case in other fields of physics. Although the role of each investigator involved in this type of collaboration tends to be well defined, the diverse perspectives of the researchers tend to enrich the quality of the project as a whole and help ensure that the work appeals to a broader audience.

4. *External collaborations*

   In external collaborations, physics education researchers work closely with education researchers who specialize in other fields (e.g., math, engineering, biology, chemistry, cognitive science, and psychology) on common research projects. While the specific nature of such a collaboration may fall under any of the three previous categories, external collaborations benefit from the introduction of diverse perspectives from different research communities. In addition, they are ideally suited to investigate questions that may transcend instruction in any specific discipline (e.g., questions pertaining to the nature of science).

Recommendations for facilitating collaborations

After much discussion, the Working Group developed several specific recommendations for fostering collaboration in PER. (It is important to note that the many of the resources proposed by the Working Group could be useful to all junior PER faculty, regardless of their interest in collaborative research.) The recommendations are discussed below.

IRB resources

One of the primary obstacles identified by the Working Group to collaboration between PER faculty at different institutions as well as to young singleton faculty embarking upon new projects was human subjects protocol and the associated documentation required by each Institution's IRB (Institutional Review Board). Indeed, differences in IRB requirements across institutions (and even across different departments within a single institution) can make it difficult for an investigator to collaborate with colleagues at other institutions. Moreover, new faculty hired at institutions without PER colleagues frequently run into considerable obstacles when attempting to secure IRB approval for the first time at an institution. In some cases researchers may find it necessary to 'educate' a local IRB, whose members might not be familiar with research of this type.

For this reason, the Working Group advocated the establishment of a single website providing IRB resources for PER faculty. The website would include several items:

1. A standard blanket IRB document: This IRB form would be written and approved by PERLOC and it would cover typical techniques used in PER (e.g., written questions, interviews, and video documentation of instruction)
2. A statement from PERLOC endorsing the Standard IRB form and indicating that it has been accepted by IRBs at a wide variety of institutions
3. Sample (anonymized) IRB forms for different types of approved PER investigations conducted at various institutions
4. Sample (anonymized) consent forms used in the above investigations.

It is anticipated that such a website might help foster increased uniformity in the area of IRB requirements and therefore foster increased collaboration. (A restricted website with preliminary versions of sample forms has already been created by members of the Working Group.)

Funding: Grants supporting collaborative work

As discussed above, some of the costs associated with collaboration are financial (e.g., the cost of travel and videoconferencing/computer networking resources). The Working Group therefore proposed a dedicated PER grant line supporting collaborative work. Preference would be given to singletons from different institutions. Ideally, these awards would serve as seed funding for the establishment of a long-term, sustainable collaboration (domestic or international). They would provide funding for travel, computer resources, and possibly students. A separate grant line would support travel to conferences (with specific allocations for graduate students and for other researchers). It is hoped that PERLOC will look into acquiring support for such grants.

Online Resources

The Working Group argued that the establishment of appropriate online resources could help facilitate collaboration with a minimal amount of overhead. While there was not sufficient time during the 2009 FFPER to converge upon a detailed list of items or documents that should be hosted online, a useful set of online resources maintained by the community might include:

- PER overview: A collection of documents intended to support faculty making the case for PER at their institution (e.g., for a new hire or a promotion or tenure case). This collection would include general information about the field, statistics such as acceptance rates for various journals, a list of research groups, and a list of tenured faculty.
- IRB resources described above
- The report from the Working Group on Collaborations in PER
- Descriptions of existing collaborations in the field and the questions they seek to address
- Advice for singletons and other junior faculty in several different professional matters, including collaborations (e.g., what to look for and what to avoid)
- FAQ for PER faculty at different stages in their careers
- List of funding sources (i.e., agencies that have funded PER in the past)
- Links to the PER community (including relevant list servers, PER pages on social and professional networks, and the PER Topical Group)
- List of technical tools and resources to facilitate long-distance collaborations.

The Working Group felt that it is imperative that individuals are familiar with one another's work prior to entering into a professional collaboration. For this reason, traditional networking (at meetings and online) was favored over the establishment of some type of online PER "matchmaking" site.

Additional efforts to encourage internal collaborations

In order to encourage collaborations that would foster the professional development of junior researchers, the Working Group also recommended the encouragement of future faculty and junior faculty to visit other groups and researchers and to explore different methodologies and research projects through the establishment of the following:

- Graduate student exchange program
- Travel funds designated for use by young faculty for short visits to other groups or researchers
- Regional retreats for junior PER faculty
- More formal opportunities for larger PER groups to host junior faculty (e.g., scheduled open houses).

The Working Group felt that many of the online resources described earlier in this report would be helpful in facilitating internal collaborations in which common techniques are employed. However, some ongoing PER projects that could be strengthened through collaborative efforts are neither documented in the literature nor presented at meetings or conferences. Therefore, the Working Group argued that improved efforts to increase the visibility of such projects (e.g., inclusion in a list of ongoing projects) would be particularly useful.

The Working Group recognized that meetings such as the FFPER do much to foster collaborations in which researchers specialize in different techniques. However, additional recommendations include:

- Encouragement of researchers to review PER papers that document projects employing techniques that differ in nature from their own
- Increased exposure of graduate students to different types of research and techniques via journal clubs, seminars, workshops, and graduate student exchange programs
- Publication of review paper(s) for the field and the development of a PER textbook.

Efforts to encourage external collaborations

The Working Group felt that members of the PER community should be exploring opportunities for collaboration with education researchers in other fields (e.g., engineering, math, and cognitive science) and with researchers in colleges of education specializing in science and math. A few specific recommendations by the Working Group to facilitate such collaborations include:

- Establishment of communication between the organizers of FFPER and the organizers of the Chemical Education Gordon Conference
- Coordination between PERLOC and ACS Division of Chemical

Education

- Development of proposals for joint conferences for education researchers from diverse disciplines.

The Working Group also suggested that PER researchers actively seek out and work with Centers for Teaching Excellence at their institutions (e.g., collaborating on the development of a Learning Assistant program). In addition, it was felt that the establishment of research collaborations with K-12 schools and community colleges may be productive. The Working Group also recommended that PERLOC identify ongoing external collaborations and facilitate contact between members of the different collaborations (using online resources). In addition, a master website of all science education research groups around the world as well as a site containing a series of short descriptions of external collaboration models (including details of establishment) submitted by the PER community were also identified as online resources that might help foster more external collaborations by highlighting common interests and productive modes of collaboration.

Conclusions

Although our efforts extended somewhat beyond our original charge, the Working Group focused much of its efforts on identifying several specific recommendations for fostering collaboration both within the PER community (internal collaborations) and between the PER community and other education researchers (external collaborations). The general consensus of the Working Group was that the development and official endorsement of online IRB documents and other resources as well as the establishment of collaboration seed grants would be most valuable in facilitating PER collaborations and supporting junior singleton researchers. On the basis of Working Group discussions, it is clear that the formation of productive, ongoing collaborations will play a key role in ensuring the vitality and advancement of physics education research as a field of scholarly activity.

Acknowledgements

The authors, as facilitators of the Working Group, would like to thank all of the other members of the Group for their insights, initiative, substantive contributions, and incredible enthusiasm: Heather Dobbins, Noah Finkelstein, Kara Gray, Jeff Hawkins, Andrew Heckler, Joss Ives, Olivia Levrini, Beth Lindsey, David Meltzer, Chaya Nanavati, Amy Robertson, Mel Sabella, Homeyra Sadaghiani, and Rachel Scherr.

MacKenzie Stetzer is a Research Assistant Professor with the Physics Education Group in the Department of Physics at the University of Washington.

Michael Loverude is an Associate Professor of Physics at California State University, Fullerton.

Working Group Report: A Physics Education Research (PER) Textbook

Report Written by Sam McKagan

Participants: Jennifer Blue, Andrew Boudreaux, Dedra Demaree, Laird Kramer, Trevor Smith, Padraic Springuel, Sam McKagan, Keron Subero, John Thompson, Jessica Watkins, Saalih Allie, Alan VanHeuvelen and Lillian McDermott. Eugenia Etkina and Karen Cummings, Co-chairs.

Our assignment: As the field of Physics Education Research has grown, we have come to a place where we can at least outline topics and content for a textbook that might be used in a graduate level PER course. How do we create a viable and meaningful textbook that is of broad use? What should such a text contain? What audience will use it? Participants in this working group addressed these and other questions.

Audience: Our group identified several possible audiences for a PER textbook, including but not necessarily limited to the following:

1. Graduate students beginning a Ph.D. in PER
2. Teaching Assistants working in reformed courses
3. High school physics or physical science teachers who were trained in traditional programs and are now working on an education-oriented Master's Degree
4. Undergraduate and/or graduate students who want an introduction to the field (perhaps this could be combined with #1 above)
5. PER users (high school teachers and college faculty) who want to learn more

Various members of the group had personal interest in each of these audiences. We discussed whether one book would be appropriate for all, or whether each audience should have its own book. There was consensus that each audience has different needs, but disagreement over how to best cater to these needs. Some members felt that each audience should have an entirely separate book, while other members felt that there should be one book with different access points or sections directed toward different audiences. Some members thought that some of these audiences needed a book more than others, but there was not consensus on which audiences were most important to address. In order to make progress, we agreed to focus the working group on determining content appropriate for graduate students beginning a Ph.D. in PER.

Format: Because our field is changing rapidly and there are many

different audiences with different needs for accessing information about PER, there was consensus that a print textbook would not be adequate. We agreed that the best format would be a web-based wiki that could easily be updated and edited by different members of the PER community, but that would be easily converted to pdf so that paper copies could be made. The group felt that an accompanying workbook would be an advantage, allowing students to engage in directed data analysis, interpretation of student responses, coding and other important skill development activities.

Content: In our discussion of content we again focused on graduate students beginning a Ph.D. in PER with the understanding that the content would probably need to be altered for different audiences. We discussed several possible titles and found that the one that best captured our aims was *Introduction to PER: Asking and answering questions in the physics classroom*. We came up with the following list of possible chapters:

A) Introduction/Overview -What is PER? Compare and contrast PER with thoughtful, reflective teaching.

B) The history of PER.

C) What do we know about how student learn? Seminal works in PER, important aspects of cognitive science, brain research, educational psychology and so on.

D) Research perspectives including example and/or important theoretical frameworks.

E) Qualitative and quantitative methods used in PER including example assessment instruments. (This would be more than just one chapter).

F) What are answerable questions? Developing a research question, examples and ranges of research projects.

G) Developing curriculum based on research.

H) PER in the context of other STEM-specific educational research fields. Also PER's connection to other fields including communication and institutional change. Political and implementation issues for PER researchers and users.

I) What are the big questions now? Why are some questions hard to answer?

Process: The working group also agreed that there should be an editorial board for the book. The editorial board should be supervised and selected by PERLOC–the Physics Education Research Leadership Organizing Council of the PER Topical Group of the American Association of Physics Teachers. PERLOC (via a volunteer who is interested in taking the lead on this project) should seek funding for stipends for the editorial board. It was noted that Sam McKagan has already acquired partial funding for the PER User's Guide, a project along these lines focused on the PER user audience listed above. If another volunteer wanted to take the lead, this project could be extended to include the other audiences as well.

Sam McKagan is a physics education research consultant in Seattle and is the editor of the PER User's Guide. She received her doctorate from the University of Washington for research on Bose Einstein Condensation and did postdoctoral work on quantum mechanics education research at the University of Colorado.

The Value of My Masters of Education (M.Ed.) degree

Amber Stuver

My first year in graduate school in a terminal Ph.D. program wasn't pleasant for me (and I have met few people who felt differently about their first year). Between a demanding course load and TA responsibilities, I felt overwhelmed. But while many of my classmates complained about their TA responsibilities taking time away from their class work, I found that TA'ing was the one thing that helped me get through my first year. Being able to help someone learn something was very rewarding to me. I loved the moments when a student who was having great difficulty with a concept had their "Aha!" moment. I also discovered that this moment couldn't be faked no matter how much the student wanted to give up and go home. Moments like these made me discover the teacher within myself.

By the end of my first year, I had found in the graduate catalog that my physics department offered a Master of Education (M.Ed.) degree. I decided to pursue it since I wanted to become a better teacher and I was willing to do the additional work of the educational courses (and I already had most of the required physics course work done) and a thesis. I then notified my department that I wished to earn the M.Ed. and was greeted with a response along the lines of, "We don't have an M.Ed. option." I had to show the office staff that it was offered in the catalog. This is not a slight against my graduate program in any way, it is merely the indication that it had been so long since any graduate student pursued this that it fell out of recent memory. Of course, the staff then agreed to my pursuing the M.Ed. and did everything in their power to support me. But that's when I started thinking… I want to be an educator in higher education. Why does the profession think that TA experience is all I need to become a good teacher? Why has no one else done this in my department?

I was initially worried about taking graduate education classes since I had never taken an education class at the undergraduate level. To my pleasant surprise, the professor was receptive to my opinions and my classmates came from a variety of backgrounds. I learned the core theories behind how people learn and how curricula are designed. I read more than I had for any other class and wrote (what felt like) even more. I thoroughly enjoyed my education classes and they not only added a little variety to the mathematical rigor of the physics curriculum, but they also gave me the breadth I needed to see it as a whole in a new way.

After completion of the M.Ed., several other graduate students

who were in the same physics program opted to earn their M.Ed. as well. I was happy that not only had I reminded the department of this option, but that other people were doing this now too.

My M.Ed. has been invaluable to me as it distinguished me from my peers as someone who put effort behind becoming a better educator. As a graduate student, when unique teaching opportunities became available, I was usually on the short list of people recommended to fill the position. When I was looking for my first professional position after earning my Ph.D., I believe my M.Ed. made me stand out from other applicants. I am currently a Caltech postdoc who works remotely from the LIGO Livingston Observatory in Louisiana; I spend about 60% of the time performing traditional gravitational wave research and the other 40% working with the LIGO Science Education Center (SEC). With the SEC staff, I work with visiting students giving them tours of the observatory and answering their (amazingly deep) questions; I help develop programs for pre-service and in-service teachers; I interact with the public at open houses; I contribute training to docents to understand our exhibits so that they can help visitors understand as well; I participate in educational research. While I am not privy to the ultimate reasons for my hire, I am confident that my M.Ed. contributed. And since I can't be a postdoc forever, I am sure the M.Ed. and all of the experiences it opened up to me will help me in the future as well.

So my question to the physics profession is, why aren't more graduate students pursuing formal education training? I am not suggesting that all graduate students should be earning education degrees or that you need to have this training to be an outstanding educator. I am also not declaring that the M.Ed. is the only option for graduate students to become better educators and to distinguish themselves as such—there are other amazing programs like the GK12 program or recognitions offered by graduate schools that require training in education. But with 56% [1] of Ph.D. graduates in the classes of 2005 & 2006 ultimately seeking employment in academia, why do so few students earn M.Ed.s? Perhaps these degrees are not offered by many departments. If that's so, why not? If the degree is offered, advertise it! For me, the physics department had already done the bulk of the work by instructing me in the first year courses which I largely used to satisfy the degree requirements.

I will be glad if the day comes that the M.Ed. no longer sets you apart from your peers because there are so many professors (and other physics professionals) out there with formal education training. I can't help but think that the quality of the physics education being offered to that generation will be improved and a service to the profession as a whole will have been done.

1. P. Mulvey, and C. Tesfaye, "Initial Employment Survey of Physics PhDs, classes of 2005 & 2006" (Figure 6), AIP Statistical Research Center.

   URL: http://www.aip.org/statistics/trends/highlite/emp3/emphigh.htm

Amber Stuver (stuver@ligo-la.caltech.edu) is the FGSA Councilor and a postdoctoral scholar for Caltech at the LIGO Livingston Observatory.

Physics Teacher Education Coalition

Section on Teacher Preparation

From the Editor of the Teacher Preparation Section

John Stewart

This edition of the teacher preparation section features two electronic resources. In the first article, Dean Zollman will describe the Pathway Project, an innovative internet-based tool for delivering targeted teaching advice when it is needed. The Pathway website features an extensive database of videos of experienced teachers offering advice on the presentation of specific physics topics. These articles are indexed through an innovative natural-language search engine which allows a novice teacher to visit the site, type a question, and get help from an expert. In the second article, in my role as editor of PTEC.org, I will describe this extensive electronic resource for institutions dedicated to improving physics teacher preparation. PTEC.org is part of ComPADRE, the National Science Digital Library (NSDL) collection for physics and astronomy education. In the Fall 2007 Edition of this newsletter, editors of other ComPADRE collections described their sites. PTEC.org was recently redesigned and this is an excellent time to reintroduce its features. Before proceeding to the articles, two announcements of interest to the teacher preparation community: first the Physics Teacher Education Coalition conference to be held in Washington D.C. in February, and second a solicitation from PhysTEC for new PhysTEC sites.

The Physics Teacher Education Coalition (PTEC) annual meeting will be in Washington D.C. immediately preceding the joint APS "April" Meeting, AAPT Winter Meeting, the National Society of Black Physicists Meeting, and the National Society of Hispanic Physicists Meeting. The PTEC meeting will be held on *February 12-13, 2010.* The theme of the meeting is "Diversity in Physics Education: Preparing Teachers for the 21st Century". The conference will feature workshops on diversity in teacher recruitment, preparing teachers for urban schools, closing the achievement gap, funding teacher education programs, collaborating across the sciences, and teaching pedagogical knowledge. The National Task Force on Teacher Education in Physics will release its report at the meeting; its findings will be presented in a plenary session. Registration is $75 for PTEC members; $250 for nonmembers. Registration will open in early November. For more information

on the conference visit www.PTEC.org; for information on PTEC membership and how to join visit www.PTEC.org/join.

The PhysTEC project requests proposals for new PhysTEC sites to develop model physics teacher preparation programs, to begin in the 2010-2011 academic year. Proposals are solicited for two types of sites:

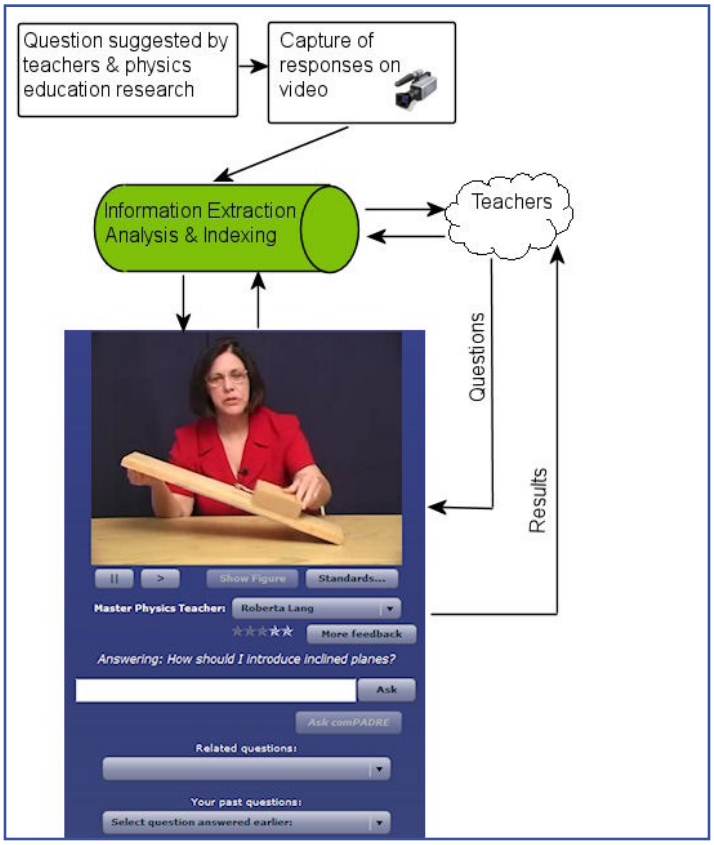
- **Comprehensive sites**, which will receive up to $100k per year for three years. These sites will implement the full PhysTEC program.
- **Pilot sites**, which will receive up to $25k per year for three years to implement specific elements of teacher preparation programs.

Institutions wishing to apply must submit a letter of interest by **November 2nd 2009**. Download the application guidelines at the PhysTEC website. Only PTEC members may apply; membership in PTEC is free. Visit the link in the previous paragraph to join. As the Co-PI of the University of Arkansas' PhysTEC site, I can attest to the transformative power of being a PhysTEC site. The connections built during the project with local school districts and with the College of Education have lived on beyond the project and have lead to further funded educational initiatives. Highly-qualified PhysTEC teachers are in classroom across Arkansas.

Physics Teaching Web Advisory (Pathway): A Tool for 24-7 Pedagogical Assistance for Teachers of Physics

Dean Zollman

Often a physics teacher, particularly one who is new to teaching physics, just needs an experienced colleague to answer a question about teaching, a particular physics topic, or give advice on a good demonstration; maybe the teacher just needs a video clip to illustrate a concept. The Physics Teaching Web Advisory (Pathway) is a state-of-the-art, Web-based digital video database that is providing just this kind of assistance.



To create a Synthetic Interview we record on video a large number of responses to questions that teachers might ask. We then match each response to many variations of such questions. Using a sophisticated algorithm in which the order of words can be as important as the words themselves, we match our responses to the questions entered by the user.

Pathway is a growing digital library for physics teaching. More than a collection of materials, Pathway combines Carnegie Mellon University's digital video library technology with pedagogical advances based on physics education research and with materials contributed by teachers. Pathway builds on a unique collaboration between several longstanding research projects in digital video libraries: advanced distance learning technologies, collaboration technologies and nationally known experts in physics pedagogy and high quality content.

Pathway's primary target audience is teachers who are relatively new to the teaching of physics. They may have some physics background but have not studied the pedagogy of physics or the research on which that pedagogy is based. Because they are busy teachers, they frequently need information on a short time scale – perhaps for tomorrow's class. They need pedagogical information quickly and at a time and place of their choosing; thus, a Web-based conversation with one or more experienced teachers could be a significant help.

Pathway's software foundation is the Informedia Digital Video Library which has been developed at Carnegie Mellon University. It focuses specifically on information extraction from broadcast television video and audio content. It operates similarly to a Web search engine, but does so by searching on video and audio information. Unlike YouTube which searches only on keywords provided by the contributor, Informedia has automated the creation of a rich, indexed, searchable multimedia information resource through speech, image, and natural language processing. Using this state-of-the-art technology, we have created two components of Pathway–a Synthetic Interview and collection of digital video learning materials.

Synthetic Interviews

An early popular Internet application was the chat room which has now been extended through applications such as Twitter and Instant/Text Messaging. During the infancy of the Internet, pundits predicted democratization of expertise and knowledge. Email and chat rooms would usher in this new age by providing a forum where anyone could ask any question of world-class experts. An error in this reasoning is that in any specialty, the number of experts is very small when compared to the general population. Experts do not scale, and cannot spend all their time answering questions.

Roberta Lang describes how she introduces torque.

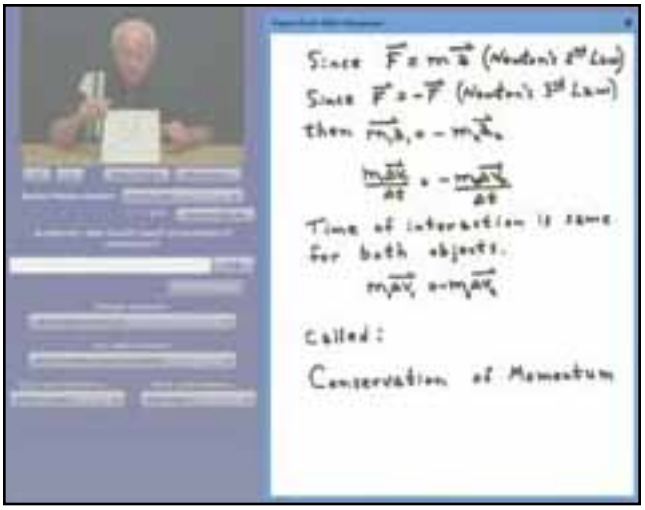
A variation to convey information is a linear interview which can contain a surprising amount of knowledge. But simply watching such a presentation in which someone else is asking the questions

is seldom an effective tool for transferring information, especially to someone who needs to know specific content "just-in-time." The Synthetic Interview addresses the passive nature of the interview by creating an anthropomorphic interface into multimedia video data of a person responding to questions (interacting with another person). However, the responses of the interviewee are presented in such a way as to simulate the experience of the user interacting with the expert.

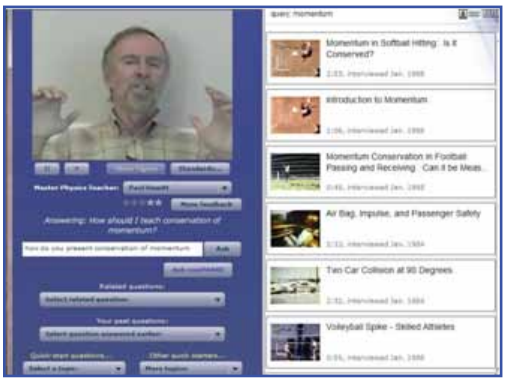
A conversation must enable the user to present the expert with questions as complete sentences, not a list of keywords. Processing of such open-ended user questions is a challenging task. However, it is a tractable task because full processing and "comprehension" of the input is not required. Instead, mapping to functional meaning categories with appropriate responses is sufficient. Synthetic Interview technology employs both structural and statistical processing algorithms to perform its categorization.

Using this technology, Pathway provides teachers a way to "converse" about the teaching of physics with four experienced physics teachers–Paul G. Hewitt, a well-known author of both high school and college physics texts; Charles and Roberta Lang, two experienced and distinguished high school physics teachers; and Leroy Salary, an Associate Professor at Norfolk State University. Together they provide a wide range of experience and advice to the physics teacher.

The Pathway Synthetic Interview database has 6,687 questions, with more than 454,000 utterances (variations), and 20,158 unique question/answer pairs. 3,569 of the questions are directly associated with National Science Education Standards. Teachers pose a question and select the experienced teacher whom they wish to ask. The software matches the question to a recorded response and plays that response. The respondent is sometimes a talking head, but also can show demonstrations, graphs, charts and equations.



Charles Lang explains how he goes from Newton's Laws to Conservation of Momentum. In keeping with the idea that he is having a conversation with the user, the equations are handwritten, as if he wrote them as he was talking.



A mock-up of how the screen will look when the Synthetic Interview and the Digital Video Library communicate via software. Above Paul Hewitt discusses how to introduce conservation of momentum while on the right are video examples that can be used in class.

Because many of the teachers are new to physics teaching, we recognized that they could need help determining what they need to ask. Thus, for each major topic, we have a list of "Quick Questions" which can be selected from a pull-down menu. Likewise, once a question has been asked, the teacher can obtain more information on the same topic by selecting from a list of "Related Questions." With these questions or just by entering another question, the teacher can continue this virtual conversation with the experienced teacher, or decide that he or she wishes to hear another person's view on the original question posed.

Digital Video Library

The Pathway Digital Video Library contains a large number of video clips that have been created during the past 20 years for physics instruction. The materials in the library are a database of video information which can be searched in somewhat standard ways. They are selected to satisfy a wide range of teaching needs, including demonstrations of physical phenomena, virtual labs, measurement from video scenes, and tips on the teaching of physics. Thus, they can provide background information, examples of teaching and video clips which can be used directly in class. The development of the library has lagged a little behind the Synthetic Interviews (and needed to be redesigned and re-thought in light of video sharing on the Web). The most recent version has just been deployed. When it is fully capable, the user will see the experienced teacher who is discussing the pedagogy of a topic on one side of the screen while thumbnails of videos related to that topic appear on the other side. A mock-up of how the user's screen might appear is shown here.

Evaluation

At this time, the evaluation of Pathway has primarily been a combination of Contextual Inquiry and Heuristic Evaluation at workshops and at professional meetings, feedback from individual users, and the beginnings of an analysis of the questions which teachers ask of the system. Users of the system continue to have very positive comments, especially noting the effectiveness of searches. Teachers who are relatively new to physics teaching have found the natural language "interviews" useful. Ongoing analysis of the questions posed by users shows that almost three-quarters of all questions relate to issues of physics pedagogy. This result

indicates the inexperienced teacher is much more interested in and concerned about the methods of teaching rather than the physics subject matter.

Most of the development work on Pathway is nearing completion. If you find the concept interesting, you could help us in two ways:

- We are looking for teachers who would like to help us evaluate the project. Please send them our way. Or, if you night be able to use Pathway in a course or a teacher workshop, let us know.
- We wish to expand the video selections in the Digital Library. If you know of some appropriate videos, have made some yourself or seen some on YouTube, let us know.

My collaborators on Pathway are Brian Adrian, Sytil Murphy and Chris Nakamura at Kansas State University and Scott Stevens, Michael Christel and Bryan Maher at Carnegie-Mellon University. Pathway is supported by the National Science Foundation under grant numbers ESI-0455772 & ESI-0455813 with earlier proof of concept grants DUE-0226157, DUE-0226219.

To visit Pathway go to www.physicspathway.org. Question or comments can be sent to dzollman@phys.ksu.edu.

Dean Zollman is William and Joan Porter Professor and Head of the Department of Physics at Kansas State University.

PTEC.org – The Internet Home of the PTEC Organization

John Stewart

The Physics Teacher Education Coalition (PTEC) is an organization of 140 colleges and universities dedicated to improving physics and physical science teacher preparation, funded by the PhysTEC project. PTEC.org is the internet home or the PTEC organization and the home of the National Science Digital Library (NSDL) collection on physics and physical science teacher preparation, a ComPADRE collection. By the time of publication of this newsletter, the new PTEC.org interface will be released as shown below.

The PTEC Conference: To support PTEC.org, the website provides information about and allows registration for the annual PTEC conference. This conference is an exceptional event which allows experts on teacher preparation to share their experience through a series of workshops. Information about the conference is available at the PTEC.org website. Further, PTEC.org houses all conference proceeding from the PTEC conference. These materials are concise descriptions of various elements of successful teacher preparation programs.

The PTEC Organization: The PTEC organization features 140 institutions of higher learning dedicated to improving the quality and increasing the quantity of highly-qualified science teachers. Each member of PTEC contributes a description of their program to the site. Membership in PTEC is free and interested institutions can join at the PTEC.org website. Members received reduced rates at PTEC conferences and workshops. PTEC is also an excellent avenue to disseminate results of funded projects. Dissemination can occur either through links on the PTEC member pages or through materials directly contributed to PTEC.org.

Each month, a PTEC member institution is featured on the homepage. The featured members are drawn from programs that demonstate excellence in teacher preparation. If possible, an article that describes some innovative or particularly successful element of their program is used to illustrate the featured member.

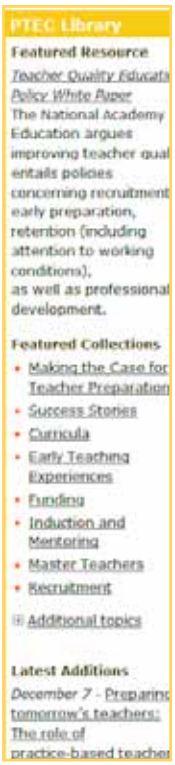
The PTEC Library: PTEC.org is also the home of the NSDL collection on physics and physical science teacher preparation. The library currently contains 400 materials including peer-reviewed articles, conference proceedings, reports, newspaper articles, recruiting materials, and even previous versions of this newsletter. All articles are about topics related to teacher preparation. Each article is tagged with extensive bibliographical data. The site contains extensive search features; searches may be restricted to PTEC.org or extended to all of ComPADRE.

Featured Collections: PTEC materials are organized into col-

lections for easy use. These collections cover many topics of interest in the improvement of teacher preparation programs or the initiation of a new program. For example, currently featured within the "Funding" collection is an article by NSF program officer Joan Prival about the new Noyce solicitation and an article by Michael Marder about fundraising for the U-Teach project. Featured collections are not static and if you have a topic within teacher preparation that should become a collection within PTEC, suggest it by emailing me at johns@uark.edu.

Seeking new resources: While PTEC contains 400 entries on physics teacher preparation, there are a number of topics where new materials are desperately needed. The library has excellent coverage of academic articles on physics teacher preparation, successful physics teacher preparation programs, funding opportunities, recent conference proceedings on the topic, as well as numerous reports on the need for improved teacher preparation. More material is needed on preparing students for high needs environments, recruiting a more diverse teaching pool, forming and managing partnerships with school districts and with other institutions of higher learning. Additional models for successful mentoring programs, particularly in high-needs schools, and models for early field experience would also be useful.

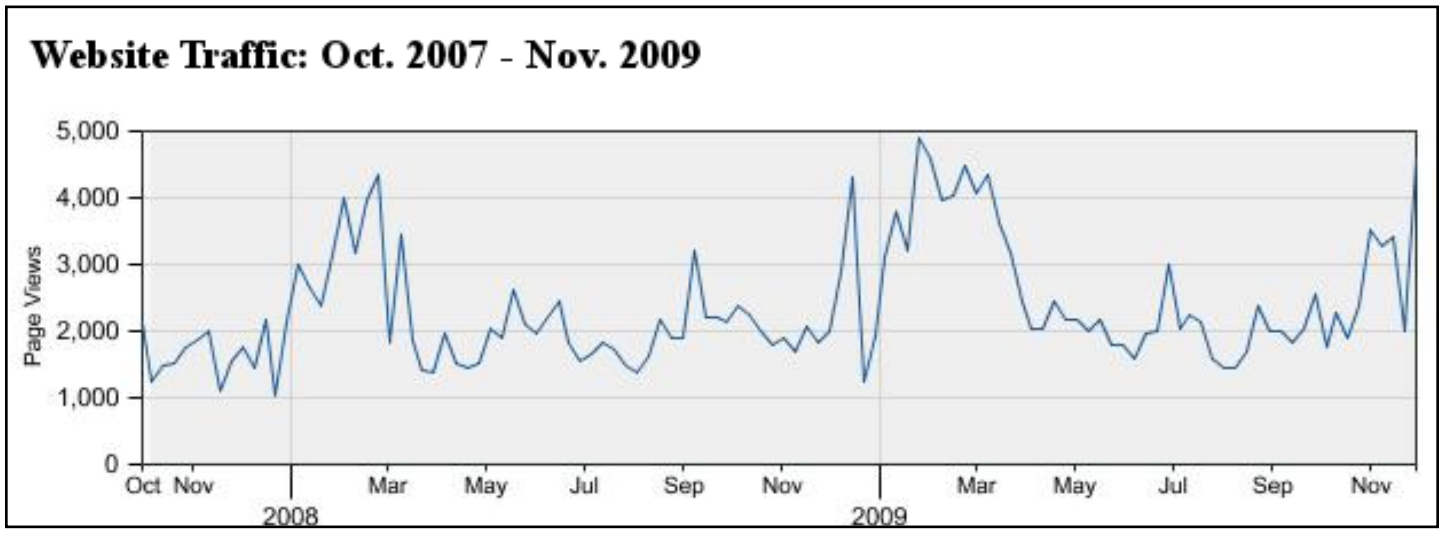
PTEC hosts many academic publications but other types of materials are also desired. Descriptions of successful mentoring, induction, or partnership programs drawn from annual reports of funded projects would be appreciated. Recruiting brochures, syllabi, course descriptions, and course materials relating to physics teacher preparation would be welcome. PTEC seeks to be the location on the internet where people passionate about physics teacher preparation go to find and share information.



To submit materials, one must first create an account at PTEC.org. Accounts are free and require only an email address. Once an account is created, click on "suggest a resource" to either upload or link to the material you wish to share.

Once uploaded or linked, your material will reach a large audience. PTEC.org is the number one hit on Google for the search string "Physics Teacher Preparation". The site received 120,000 page views in 2008 and the number of visitors continues to grown as shown below.

John Stewart is an Assistant Professor of Physics at the University of Arkansas. He was CoPI of the Arkansas PhysTEC site, is Senior Staff on the Arkansas College Ready Math-Science Partnership, and is editor of PTEC.org.



Browsing the Journals

Carl E. Mungan

• In the October 2009 issue of *The Physics Teacher* (http://scitation.aip.org/tpt/), H.K. Wong points out on page 463 a flaw in a simple explanation of a unipolar motor (made of a battery, nail, rare-earth magnet, and wire) that I have often demonstrated in class. The torque which rotates the magnet cannot be due to the internal current flowing through the magnet. Instead it must arise from a reaction to the force that the magnet exerts on the wire near the point at which they touch each other.

• I enjoyed Jeremy Bernstein's biographical ruminations about Dirac (and other physicists of his era) on page 979 of the November 2009 issue of the *American Journal of Physics* (http://scitation.aip.org/ajp/).

• I find simple demonstrations of atmospheric buoyancy to be amusing and instructive. The November 2009 issue of *Physics Education* (http://www.iop.org/EJ/journal/PhysEd) discusses two. On page 668, a person stands on a scale while wearing a Santa suit that can be filled with air. Does the scale reading change noticeably? On page 569, a syringe (with its tip capped off) is placed on a sensitive balance. Does its measured weight depend on whether the plunger is pressed in or pulled out? In one case the answer is no and in the other the answer is yes. If you add a volume of air to an object, both the gravitational and buoyant forces increase by the same amount, unless the added air is at a substantially different pressure than the surrounding atmosphere. (Now you're ready to try the "alka-seltzer in a latex glove demo" at http://stokes.byu.edu/alkaseltzer.html that Harold Stokes presented at an AAPT meeting a few years ago.)

• A couple of papers caught my eye in the most recent two issues of the *European Journal of Physics* (http://www.iop.org/EJ/journal/EJP). On page 1173 for September 2009, Agrawal discusses a simplified version of the Curzon-Ahlborn (CA) engine. Unlike a Carnot device which optimizes the efficiency but at the expense of infinitely slow operation, a CA engine maximizes the rate at which work is output. Secondly, using a numerical wind-tunnel model on page 1365 of the November issue, a Spanish pair of applied physicists show that bicyclists traveling as a tight group benefit not only the behind riders (by drafting) but even the cyclist at the front of the pack!

• A pair of Russian researchers present a detailed vector kinematics solution to the dog-and-rabbit chase problem starting on page 539 of the September 2009 issue of the *Latin-American Journal of Physics Education* (http://www.journal.lapen.org.mx/).

• A brief overview of photoacoustic spectroscopy of nanomaterials can be found on page 1238 of the October 2009 issue of the *Journal of Chemical Education* (http://jchemed.chem.wisc.edu). This technique is particularly appropriate for materials that scatter light too much to be easily studied by conventional absorption spectroscopy. The idea is to place a sample in an air-tight chamber, hit it with a chopped laser so that the sample and hence the surrounding air is periodically heated, and measure the resulting pressure oscillations with a microphone.

Carl Mungan is an Associate Professor of Physics at the U.S. Naval Academy in Annapolis, MD.

Web Watch

Carl E. Mungan

• The University of Nottingham has a series of sixty videos at http://www.sixtysymbols.com/ built around various symbols denoting key concepts in physics and astronomy. (To be fair, they invented a few nonstandard symbols, such as a sillouette of a drinking bird, in contrast to traditional symbols such as physical constants, the planets, and so on.) I think the coefficient of restitution demonstration (symbol "r" near the end of the list) of tiny balls bouncing between compartments on a vibrating platform is pretty nifty.

• There has been lots of positive buzz about the seven videos of Feynman's Messenger lectures (delivered at Cornell University in 1964) on Microsoft's Project Tuva site at http://research.microsoft.com/apps/tools/tuva/index.html.

• Speaking of videos, there are a set of interesting chemistry and physics movies filmed in a Singapore enrichment classroom (with students present) at http://www.plsingapore.com/video.htm. The one demonstrating that a helium balloon sinks when it's placed inside a helium bag caught my eye, although aspects of it did not look totally safe. Use your own judgment if you decide to repeat those aspects!

• There are also plenty of good textbooks appearing (for free!) on the web these days. For example, I learned a lot even from the first few pages of Tatum's *Celestial Mechanics* at http://orca.phys.uvic.ca/~tatum/celmechs.html. For the intro physics course, you would probably want to take a look at the Light and Matter series at http://www.lightandmatter.com/. Looking for an advanced text for mechanics? Try Sussman and Wisdom's book at http://mitpress.mit.edu/SICM/book.html. Need a reference handbook of advanced math functions? It's hard to beat Abramowitz and Stegun for comprehensiveness at http://www.math.ucla.edu/~cbm/aands/.

• Do you have a question about how physics explains everyday phenomena? Well, Louis Bloomfield claims he can explain how everything works at http://www.howeverythingworks.org/. I'll leave it to you to try and stump him, if you can!

• John Denker has a very extensive web site about how airplanes fly at http://www.av8n.com/how/. It includes not only the usual discussion of various common fallacies about wings, but plenty of practical physics for real pilots.

• Lately I've enjoyed perusing some of the articles on the I*nside Higher Ed* website at http://www.insidehighered.com/. Also check out *BlueSci* at http://www.bluesci.org/ which is a science magazine written by Cambridge University students.

• The Nobel prizes were announced recently. A complete description of the physics prizes in chronological order can be found at http://nobelprize.org/nobel_prizes/physics/laureates/.

Carl Mungan is an Associate Professor of Physics at the U.S. Naval Academy in Annapolis, MD.

Executive Committee of the Forum on Education

Chair: Peter Collings
(04/09-03/10)
Swarthmore College

Chair-Elect: Lawrence Woolf
(04/09-03/10)
General Atomics
(Chair of the Program Committee)

Vice Chair: Chandralekha Singh
(04/09-03/10)
University of Pittsburgh
(Chair of the Nominating Committee)

Past Chair: Ernest Malamud
(04/09-03/10)
University of Nevada, Reno
(Chair of the Fellowship Committee)

Sec/Treas: Bruce Mason
(04/08-03/11)
University of Oklahoma
(Website Administrator)

Forum Councilor
Gay Stewart
(01/09-12/12)
University of Arkansas

General Members-at-Large:
Olivia Castellini
(04/07-03/10)
Museum of Science and Industry, Chicago

John Thompson
(04/08-03/11)
University of Maine

Laird Kramer
(04/09-03/12)
Florida International University

APS/AAPT Members-at-Large:
G. Samuel Lightner
(04/07-03/10)
Westminster College

Stamatis Vokos
(04/08-03/11)
Seattle Pacific University

Amber Stuver
(04/09-03/12)
California Institute of Technology

Non-voting Members:
Chair, Committee on Education
Peter Collings
Swarthmore College

APS Liaison
Ted Hodapp
APS Director of Education & Diversity

AAPT Representative
Lila M. Adair, AAPT Past President
Piedmont College

AIP Representative
Jack Hehn, AIP Director of Education

Newsletter Editors:

Spring, 2010: Amber Stuver, CalTech
Deadline: November 15, 2009

Summer, 2010: Carl Mungan,
U. S. Naval Academy
Deadline: June 1, 2010