APS physics
Forum on Education
American Physical Society

Spring 2012 Newsletter

Paul J. Dolan, Jr., Editor

IN THIS ISSUE:

From the Chair

Chandralekha Singh

Now that my term as the FEd chair is coming to an end, I would like to take this opportunity to thank all of the FEd executive committee members for their help. I am very grateful to Renee Diehl, the chair of the FEd program committee for the APS March and April meetings. The program committee that she chaired has organized excellent invited sessions sponsored or co-sponsored by the FEd for the March and April meetings on graduate, undergraduate and K-12 education and outreach. I would like to thank Paul Cottle, the chair of the FEd nominating committee, and his team for coming up with an excellent slate of candidates for vice-chair and the two members-at-large. I would also like to thank Larry Woolf, the FEd past chair, who was also the chair of the fellowship committee for all his help and support this last year. The FEd secretary/treasurer Scott Franklin deserves a very special thanks for performing his duties extremely well, even though it was his first year on the task. I also sincerely thank Nic Rady (Summer 2011), Andrew Elby and Rachel Scherr (Fall 2011) and Paul Dolan (Spring 2012) for volunteering as Editors of the FEd newsletters. If you would like to edit a FEd newsletter, please contact me.

As I mentioned in the Fall newsletter, I encourage you to consider those who should be nominated for the APS Excellence in Physics Education Award. This award recognizes and honors a team or group of individuals (such as a collaboration), or an exceptional individual, who has exhibited a sustained commitment to excellence in physics education. More information about the award can be found at http://www.aps.org/programs/honors/awards/education.cfm. The deadline for nominations for this award is July 1. I also want to remind you of a new award by the APS Committee on Education (APS COE). This new COE Award for Improving Undergraduate Physics Education recognizes best practices in undergraduate physics education. More information about this award can be found at http://www.aps.org/programs/education/undergrad/faculty/award.cfm. The deadline for nomination for this award is July 15 each year. In addition to the above awards, please consider nominating individuals who have made lasting contributions to physics education for APS Fellowship through the FEd. The deadline for APS FEd Fellowship nominations is April 1 each year. The individuals nominated must be FEd members. Each FEd nomination is evaluated by the FEd Fellowship committee.

The Editor for the next Summer newsletter is Nic Rady. Please consider writing an article for this newsletter and email it to Nic at nhrplh@gmail.com. Finally, if you have any suggestions related to FEd activities, please let me know.

Chandralekha Singh is a Professor in the Department of Physics and Astronomy at the University of Pittsburgh. She is Chair of the APS Forum on Education. She is also the Chair of the editorial board of the Physical Review Special Topics: Physics Education Research.

From The Editor: Who is NOT learning Physics?

Paul Dolan

I had the (unplanned) opportunity recently to spend a few days in the local hospital. (I'm much better now, thank you.) Two somewhat related things struck me while I was there.

Almost without fail, the doctors, nurses and other personnel who knew that I was a physics professor had some bad memories of having taken physics. They did not like the course, they did not do well, and reading between the lines, I infer that they feel they did not learn much in the course. (One of my nurses indicated that physics was the ONLY grade of D she had in at otherwise quite good college record.) Certainly, this is not a new observation, but it is unfortunate that this 'bad taste' of physics with non-physicists, especially in science-heavy professions, is still so prevalent.

The other item is in fact how much physics WAS involved in my diagnosis, treatment and care. One can list the wide variety of non-chemical diagnostic tools that one encounters in a medical center: MRI (that is NMR), various types of X-Ray Imaging, and Doppler Ultrasound Imaging, not to speak of simple optical imaging and various types of 'scopes' to peer where one would not normally see. My problem is one deeply set in fluid dynamics, and in fact a small piece of NiTiNol wire was involved at one point, bringing in some condensed matter/materials physics.

I actually found the staff overall to be quite knowledgeable and capable. But, we need to remember ALL of our audience – not just the physics majors. What can we do to make their physics courses more palatable and more pertinent (without being simply made 'easier')? Do we need to include more useful & interesting applications in our courses, as some texts are now doing? Or do we ourselves need to be more broadly knowledgeable, so that we can invoke those applications that seem to be pertinent to a particular audience?

I have actually come home with a few interesting tidbits that I'll be sharing with my classes, both for my physics majors and for my general education students. I hope this information will make some of what they learn this term more pertinent. I encourage you to find your own interesting bits, with whatever 'adventures' you may have, and share these with your students (and perhaps here in a future FEd Newsletter).

Paul Dolan is Professor of Physics at Northeastern Illinois University in Chicago, and also teaches in the MSTQE, "Middle School Teacher Quality Enhancement" pre-service teacher program. He may be contact at P-Dolan@neiu.edu.

About the Forum on Education Sessions at April APS Meeting 2012

Renee Diehl

The Forum has a wide range of exciting sessions planned for the March and April 2012 APS meetings, to be held in Boston and Atlanta, respectively. Highlights of the March meeting sessions were reviewed in the Fall Newsletter. Here, we review some of highlights of the April meeting sessions. As usual, these sessions promise something of interest for everyone.

Supply and Demand of High School Physics Teachers

This invited session will kick off with an overview of the problem with teacher supply from an economist's perspective. Tim Sass, an Economics professor at Georgia State University, will speak about his research on teacher labor supply, the measurement of teacher quality, and school choice. Susan White of the American Institute of Physics Statistical Research Center will give a statistical perspective on physics in US high schools, and Monica Plisch from APS will speak about the PhysTEC project, which aims to improve and promote the education of future physics teachers.

The Role of Physics Departments in Preparing Instructors of Physics

David Haase from North Carolina State University will present a summary of the recent Report on the National Task Force on Teacher Preparation, and an analysis of how well we build the foundation of physics as a discipline. Simon Knapen and Michael Manhart, from Rutgers University, will speak about their work to prepare physics Ph.D. students as instructors. And finally, Rachel Scherr from Seattle Pacific University will present her experience in preparing learning assistants.

Research in Cosmology Education

In collaboration with the Division of Astrophysics, the Forum will present a session on research in cosmology education. This session will be kicked off by Kim Coble from Chicago State University, with a talk on her work to create an immersive web-based curriculum in cosmology. Janelle Bailey from University of Nevada, Las Vegas will speak about her research on students' ideas about cosmological concepts, and the session will be wrapped up by Ed Prather, from University of Arizona, speaking about his research into a lecture-tutorial approach to addressing students' difficulties with learning cosmology.

Teaching and Learning Physics through ComPADRE

The Educational Technology Committee of AAPT is organizing this session on ComPADRE, which is a network of free online resources for faculty, teachers and students of physics and astronomy. The speakers are Wolfgang Christian, Ramon Torres-Isea and Taha Mzoughi, who will speak about ComPADRE resources for upper-level physics courses, advanced labs, and introductory courses, respectively.

Goals and Assessment of the Physics Graduate Program

The assessment of graduate physics programs is a rather new idea, and this session will outline ideas for how it can be accomplished. This session is being organized by the Graduate Education Committee of AAPT, and includes contributions from Kenneth Heller, Stefan Zollner and Harald Griesshammer.

Students as Colleagues: An Examination of Teacher-Student Collaboration in Improving Educational Environments

This session considers two programs that engage undergraduate and high school students as physics colleagues. The first invited talk by Badr Albanna and Joe Corbo will describe the Compass program at UC Berkeley, which offers comprehensive instruction and support to selected undergraduates.This talk will be followed by a panel discussion of the program, with panelists Gina Quan and Ana Aceves, undergraduate participants in the program. The second invited talk will be given by Kenneth Tobin, is about a program he has developed in a New York City high school, and will be followed by a panel discussion with participating high school students.

NOTE from the editor – there is also a session being organized by Peggy Norris celebrating the 100th Anniversary of Cosmic Ray Physics. This is a contributed paper session, and they are also hoping to have detectors and other items of interest on hand for the "celebration".

FEd Session Times for March 2012 Meeting, Boston, MA

Monday 2/27/12, 8:00-11:15 "Research Collaboration Between Mentors and Undergraduate Students"

Monday 2/27/12, 8:00-11:15 "Teaching quantum information science at liberal arts colleges"

Monday 2/27/12, 11:15-2:30 "Astronomy's Detectors and Physics Education"

Tuesday 2/28/12, 8:00-11:15 "Novel and Proven Methods of Communicating Science to the Public"

Tuesday 2/28/12, 11:15-2:30 "K-12 Science Education: Closing the gap with the leading nations"

Wednesday 2/29/12, 8:00-11:15 "Scientific Reasoning in a Physics Course"

Thursday 3/1/12, 8:00-11:15 "Entrepreneurship - the quest for start-up success based on research advances"

FEd Session Times for April 2012, Atlanta, GA

Saturday 3/31/12, 13:30-15:15 "Goals and Assessment of the Physics Graduate Program"

Saturday 3/31/12, 15:30-17:15 "Research in Cosmology Education"

Sunday 4/1/12, 8:30 – 10:15 "An Examination of Teacher-Student Collaboration in Improving Education Environments"

Sunday 4/1/12, 13:30-15:15 "Teaching and Learning Physics through ComPADRE"

Sunday 4/1/12, 15:30-17:15 "High School Physics Teachers: Supply and Demand"

Monday 4/2/12, 10:45-12:30 "The Role of Physics Departments in Preparing Instructors of Physics"

Notice of the Physics Research & Education Gordon Conference:

"Astronomy's Discoveries and Physics Education"

The biennial Gordon Research Conference on Physics Research and Education will be June 17-22, 2012 at Colby College in Waterville, ME. This year's topic is "Astronomy's Discoveries and Physics Education." Leading research astronomers will review major discoveries; AER and PER researchers will discuss challenges and opportunities of adapting these materials to the needs of physics instruction; physics professors from a variety of institutions will describe current uses of astronomy's discoveries and technologies as contexts for teaching undergraduate physics. Program and registration information are at
http://www.grc.org/programs.aspx?year=2012&program=physres.

A major goal of the conference is to inspire participants to produce astronomy based teaching materials that will induce physicists to use elements of astronomy as contexts for teaching physics. The remarkable discoveries and technologies of astronomy have produced a revolution in our view of the cosmos. Our students should know this new perspective and understand the physics that justifies it. (See *Am. J. Phys*. 80, 5-6 (2012).)

Thanks to generous contributors like the FEd there are some funds to help prospective participants attend. The organizers especially wish to attract to the conference graduate students, post-docs, and early-career and two-year college physics faculty. For further information contact cholbrow@mit.edu.

NOTES from the editor: Please don't be put off by the Gordon Conference Process of 'Applying for and Invitation' to attend – we expect that available space should be the only limitation (so apply early!).

There is additional information about using astronomy to teach physics at http://betterphysics.org.

ALPhA BFY (Beyond the First Year) Conference

Are you looking for lab-tested experiments for your intermediate and advanced laboratories? Not finding just what you need from the Advanced Lab section of Compadre (http://www.compadre.org/advlabs/)? Then the Conference on Laboratory Instruction Beyond the First Year (BFY) is tailor-made for you. The BFY Conference will be held at the University of Pennsylvania and Drexel University, July 25-27, 2012. This will be an unusual and excellent opportunity for hands-on exposure to a broad selection of contemporary instructional labs appropriate to Modern Physics, Electronics, Optics, and Advanced Lab courses, as well as to key instructional labs in Statistical Physics, Condensed Matter and Materials Physics, Quantum Mechanics, etc. Conference participants will share their laboratory expertise and materials in a variety of venues, including structured opportunities to discuss specific laboratory topics and curricular models that are effective at different types of institutions. Commercial vendors of advanced laboratory equipment will be present to provide working demonstrations of their products. More information can be found at http://www.advlab.org/.

A similar conference, the 2009 Topical Conference on Advanced Laboratories, sold out and received terrific reviews. Excellent invited speakers focused attention on different advanced topics, and a high degree of interaction between participants was facilitated through poster sessions, breakout sessions, and experiment workshops (where participants were guided through experiments of their choice, actually using the apparatus). The archives of this conference are available at http://www.compadre.org/advlabs/events/event.cfm?ID=2. Although these archives are very helpful, actual attendance at the conference helps participants to make contacts with fellow lab instructors with similar interests and complementary skills that can facilitate your development of experiments at your home institution. It is anticipated that the 2012 BFY Conference will sell out, so please register early! Please note that the Summer Meeting of the AAPT (July 28 – August 1, 2012) immediately follows the BFY Conference, and will feature additional workshops and sessions of interest to intermediate and advanced laboratory instructors.

APS Members Recognized by AAPT for Excellence in Physics Education

AAPT recognized physicists, Charles Holbrow (FEd), Brian Greene, and Kip Thorne with major awards during the 2012 Winter Meeting in Ontario, California. Holbrow was named as the 2012 Oersted Medal recipient, Greene was presented with the Richtmyer Memorial Lecture Award, and Thorne received the John David Jackson Excellence in Graduate Physics Education Award. All three awardees gave plenary talks in conjunction with the recognition. Designed to develop, improve, and promote best practices for physics education as part of the global need for qualified STEM teachers, AAPT meetings bring together an international cadre of emerging physics professionals, physics educators, physicists, policy makers, and industrial scientists who are dedicated to advancing the greater good through physics education. Learn more about the Winter Meeting and view the plenary talks at www.aapt.org/Conferences/wm2012/index.cfm

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Upcoming AAPT Meetings and Workshops

Built around the theme, *Physics: The Experimental Core*, the AAPT 2012 Summer Meeting will be held July 28-August 1 at the University of Pennsylvania in Philadelphia, Pennsylvania. AAPT Area Committees have developed a rich and diverse program of educational sessions, panel discussions, poster sessions, and plenary talks to meet the needs of students, researchers, and education professionals.

Highlights of the meeting include the presentation of the David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching, the Robert A. Milikan Medal, and the Klopsteg Memorial Award. Watch the AAPT website (www.aapt.org/Conferences/sm2012/) for announcement of these award winners.

The annual Apparatus Competition, established to recognize, reward, and publicize worthwhile contributions to physics teaching through demonstration and experiment, is held during the Summer Meeting. Whether developed to pique the interest of students, used in lecture and demonstration, or simply used to help teach physics in new or fascinating ways, teachers are continually engineering apparatus to aid physics instruction. The Apparatus Competition is where you can share your apparatus with others. For more information, please visit the competition web site at: www.aapt.org/Programs/contests/apparatus.cfm.

SPIN-UP Workshop, Austin, TX May 4-6, 2012

Do you want to grow your undergraduate physics program? AAPT, in cooperation with APS and AIP, and with support from the National Science Foundation invites faculty teams from physics departments to attend a May 4-6, 2012 workshop in Austin, Texas. The goal of the SPIN-UP Regional Workshop program is to enable physics departments in a wide variety of institutions to build the departmental infrastructure that will produce long-term improvements in undergraduate physics programs and to enhance both the number of students studying physics and the quality of student learning.

Each workshop invites teams of 2-3 faculty members, including the chair and/or the associate chair for undergraduate education, to work with an experienced group of physics faculty members, including representatives from departments that have recently seen large increases in the number of undergraduate majors. Each department will analyze its current situation and where they would like to be and then develop plans to implement sustainable change to meet the department's goals.

Participating departments will cover their own travel expenses in order to demonstrate a commitment to making real change. The NSF grant will provide support for hotel accommodations. Departments may apply for a limited number of travel support supplements as well. For the May, 2012 workshop, preference will be given to teams from colleges and universities in Texas and nearby states, but other teams will be accepted if space is available.

For more information go to the link http://www.aapt.org/Programs/projects/spinup/spinup-regional.cfm or contact Ruth Howes at rhowes@bsu.edu ; Phone: (505) 955-0836. Program details and registration information will be available beginning in mid-February 2012.

Biennial Physics Department Chairs Meeting, June 8-10, 2012
The American Association of Physics Teachers and the American Physical Society will be hosting the biennial Physics Department Chairs Meeting June 8-10, 2012 in College Park, MD. The meeting provides an opportunity for department chairs to learn about recent developments in physics education, research activities, and science funding and to talk with other department chairs about a broad spectrum of physics department issues. APS will organize an optional Congressional visit day on June 7. Program information and registration details will be available in February 2012. Information about previous Department Chairs meetings is available at http://www.aps.org/programs/education/conferences/chairs/.

Physics and Astronomy New Faculty Workshop, June 25-28, 2012
Physics and astronomy department chairs are invited to nominate members of their faculty who are in the first few years of their initial tenure-track appointments to attend the nineteenth Physics and Astronomy New Faculty Workshop, June 25-28, 2012 at the American Center for Physics in College Park, Maryland. This Workshop is sponsored by the American Association of Physics Teachers, the American Physical Society, and the American Astronomical Society and is funded by the National Science Foundation.

The Workshop will begin on Monday, June 25, at 1:30 pm and concludes at noon on Thursday, June 28. The program for the June 2012 workshop will be similar to the June 2011 program (see http://www.aapt.org/Events/newfaculty.cfm). A formal notice requesting nominations will be sent to physics and astronomy department chairs in mid-February.

Call for Nominations: Awards and Fellowships

Larry Woolf

APS Excellence in Physics Education Award
This award recognizes and honors a team, group of collaborating individuals, or exceptionally a single individual, who has exhibited a sustained commitment to excellence in physics education. The Award consists of $5,000, a certificate citing the achievements of the group or individual, and an allowance for travel expenses to the meeting where the award is presented and the awardees present a talk. The award is given annually. The application deadline is July 1, 2012. Please consider nominating outstanding candidates, including your own group. Details are at: http://www.aps.org/programs/honors/awards/education.cfm and at http://www.aps.org/units/fed/awards/education.cfm.

APS Fellowship through the Forum on Education
APS members are eligible for nomination and election to Fellowship. Each FEd nomination is first evaluated by the Fellowship committee of the FEd. After a subsequent review by the APS Fellowship Committee, the successful candidates are elected by APS Council. Fellowship is therefore a distinct honor signifying recognition by one's professional peers. The deadline to submit an application for fellowship nomination is April 2, 2012. Please consider nominating outstanding candidates. Application details are at http://www.aps.org/programs/honors/fellowships/nominations.cfm.

APS Committee on Education Award for Improving Undergraduate Physics Education
This new award, sponsored by the APS Committee on Education, goes to a department or program and recognizes best practices in undergraduate physics education. See http://www.aps.org/programs/education/undergrad/faculty/award.cfm for details. The deadline for nomination is July 15, 2012.

Larry Woolf, a physicist at General Atomics, is the Past Chair of the APS Forum on Education.

2011 APS Fellows Nominated by the Forum on Education

Larry Woolf

It is a pleasure to recognize and congratulate our members, shown below, who have recently been elected to APS Fellowship upon nomination by the Forum on Education for their significant contributions to physics education. (Brief Bios of each Fellow follow.)

Noah Finkelstein (University of Colorado, Boulder)
Citation: For advancing physics education research through studies of student learning in context and for extensive professional service at all levels from individual mentoring, to developing model programs, to national advocacy.

Chandralekha Singh (University of Pittsburgh)
Citation: For pioneering research extending the impact of physics education research to advanced topics, especially quantum mechanics, and for leadership in organizing physics education activities at the national level.

The APS is now accepting nominations for the 2012 class of APS Fellows.

The deadline for consideration by the FEd is April 2, 2012, and we encourage members to nominate outstanding candidates. Instructions for preparing nominations are available at:
http://www.aps.org/programs/honors/fellowships/nominations.cfm

The FEd Fellowship committee consisted of the following members:
Ruth Chabay, North Carolina State University
Peter Collings, Swarthmore College
Lynn Cominsky, Sonoma State University
Bruce Mason, University of Oklahoma
Lawrence Woolf, General Atomics, Chair

Larry Woolf, a physicist at General Atomics, is the Past Chair of the APS Forum on Education.

Noah Finkelstein received a Bachelor's degree in mathematics from Yale University and his PhD. for work in applied physics from Princeton University. He is currently an Associate Professor of Physics at the University of Colorado at Boulder and conducts research in physics education. He serves as a director of the Physics Education Research (PER) group at Colorado, one of the largest research groups in physics education. Finkelstein is PI or Co-PI on many nationally funded research grants to create and study conditions that support students' interest and ability in physics. These research projects range from the specifics of student learning to the departmental and institutional scales, and have resulted in over 80 publications. Finkelstein is also a co-PI and a Director of the Integrating STEM Education initiative (iSTEM), an NSF-i3 funded program to establish a national-scale Center for STEM Learning. He is also a key figure in the Colorado Learning Assistant program that is designed to transform undergraduate education and recruit and prepare the next generation of STEM teachers. Finkelstein is increasingly involved in policy, and in 2010, he testified before the US Congress on the state of STEM education at the undergraduate and graduate levels. Finkelstein has and continues to serve on many national boards in physics education, including: Inaugural Member (2006) and Vice-Chair (2008) of the Physics Education Research Leadership Organizing Council, and Chair (2011, 2012) of the Committee on Education of the American Physical Society. He is a member of the technical advisory board for the AAU's Initiative for Improving Undergraduate STEM Education 2011, and is very involved in APLU's efforts in the Science and Mathematics Teacher Imperative.

In 2007 he won the campus-wide teaching award; in 2009 he won the campus Diversity and Excellence award; and in 2010 he won the campus Graduate Advising Award.

More information on:
Noah: http://spot.colorado.edu/~finkelsnon
PER: http://per.colorado.edu
On the LA program: https://laprogram.colorado.edu/
On studies of transforming STEM : http://www.stemreform.org
On a Center for STEM education; http://www.colorado.edu/istem

Chandralekha Singh is a Professor in the Department of Physics and Astronomy at the University of Pittsburgh. She obtained her Ph.D. in theoretical condensed matter physics from the University of California Santa Barbara and was a postdoctoral fellow at the University of Illinois Urbana Champaign, before joining the faculty at University of Pittsburgh. She has been conducting research in physics education for more than a decade. She is a pioneer in conducting educational research related to the teaching and learning of quantum mechanics.

She has co-organized two physics education research conferences. She was the co-chair of the 2010 Gordon Conference on Physics Research and Education and was the guest co-editor of the May 2010 Gordon Conference theme issue of the *American Journal of Physics*. She co-organized the first conference which brought together physicists, chemists and engineers from various engineering departments to discuss the future of materials science and engineering education in 2008. She is currently Chair of the APS Forum on Education.

High School Physics, First or Last, Must Be Mathematical

Stewart E. Brekke

The language of physics is primarily mathematics. To teach a physics course to students without mathematics is not only deluding him/her, but also cheating that student out of the understanding of the true nature of the physical universe. Most teachers would not hurt their students in that manner–i.e., by teaching them something that is not true or half true. One reason physics first or physics last in high school must be mathematical is that the mathematical course enhances logical thinking and reasoning which transfers to all aspects of life. This type of thinking helps all kinds of students to deal with future academic work, but also with problem solving situations in their lives. The qualitative course does not have the power to develop rationality the way in which the mathematically based course does. Further many students are mentally disorganized and the mathematical course helps them to organize their thoughts. Literacy in science, especially in physics and chemistry, is not gained by memorizing definitions and concepts. Rather, it is the capability of doing physics with mathematically based problem solving, manipulating formulas, taking data and analyzing it quantitatively. One criterion for measuring physics literacy in a student is determining if that student can calculate the average speed of an object given the distance traveled and time elapsed. The language of physics is mathematics, and if we do not give the student the mathematical course, we are deluding that student with misinformation, making the student think that he knows a subject, physics, when he really does not. Certainly, knowing concepts and ideas of physics is essential, but also doing the mathematical portion, the main portion of physics, is a fundamental aspect of any physics course, physics first or physics last.

In my experience in teaching physics and chemistry to 'at risk' students in the inner city schools of Chicago, I have found that there are many students in the average high school, majority and minority, capable of doing mathematical problem solving high school physics, not just those in the upper 30%, provided the physics teacher makes an above average effort to teach scientific notation, units, and the single concept approach per class session, with drills and practices, including the algebra and trigonometry when needed. With the mathematical physics course, first or last, the lives of our high school physics will be enhanced. We cannot change their lives with a qualitative course, such as conceptual physics, which does not really provide a solid foundation for learning any science, such as chemistry or biology, nor prepare them for any worthwhile career, nor rational thinking in an increasingly technological world.

We therefore cannot leave an optional mathematical physics course for the senior year of high school. If the student takes the non-mathematical Physics First course and later does not take the mathematical algebra-trigonometry physics in his/her last years, he will probably be locked into a lower paying career since he will not readily master the standard mathematically based college chemistry and physics courses upon which careers in medical fields, engineering and the sciences are based. That student will probably have a lower paying job the rest of his/her life in a non-satisfying career. This is especially true for minority students who are often given non-mathematical physics and/or chemistry in high school depriving them of an opportunity to improve their economic status. A number of these minority and majority students try to take a real chemistry and/or physics course, mathematically based, in higher education only to find themselves lost and far behind the other majority and minority students who have had the mathematically based physics course in high school. Often, these intelligent majority and minority students have the mental ability to do a standard mathematically based physics and/or chemistry course, but do not have the problem solving skills to readily master a quantitative type physics and/or chemistry course, thereby thwarting their upward mobility in society through good paying scientific, technical or medical careers.

Placing physics first in the high school science curriculum is supposedly done to provide a solid scientific foundation for the understanding of high school chemistry and biology, since physics is the subject upon which all sciences are based. Often, in a course called "conceptual physics", given often as the Physics First course, very little or no mathematics is used. One real reason conceptual physics does not utilize much mathematics is that most high school students in the United States take basic algebra, the mathematics needed for the standard basic high school physics course, in the first year, usually at the same time they are taking Physics First, thus depriving the ninth grade physics student, it is often thought, of sufficient mathematical background to do the standard basic high school course. Also, many students, from above average to average, especially in the inner cities of our country, are weak in arithmetic, fractions, decimals and long division, and for many years were given non-mathematical science courses. Because of this weakness in arithmetic and algebra and lack of insight, many high school physics instructors simply gave up on these otherwise bright and capable students and offered them a non-mathematical physics or physical science course.

Even Paul Hewitt, a founder of the current "conceptual physics" approach, has recognized the need for more mathematics in the conceptual physics course. He has written a problem solving manual to accompany his text "Conceptual Physics" and has pointed out that in his opinion we need "both" the quantitative and qualitative aspects of the introductory physics course .

Physics teachers in high school and higher education should realize that for many years basic algebra and trigonometry have been taught in the elementary school in 7th and 8th grade. Also, I have found that taking a period to teach or recall some basic trigonometry with high school physics students, or teaching the basic trigonometry as the physics course progresses to 'at risk' students, is entirely feasible and pays dividends in higher level physics learning through mathematical problem solving.

In teaching at risk inner city students, average to honors, I have found that many students, even learning disabled students with math problems, can overcome the arithmetic barrier using basic inexpensive pocket calculators thereby virtually eliminating the fraction, decimal and division problems encountered in a basic physics or chemistry course. Furthermore, even if the student has not had formal algebra in elementary school, basic use of formulas is done throughout the elementary student's mathematical education, such as using the formulas for the areas of various geometrical figures, like squares and triangles. Even the most at risk students can substitute a value for a variable with a little help from the instructor and then use his pocket calculator to produce a correct answer. Especially if the physics teacher, concentrating on one problem type, not only puts an example problem on the board showing the students how to substitute, but also if he goes around the room helping individual students to use their formulas, with drills and practices, substitution behavior will be mastered by many students. My experience has shown that if this learning method, using a single problem type, and going around the room helping individual students, with drills and practices on that single problem type, is done in the first part of the mathematical physics course, most students, average to honors to 'at risk', will become mathematically literate physics problem solvers. This approach makes it easier for the high school physics teacher to reach all the students in his classes, not the just the few that can afford tutors or have a college educated relative who can show the average student how to solve his physics problems. We must remember that the great physicists such Bohr, Planck and Rydberg, all had tutors to help them pass their physics exams and solve their physics problems.

The Physics First teacher, in my opinion, must teach the basic algebra and trigonometry himself as the Physics First course progresses through the year, and not wait for the students' algebra teacher. This takes valuable physics time, especially at the beginning of the school year, but pays great dividends as the physics course continues through the year. In reality physics time is not very valuable unless it has a solid mathematical foundation. Furthermore, many more students will take ninth grade physics first and later skip a final mathematical physics course in his/her senior year.

In conclusion if we do not provide a solidly mathematical Physics First course, we are not only depriving the student of a true experience in physics, but also giving that student a misconception of what physical sciences are, possibly setting the students up for failure or disaster when they take a mathematically based physics or chemistry course in higher education, let alone limiting otherwise capable and intelligent students to lower level careers, thereby destroying their upward mobility and chance of equality in an increasingly technological society.

Stewart E. Brekke is a retired high school physics and chemistry teacher from the Chicago Public Schools, and lives in Downers Grove, IL; Stewabruk@aol.com

Necessities for improving STEM education

George O. Zimmerman

For years many of us have deplored the state of STEM education in the United States. (STEM stands for Science, Technology, Engineering, and Mathematics.) The TIMSS Study[1] ranks the United States fourth graders in 11th place in mathematics and eighth graders in 15th place in 2003. The scores were somewhat better in science: U.S. students were in 6th and 8th place.[1] The 2007 statistics are similar in mathematics: 11th in fourth grade and 15th in eighth grade; in science we came in at 8th and 11th, respectively, behind countries such as Latvia, Hungary, Slovenia, and others.

Despite many initiatives by the federal government[2], scientific organizations[3], and numerous efforts by teachers and local school districts, we still see newspaper articles such as "CEO caught in hiring dilemma,"[4] describing the difficulty of the CEO of the Raytheon Corporation to find qualified people to fill its technical staff positions. Such shortfalls exist despite the current economic downturn.

I suggest that STEM education in the U.S. will not improve until we recognize that our children enter school with a handicap, and this handicap is exacerbated by the ways we try to convey and treat STEM subjects in the early grades. We need to revamp our curriculum to address this problem. Such restructuring will not necessarily increase the STEM workforce, but it will make for a better educated workforce.

We need to recognize that our students enter school with a handicap as far as STEM education is concerned, and that handicap is caused by the presence of ubiquitous technology, which, despite making our lives easier, hinders our children from learning the skills that are prerequisite for STEM careers. Those skills are the practical and intuitive knowledge of arithmetic, weight, mass, and volume, among others. Because that technology replaces many of the necessary processes such as counting, weighing, exchanging money and such, our children are not exposed to activities, which in previous years were necessary in everyday life. These are still necessary for STEM learning. The Atlantic magazine asked: "Is Google making us stoopid?"[5] It is not only Google but much of our modern technology that contributes to this lack of early authentic experiences. This handicap is often overlooked by educators, and our children are taught assuming that that handicap does not exist. Our STEM woes will not be fixed until this handicap is recognized and that a remedy for it be found in the curriculum. In less technologically advanced countries this particular handicap is lessened because of the experiences of the daily routines necessary for life.

How are we to understand the existence of this handicap? An analogy is that of driving a car. It is necessary to know how to unlock the car, start it, and know where the steering wheel, accelerator, and brake pedal are, as well as how to turn on the lights. No knowledge is required of the internal combustion engine, the alternator or ignition system, battery, or the computer system that controls the functioning of the car. Most people can get along well without this knowledge as long as nothing goes wrong.

If something does go wrong and we need a repair, it often takes only the knowledge of a phone number or an e-mail address to get help to fix the problem. The repair is often a replacement of a part, which is done by a technician whose knowledge may be confined to which part to replace given certain symptoms. Some technicians do not really understand the principles on which the appliance or instrument – a car in this case – is based. Ordinary people, much less children, appear not to need a knowledge of STEM in their daily lives, and if people have technological problems, all they simply need to know is how to contact someone who can fix the problem. In contrast, it is necessary for STEM teachers and learners know the foundation and principles, both qualitative and quantitative, on which our technology is based.

We live in a non-quantitative society. Much of the older STEM workforce grew up in an environment quite different from the present. If you grew up 50 or more years ago, you went to a grocery store, chose the produce, weighed and bagged it, and went to the cashier to pay. The grocer would reweigh the items, figure out the cost, often writing on the bag with a pencil, and you would pay with cash, either by giving the correct change or making sure that you received the correct change back. These experiences gave us a sense of mass, weight, and quantity. The consumer had to use arithmetic to make sure that he or she or the grocer did not get shortchanged. Similar skills were acquired by shopping for other goods, such as clothing when it was made to order.

These experiences were still available and necessary a few decades ago in Europe, when supermarkets were still a rarity. I am reminded of my experience in Holland, where I spent a sabbatical. I had to go to a butter shop to buy butter, a cheese shop to buy cheese, and a bakery to buy bread.

Today, we go to a supermarket, take a box, bottle, packaged vegetable, or fruit off the shelf, put it into a shopping cart, bring it to the checkout counter where it is scanned and payment is made with a credit card. There is usually no encounter with weight, mass or numbers, or any other physical and mental attributes necessary for STEM education. Nowadays even those experiences are not familiar to some of our urban children and some schools institute "Field Trips" to the supermarket for their students.

Although today's technology makes our lives easier, it deprives students of the early experiences that would help them to master the skills on which they are tested for adequate performance in STEM subjects. We test our students about numbers and quantities which were necessary in the past for living in our society. Today those learning STEM subjects need visceral hands-on experience with the physical world, and this experience is lacking. A curriculum needs to be devised to bring back such experiences into the early grades.

This lack of early experiences is exacerbated by some of the latest educational practices and philosophy which embrace the notion that the teacher can get a better understanding of students' ways of thinking by encouraging them to express their preconceived ideas, without the teacher criticizing or daring to correct erroneous concepts, for fear that the student would be discouraged from further staying in the educational system. This practice, which is a version of the Socratic Method now being used by many teachers, may be detrimental to the teaching of essential facts about the world and accepted ways of thinking. It also hinders the development of reasoning necessary for the correct quantitative conclusions.

An additional hindrance is the teaching of advanced subjects, such as algebra and calculus, before the prerequisite arithmetic and manipulation of numbers has been adequately addressed. By 'putting the cart before the horse' students run into many difficulties in understanding STEM subjects.

An example of this philosophy is the following quotation from the Massachusetts Mathematics Teaching Standards[6]: "For children to develop confidence in their problem-solving abilities, teachers should be supportive in responding to "wrong" answers. In estimation, for instance, teachers should reassure children that being absolutely correct is unnecessary – children may need the opportunity to change their estimates as the activity evolves." A similar philosophy is expressed in the "Conceptual Framework for New Science Education,"[7] although the latter also recommends a "hands on" curriculum which might improve our current STEM curriculum

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We need to emphasize that **correct answers matter**. We should also teach some of the observations and theories on which science is based, and skills such as addition, subtraction, multiplication, and division before we ask students to reason about them. I recommend that only one arithmetic method be introduced initially, and one numerical system. (I suggest the decimal.) Only after students are familiar with one system can they analyze it and be introduced to other methods and systems by analogy. Without this fundamental knowledge, most students will flounder in the present STEM curriculum.

Our present situation might be compared to past educational reforms, which, taken to extremes, had negative outcomes for STEM education. In the preface to a physics text published in 1892,[8] the authors write:

During the past decade the teaching of Physics in high schools and universities has undergone radical revision. The time-honored recitation method has gone out and the laboratory method has come in. As a natural reaction from the old regime, in which the teacher did everything, including the thinking, came the method of original discovery; the textbook was discarded and the pupil was set to rediscovering the laws of Physics. Time has shown the fallacy of such a method, and the successful teacher, ... has already discovered the necessity of a clearly formulated, well digested statement of facts, a scientific confession of faith, in which the learner is to be thoroughly grounded before essaying to explore for himself. The maxim, 'That only is knowledge which the pupil has reached as the result of experiment,' has been found to have its limitations. With no previous instruction, the young student comes to the work without any ideas touching what he is expecting to see ... He has no training in drawing conclusions from his own experiments. He …will not be apt to discover little beyond his own ignorance, a result, it must be confessed, not necessarily without value. Before the pupil is in any degree fit to investigate a subject experimentally, he must have a clearly defined idea of what he is doing, an outfit of principles and data to guide him, and a good degree of skill in conducting an investigation.

A similar reform occurred in the 1960s when a number of interesting innovations were introduced but the reform also eliminated or eclipsed the teaching of some fundamentals. The educational reforms of the 1960s introduced advanced mathematical concepts such as probability and algebra, and scientific concepts such as atomic physics, the genome, and cellular biology into the lower grades. These concepts came at the cost of neglecting to teach the fundamentals.[9] The creators of those curricula did not realize that they themselves possessed a vast fundamental knowledge to draw on in order to grasp the wonderful concepts and insights which they wanted to teach the students. To the curriculum creators those concepts were simple and obvious. Because the students lacked this background, the curricula failed in their goals, for the most part. Reasoning without the knowledge of the subject to which the reasoning is directed does not work.

I have observed by talking to education professors, teachers, curriculum developers and by reading current curricular materials, both paper and web-based, that there is a tendency to use the Socratic Method, in which we quiz the students rather than teach them. We need to teach students about the world around them. Students need to understand the facts about the physical world to give them more practical skills, and to learn some fundamentals, such as arithmetic. To prepare our students to learn STEM subjects we need to re-reform our elementary school curricula to include programs to acquaint students with their world, rather than only with the technology. We cannot expect students to reinvent all the knowledge of the civilized world by themselves.

In summary, to make STEM education more effective we need a greater emphasis on practical skills, we need to teach arithmetic before we teach algebra and mathematical reasoning by teaching initially a single method of numbers and procedures, and by postponing the use of the Method until students and teachers have enough practical and fundamental knowledge of facts to base it on.

1. National Center for Education Statistics, U.S. Department of

Education, NCES 2005-005 (December 2004) reports the results of the Trends in International Mathematics and Science Study (TIMSS).
2. See http://www2.ed.gov/policy/elsec/leg/esea02/index.html.
3. http://en.wikipedia.org/wiki/Science_education; also see the AAPT website, www.aapt.org/.
4. Hiawatha Bray, "CEO caught in hiring dilemma," *Boston Globe*, June 23, 2010.
5. Nicholas Carr, "Is Google making us Stoopid?," *The Atlantic* 302 (1), 56—63 (July/August 2008).
6. "Kindergarten learning experiences," <www.doe.mass.edu/frameworks/>.
7. Board of Science Education, Center for Education, The National Academies, <http://www7.nationalacademies.org/bose/Standards_Framework_Homepage.html>.
8. H. S. Cathart and H. N. Chute, *The Elements of Physics* (Allyn and Bacon, Boston, 1892).
9. See the Algebra Project at the Kaput Center of the University of Massachusetts at Dartmouth, <www.kaputcenter.umassd.edu/>.

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Is the textbook obsolete?

Peter Lindenfeld and Suzanne White Brahmia

Not so long ago it was the teacher who was said to be obsolete. What was needed, we were told, was a "resource person", to answer questions and to supply information. Today, with the Internet, even that function is no longer necessary. Interestingly, it turned out that the students wanted and needed the guidance, the schedule, the pace, and the insights of the teacher.

How about the textbook? Doesn't the Internet supply all the information, perhaps to be supplemented by handouts with readings and problems that can be adjusted to fit each teacher's and each course's needs? Again, perhaps surprisingly, the much maligned textbook remains the anchor of just about every introductory physics course. The reasons for their staying power, are, however, likely to be different for the teachers and the book.

The textbook remains central to most courses in the face of the fact that the 'normal' text has not changed significantly in decades. It comes in different versions with minor differences. It has 1000 to 1500 pages, and you can easily guess the generic table of contents. It is not entirely a caricature to say that students don't read it, and professors look only at the end-of-chapter problems to see which ones should be assigned. In fact, surveys conducted at the University of Colorado show that this seems to be so for the majority of students.[1]

Perhaps that is not completely the fault of the audience. Is the survival of the book (unlike that of the teacher) primarily the result of tradition and inertia, rather than of its value as a tool for teaching and learning? Perhaps the writing and the presentation can be so vivid that the students will want to read what's there. Perhaps the pages don't have to open to dense mathematical derivations full of boxed and numbered equations.

This may be the time to look from scratch at the content and the organization of the text, and hence also of the course. Is it still appropriate to spend half the time and space on classical mechanics? And to leave everything that happened after the 1890s to a lump of 'modern physics' that gets less than prime-time attention at the end?

It's time for full disclosure: we have tried to act on these questions.[1] We looked at each topic as if it were new. We have 367 pages of which about 100 are on mechanics. We eventually get to quantum mechanics, to which we have an unusually accessible and straightforward introduction that helps us to describe applications such as transistors and solar cells. We have about 50 examples and questions based on the PhET ("Physics Technology Education") simulations developed at the University of Colorado. "Guided-review" questions are keyed to the examples in the text, so that students are encouraged – almost forced – to go back to the examples and to the surrounding text.

This is not the place to describe our book in detail. (More can be seen on the book's website.[2]) It may be appropriate, however, to show that there can be a new and fresh approach to the introductory course and to encourage others to explore new possibilities. The editor of one of the large publishing houses said that physics textbook choices tend to be very conservative and traditional. Equally discouraging was a colleague's comment that "I hope to die using the textbook that I'm using now because I have no time to write new notes."

Perhaps it is time to go beyond the pattern that was already inadequate in the last half of the 20th century and to develop courses and books more appropriate for the present one.

1. Noah Podelefsky and Noah Finklestein, *The Physics Teacher* 44, 338 (2006).
2. *Physics – The First Science*, Peter Lindenfeld and Suzanne White Brahmia, Rutgers University Press 2011, <www.firstscience.rutgers.edu>.

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A Course to Prepare Physics Students for the Research Laboratory

David G. Haase, Hans Hallen, and David P. Kendellen

As at many other campuses, at North Carolina State University we encourage physics majors to pursue undergraduate research. It is common for even our sophomores to ask faculty about opportunities to work in their research groups. Although this is a positive outcome, it has forced our faculty to rethink how courses prepare students to work in a lab.

At NC State the physics majors take labs coupled to the three-semester calculus-based introductory course. The students work with Vernier/Pasco type laboratory equipment and there is some emphasis on "figuring it out for yourself." The labs focus on verifying the physics subject matter: mechanics, E&M, and modern physics. Unfortunately, our majors may not take another lab course until the Advanced Laboratory in the senior year. This one-semester course for second semester sophomores includes instrumentation, electronics and data acquisition activities and two extended experimental projects.

Our faculty observed that the undergraduate students were not prepared to work in a research lab environment. Faculty or graduate students had to spend significant time acquainting the undergraduates about basic lab skills. In response, we surveyed the faculty as to what skills or knowledge undergraduates should possess prior to entering their labs. The long list we received included skills with electronic devices and measurements, safety training and basic lab techniques, skills in vacuum, temperature and optics, additional practice in measurement and data analysis, familiarity with LabVIEW, and many more topics. Our favorite response was that an undergraduate should learn "How to know what to do when you do not know what to do."

Obviously we could not fulfill all of these objectives in a one-semester course. Instead we tried the following.

Three semesters ago we started an Instrumentation and Data Analysis for Physics lab course that meets two times/week, each for two hours. Although most of labs are about electronics, the emphasis is on learning basic laboratory instrumentation and troubleshooting skills. Learning to use the laboratory notebook as a learning tool and a scientific record is strongly emphasized. During the class meetings, the students complete investigations on basic electronic measurements, passive AC circuits, diode circuits, operational amplifiers, a brief introduction to LabVIEW, 555 timer circuits, digital logic gates, noise, and a concluding lab investigation.

There are several substantial out-of-class exercises that are coupled to laboratory skills. There is a formal lab safety unit that makes use of the university's web based safety information. The students are introduced to basic shop practices and must produce simple drawings suitable for that first visit to talk with the shop foreman. There is a unit on Communication in Science, which makes use of materials from a university resource (http://www.ncsu.edu/project/posters/NewSite/), and requires students to write critiques of formal seminars and research posters. In two units on Data Analysis the students review systematic and statistical errors and prepare analyses of experimental data from the research literature.

There is no textbook. The faculty wrote the laboratory exercises. Like any lab person, the students often refer to Internet sources for background, instruction manuals, and specifications on equipment or circuits.

We have found electronics and instrumentation to be an effective vehicle to teach students experimental skills and habits. There are many situations to troubleshoot and few safety issues. Because electronic components are cheap we can afford to let the students make mistakes and to explore variations on circuits. Of course, electronics has direct application to a variety of physics research environments.

The students' performances are assessed on the basis of readings of laboratory notebooks, homework assignments and reports, and mid-term and final exams. Both exams included a lab practical component, such as designing and building a simple circuit to meet a specification.

The students were surveyed at the conclusion of each semester and we have received anecdotal feedback as well. They seem to have been generally pleased with the course and challenged by it. Almost all thought there was no need for a text. They felt they had learned trouble-shooting skills and how to use a laboratory notebook. They also said they had a better idea of what an experimental physicist does. They reported working about 2 hours/week outside of class and considered the course moderately difficult. They are telling other students that the course was worthwhile. We have not yet obtained significant data on the course's impact on student performance in the research laboratories or in the Advanced Laboratory course.

The Instrumentation and Data Analysis for Physics course is now a graduation requirement for our Physics BS degree. The senior-level Advanced Laboratory will be restructured to include more projects. We now plan to provide the course for 60 majors/year and are considering how to best train graduate students to serve as Teaching Assistants.

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Astronomy Outreach Adventures in Rural Guatemala!

Linda Strubbe

¡Vamos a ver la Lu-na! ¡Vamos a ver la Lu-na! (We're going to see the Moon!) Joni, Kevin and Óscar chanted in sing-song as they carried two tables for me down the rocky path to their house in Fátima, Guatemala. I was carrying a tiny tripod and my Galileoscope, a plastic 2" refracting telescope designed for the International Year of Astronomy in 2009. The weather had been terrible the last couple of weeks, including two serious storms that caused massive landslides, even closing down the only road into the community for several days. But that evening, the clouds were finally disappearing. After dinner (fried cornmeal) in my host family's concrete house (shared by 10 people and 2 rabbits), I spotted Jupiter rising over their corrugated metal roof, and occasional hints of the crescent moon through the clearing clouds in the west–and soon perhaps twenty-five kids and adults from the neighborhood were clustered around me and my telescope delicately perched on the tables. I picked up 6-year-old Joni to look through the eyepiece: I explained that just as we have a moon, the planet Jupiter has moons, and so he'd see a bright circle with four little points of light in a line (the Galilean moons). A huge grin, and he pronounced it "*Calidád*." (Quality!)

The night was *Calidád* for me too. I'm an astrophysicist with a strong interest in education, particularly in the developing world. After visiting Brazil for a conference in 2009, I decided I wanted to come back to Latin America and get to know a community of people there, seeing if I could help by offering my primary expertise–teaching astronomy/science. After graduating with my Ph.D. from U.C. Berkeley in July 2011, I took a few months off before starting a post-doc in Toronto (at the Canadian Institute for Theoretical Astrophysics) to do astronomy outreach in South Africa and Guatemala. In Guatemala, I spent six weeks at a Spanish language school called La Escuela de la Montaña (the Mountain School, http://www.hermandad.com/mschool.html), in the western highlands about an hour outside the city of Quetzaltenango by "chicken bus" (originally Bluebird school buses from the U.S. which have been colorfully repainted and are typically crammed with two to three times as many passengers as their U.S. specs intended). The school is in a rural area of coffee plantations, and associates closely with two tiny communities, Fátima and Nuevo San José. The school employs people from the communities, and Spanish-language students (like me) eat three meals a day in the communities with a host family that rotates each week. In this way, I had the amazing opportunity to know and learn from and make friends with people whose life situations are very different from my own. I'd also come with the idea (or hope) that most anyone in the world–even with very little education–would be curious about the universe, its contents, and our place in it. And that night, with a throng of people excitedly jostling to see Jupiter, then the Moon, then Jupiter again, then the Moon again(!), I felt that this could well be true. I'm writing this to tell you a bit about my astronomy outreach work here, and to simply give you a flavor of life–sights, sounds, smells, and, above all, people–in the Guatemalan countryside.

Guatemala lies just south of Mexico and is home to 13 million people, about 40% of whom are indigenous Mayan. The country recently suffered 36 years of civil war that ended only in 1996, leaving Guatemala with the second lowest United Nations Human Development Index (a measure of poverty, education, and health) in Latin America, ahead of only Haiti. In the community where I stayed, people live on \$3 per day (normalized for purchasing power): less than half of the country's mean; a few percent of a North American post-doc's salary. Most men there are temporary or day laborers in agriculture or construction, and unemployment is very high. The families live in concrete and corrugated metal houses, and do have electricity and running water; most have televisions and cell phones as well. Education in Guatemala is free and compulsory only through 6th grade, and the national illiteracy rate is 25%. Guatemalans today have spent on average only 4 years in school, though the situation has been improving significantly, and a child who enters school now is expected to finish with more than 10 years of education.

Astronomy can be a unique gateway to science for promoting education in developing countries (and developed ones as well). Astronomy is *accessible*–people anywhere can observe and wonder about the stars, Moon, planets, and Sun–and astronomy is *inspiring*, offering a means to study philosophical questions about where we came from. In preparing for my trip, I thought about and pieced together three major goals of astronomy outreach in the developing world. Most directly, interest in astronomy can encourage children to pursue their education, preparing them for jobs in science and technology (which will improve their lives economically and more broadly help build the country's knowledge economy). Learning scientific thinking and questioning can also encourage people to question objectively and look for explanations about their own life situations, not just accepting things as they are, and encouraging them to work for change. And thirdly, astronomy can offer perspective on our lives on this planet, encouraging feelings of global citizenship and tolerance and promoting peace. (Based on ideas like these, the International Astronomical Union created a Strategic Plan for using astronomy to promote development, available at http://iau.org/static/education/strategicplan_091001.pdf. A new Office of Astronomy for Development has been established in Cape Town, South Africa to carry out these ideas: http://www.astronomyfordevelopment.org.)

Schools weren't in session during my visit because of the coffee harvest, so most of my outreach was through informal time spent with children. My strategy was to pique people's curiosity and stimulate them to ask questions by showing them interesting materials–a children's book about the Solar System, a foot-diameter inflatable ball printed with satellite photography of the Earth, pictures of planets and galaxies, diffraction grating glasses, and of course, the Galileoscope. I can illustrate my experiences by telling you about three children I got to know–Jesmin, Luis, and Roxana.

Jesmin demonstrated the most tenacity of all the people I met during my trip. A rainy afternoon during my second week, I passed 10-year-old Jesmin in the street in front of her house. "What's your name?" she asked me. Then, very directly, "Do you have books? Can you come and read with me?" I've never seen a North American child do anything like this. Of course, I said yes! Over the subsequent days, she and her little brother Juan Carlos read with me Spanish versions of classics like *Clifford the Firehouse Dog* and *Where the Wild Things Are* (borrowed from the Mountain School). Jesmin's reading level wasn't bad for her age (though 8-year-old Juan Carlos couldn't read at all). The family has no books; Jesmin's father Enrique has tried three times to cross the border into the U.S., leading to his incarceration and eventual deportation back to Guatemala in shackles. Jesmin's directness and desire to leap at learning opportunities struck me deeply.

Jesmin's neighbors Luis (8 years old) and sister Roxana (11) cannot read or even identify most letters of the alphabet–but they did a little better with arithmetic. I first gave them subtraction problems less than 10, and they used their fingers; then less than 20, and they used their toes as well. What would they do for more than 20? I asked them 25–4. There was a pause. Then Luis grabbed a stick and started making tallies in the dirt. He counted up to 25, then counted 4 from the end and erased them, then counted up from the beginning again. Roxana followed and soon they were racing each other to solve my subtraction problems! "Another one, another one!" they cried. Their resourcefulness and enthusiasm were terrific, but they didn't see patterns and short-cuts. Then Roxana and I worked together for a while, trying to see how to do problems like 55 – 3 without needing her stick. She occasionally held her head like it was hurting a little, but she pressed on practicing and started to get the hang of it. "I'm learning!" she declared proudly. Her learning-powered joy and self-respect were so evident! Meanwhile, Luis loved playing with the Earth Ball–he learned how to find Guatemala, California and England, and proudly showed anybody who walked by on the street.

The Galileoscope star parties were the biggest hit through my stay in Guatemala. Every clear evening, I set up the telescope and invited people to look at the Moon (during the right part of the month), Jupiter and its moons, and the Pleiades. My Spanish teacher Abby invited me to dinner at her house in the nearby town of Colomba for Día de los Muertos (Day of the Dead, November 1), and asked me to bring my telescope. Her extended family and neighbors joined us, including another teacher Anny who looked back at the Moon again and again and again! The two night watchmen at the Mountain School, Gustavo and Rubén, liked looking through the telescope as well, and told me about star names from their culture: the *Santa Marías* (the three stars of Orion's belt) and the *Siete Cabritas* (seven little goats–the Pleiades). I also had a star party for young teenagers who come to the Mountain School every week for a youth night. When most of those kids had looked through the telescope, I saw a group of older kids hanging out in the background and smoking.

Thinking to myself, "Astronomy is for everyone!" I invited them over as well, and they seemed to enjoy looking at Jupiter; the next morning I learned they were members of a gang! But the biggest star parties were at the very end of my trip, with a group of children (and their families) who were attending a summer camp at the volunteer fire department in Colomba. I first visited the fire department one morning to do astronomy activities with the 30 kids. My goals were to show them that their own everyday observations have physical explanations, that they could ask *why* (I had them all repeat "Why?!" out loud with me), and that the same physical principles hold throughout the Universe. We made models of the Moon orbiting the Earth and the planets orbiting the Sun, with the kids walking around in concentric circles holding signs saying planet names. Two days later I came back for a star party. The sky took hours to clear, but the families were very patient; their laid-back attitude paid off, and eventually we all got to look at Jupiter through the telescope. Afterwards, one of the parents took photos of me with all of her kids. And the event was exciting enough for the local television news station to cover it! (Roxana asked me afterwards: “When we saw you on TV, could you see us, too?”)

Almost everyone I talked to in Guatemala was excited to talk about astronomy with me. People were very warm and welcoming, and a teenager told me it was cool to talk to a scientist since they just don’t meet scientists in their rural area. Occasionally I was disappointed to see the mothers focus on practicalities with their kids rather than capitalizing on teachable moments; for example, Joni was asking me lots of questions about planets at the dinner table, but his mother took away the planet pictures and said he needed to eat. (Later, though, Joni ran down the street to me wearing the diffraction grating glasses I’d given him!) Here are some of the questions people asked me: *Are other stars really like the Sun? Which countries are on Jupiter? Which people and animals live on Jupiter and the Moon? What’s below us on Earth?–Water? What happened to Pluto? Why is Africa yellow? What causes the motion of the continents?* [From 10-year-old Evelyn, the most scientifically advanced child I met there, after I showed her that South America and Africa fit together] I*s the world going to end in 2012?* and *What are meteors?*

Although I don’t expect that most people I met will remember specific pieces of astronomy I taught them, I am hopeful that the memory of looking through the telescope and asking questions about the Universe will stay with them, and that this curiosity will push them to keep learning, despite the severe shortcomings of their education system. And there are some reasons to feel positive about their education. The Mountain School provides scholarships to many local children for their schooling past 6th grade (from donations and our tuition: http://www.escuelamontana.org/), and has almost completed building a community library: children will be able to do homework and read books there, and the community will have free access to the internet. Once the community is connected, I’m hoping to continue doing some science activities with them remotely; I’m also planning to send them eclipse glasses to watch the transit of Venus in June. And in a few years, I hope to return in person.

In conclusion, my experiences in Guatemala were deeply rewarding for me: I learned a great deal about another culture and another way of life, and was able to give a poor community something they appreciated very much. I highly encourage any scientist with interest in developing countries to engage in some science public outreach abroad, either in person or remotely. People there want to know more about the Universe and stand to improve their lives by learning science–and we scientists have the knowledge and curiosity to share with them!

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Physics Instructional Resource Association

An Introduction to PIRA (Physics Instructional Resource Association)

Dale Stille

PIRA Physics Instructional Resource Association

PIRA is an association of professionals dedicated to the support and advancement of physics education. Since 1986 we have worked together and in alliance with physics educators and support specialists to develop effective teaching tools and techniques to aid and promote physics education. Specifically, PIRA promoted and allowed the sharing of ideas on both physics labs and demonstrations, the teaching tools with which many of our group were involved in for their respective professions mostly at the college or University level. Since this beginning, PIRA has grown into an association of members including lecture demonstration specialists, instructional laboratory specialists, physics outreach specialists, teachers, professors, public outreach specialists, community outreach coordinators, and others. We support the sharing of teaching ideas and physics education and outreach efforts in elementary schools, high schools, community colleges, and universities. Although most members reside in the United States, PIRA is now truly a global association.

PIRA is also an affiliate of the American Association of Physics Teachers (AAPT). As such PIRA sponsors several workshops and talks at the annual AAPT national meetings. These workshops or sessions are presented by knowledgeable, accomplished professionals and offer current and relevant information to those who support physics education and outreach. The sponsored workshops and talks are excellent opportunities for professional development. We’ve now started branching out this effort by giving local workshops for area AAPT groups, national joint APS/AAPT meetings, and also by giving these workshops at local or National Science Teacher Association (NSTA) meetings, the largest organizations of science teachers in the US. Though we’ll always be part of AAPT, we feel the need to share this expertise wherever it may be useful. However, many of our members are also members of APS or have been involved in APS outreach programs for many years. In fact almost all of our membership participated in the APS 2005 World Year of Physics initiative in one form or another and a significant number of those people continue to cultivate that connection by participating in other APS initiatives such as the recent LaserFest outreach celebrations.

The free exchange of knowledge and ideas, and the willingness to support colleagues whenever possible are hallmarks of the PIRA organization. Nowhere is this more evident than on the Tap-l listserve. Primarily devoted to discussions of demonstrations, labs, demonstration apparatus, and laboratory equipment, members are encouraged to post questions when the need arises and to contribute whenever they can. We pride ourselves on providing information and answers **very** quickly. Information on how to join the listserve can be found at our website listed below.

One of PIRA's most important contributions to physics education is the PIRA Demonstration Bibliography. The demonstration bibliography is a compilation of thousands of referenced demonstrations, all categorized according to physics concept. The bibliography, available in book form and on the web, is an invaluable asset to anyone involved in the use, acquisition, and organization of physics demonstrations.

A recent popular addition to our website has been the "What the heck is THIS?" section devoted to Antique Physics Apparatus. If you have some old equipment in the classroom, storeroom, or that dark back corner that you can't identify you should send us a picture. Tom Greenslade, Jr., the grand master of antique apparatus identification will happily process your request.

The PIRA web site can be found at www.pira-online.org. If you are interested in advancing and promoting physics education and outreach please consider a membership in PIRA and/or feel free to contact us if you have any questions about PIRA and how we can help you!

Dale Stille can be found setting up & performing your favorite physics demonstration daily at the University of Iowa, as well at at AAPT and PIRA meetings, and at various Outreach locations, or at dale-stille@uiowa.edu.

Answer to the Challenge to the Readers

Paul Dolan

In the Spring 2011 Newsletter, I issued a Challenge to the Readership: to be on the watch at the various research meetings you might attend during the year for those new materials, techniques and phenomena that can be directly imported into the classroom or educational lab. I'd like to take this opportunity to reissue that Challenge, but also to share with you the best answer that I received during the year.

In the Spring 2011 newsletter, I had noted my use of the '1-2-3' (YBCO) High-Temperature Superconducting material in several classes (having done research with these materials previously). Several readers did request my 'recipe' for this material. What I was lacking, though, was a decent 'from scratch' recipe for the Bismuth compound (BSCCO). Former FEd Chair Larry Woolf sent me a selection of papers[1] with not only the basic recipe, but with suggestions for variations and dopings of interest. My students have not had the time to make anything other than YBCO (yet), but I hope some of them will be able to also cook up some BSCCO in the near future – thanx Larry!

1. N.M. Hwang, et al, *Appl. Phys. Lett*. 54, 1588 (1989); H.G. Lee, et al, *Appl. Phys. Lett*. 54, 391 (1989); R. Ramesh, et al, *J. Mater Res*. 6, 278 (1991); R.Y. Lui, Supercond. *Sci. Tech*. 5, 482 (1992).

Physics Teacher Education Coalition

Section on Teacher Preparation

Teacher Preparation Section

John Stewart

In this issue, we begin with a description of the teacher preparation program at Boston University, one of the newly funded PhysTEC sites. This site mixes some of the traditional PhysTEC components, the teacher in residence and learning assistants, with the results of a number of funded projects supporting in-service teachers.

The second article discusses efforts to connect working teachers with university faculty and professionals in industry by forming Professional Learning Communities (PLC). PLCs are an exciting idea that allows the leveraging of money spent on professional development by fostering communication. We use PLCs extensively in our College Ready in Mathematics and Physics NSF Math-Science Partnership at the University of Arkansas and encourage participants in our professional development workshops to establish PLCs at their home schools.

The third article discusses an APS initiative to help physics departments increase their graduation rates. Increased graduation rates have become increasingly important as many states, seeking to save money, consider closing programs with low graduation rates as discussed by Ted Hodapp in his Back Page article in the *APS News* in December 2011 (http://www.aps.org/publications/apsnews/201112/backpage.cfm). While not directly a teacher preparation issue, it has been our experience that the best way to increase the number of physics teachers is to increase the number of physics majors. While our department would not be threatened if the State of Arkansas closed programs with few graduates, it would directly affect the number of qualified physics majors in the state, our graduate recruiting, and the job prospects of our doctoral students.

John Stewart is a the University of Arkansas

The Boston University PhysTEC Program

Andrew Duffy

Overview

Boston University has been awarded a three-year PhysTEC grant (2011-2014) to support efforts aimed at increasing the number of licensed physics teachers we graduate. We also have internal funding, with equal shares from the School of Education, the Department of Physics, and the Office of the Provost, to sustain the project for an additional three years (2014 – 2017). Project team members are Andrew Duffy (PI), Bennett Goldberg, and Manher Jariwala, all from the Department of Physics; Peter Garik (co-PI), from the School of Education; and this year's physics teacher-in-residence, Juliet Jenkins.

Background

While PhysTEC has been operating for several years, Boston University (BU) is the first PhysTEC-funded site in New England, so one of the goals of the BU program is to serve as a model program for the New England region, helping raise awareness about the PhysTEC program, and providing guidance and ideas for recruiting and training of new physics teachers.

Boston University has been active in physics education projects for a number of years. Some of our projects that helped lay the foundation for our PhysTEC effort include:

1. Project ITOP (Improving the Teaching Of Physics) – since 2004, we have been teaching 10 two-credit graduate-level courses for in-service teachers who are teaching physics. The program is led by Peter Garik, of the School of Education, and Andrew Duffy, of the Department of Physics, and the course instructors at present are Manher Jariwala, of the Department of Physics, and Nicholas Gross, of the Department of Astronomy. For the first six years of the program, the Massachusetts Board of Higher Education provided funding, and Arthur Eisenkraft of the University of Massachusetts Boston was a key collaborator. The ITOP courses range from the first course, on Newton's laws of motion, to courses dealing with quantum physics, special relativity, and computer modeling of physics phenomena. The courses are designed so that teach-

ers who are teaching physics without having a solid background can gain a deeper understanding of physics. We have attracted many such teachers to the program, several of whom have gone on to pass the Massachusetts Tests for Educator Licensure (MTEL) in Physics. The courses have also attracted teachers who have an excellent physics background, and those teachers also report that the courses are valuable. In addition to the physics content, all the ITOP courses include a significant amount of content drawn from the conceptual history of physics (CHOP) and the Physics Education Research (PER) literature, so the teachers are being challenged on many levels.

2. Inquiring Minds: Immersion in Science – this project, funded by the Massachusetts Board of Higher Education STEM Initiative, the Stephen D. Bechtel Jr. Foundation and Schlumberger-Doll Research, is another example of the close collaboration that exists between the Department of Physics and the School of Education at Boston University. Bennett Goldberg, of the Department of Physics, and Glenn Stevens, of the Department of Mathematics, are the PIs of the program. Peter Garik and Don DeRosa, of the School of Education, largely developed the pedagogical approach and assessment model, and have been instructors along with Andrew Duffy and Manher Jariwala. Inquiring Minds brings elementary and middle-school teachers to campus for two weeks in the summer for an immersive experience in science. In recent summers, these teachers have either been in our Immersion in Green Energy course, or our Immersion in Global Energy Distribution course, which examines factors related to climate change. In both courses, the teachers work in teams on an in-depth project, either aimed at investigating a type of alternative energy or a factor connected to climate change. The intent is to give them a hands-on experience in doing science, so that they are better able to bring the practices of science into their own classrooms.

3. Boston Urban Scholars GK-12 program – our NSF-funded GK-12 effort (now transitioning to internal funding and self-support) is led by Bennett Goldberg of the Department of Physics. This program has had two rounds of NSF funding, allowing us to establish a close partnership with the Boston Public School system, and, every year, to partner science and engineering graduate students with local high school science teachers. Generally, the graduate students spend 10 hours per week at the school, with many of these hours spent in the classroom working closely with the teacher and the students.

Project Activities

BU's PhysTEC program refocuses our efforts on pre-service teachers rather than on in-service teachers. Over the past several years, Boston University has graduated one or two physics teachers per year, either from the School of Education's Masters of Arts in Teaching (MAT) program (a one-year program that students come to BU to do after, generally, completing an undergraduate degree in physics), or from the four-year School of Education undergraduate program. 1-2 physics teachers per year is not atypical for an institution our size (18000 undergraduates), but an important goal of the project is to increase this number, to help address the national shortage of highly qualified physics teachers in the classroom.

One effective way to encourage more students to become teachers is to give students early teaching experiences with low barriers to becoming involved. We have a new Learning Assistant (LA) program at Boston University, modeled on the LA program at the University of Colorado, and funded by the Office of the Provost, the College of Arts and Sciences, and the departments using LA's. These LA's are undergraduate students who recently took the course themselves, and who are now working alongside graduate teaching assistants (TA's) to help their fellow undergraduates learn the material. The students in the course generally find the LA to be somewhat more approachable than the professors or even the TA's, and having an LA in a discussion section that would otherwise have a single TA for up to 30 students has a significant impact. It is hard for one person to address all of the student issues and questions, but having a team with a TA and an LA working together makes for an improved learning environment.

The Learning Assistants take a two-credit pedagogy course during their first semester as an LA, allowing the LA's to read various papers on different approaches to teaching; encouraging them to reflect on their own teaching experiences; and giving them a venue where they can exchange ideas with their fellow LA's. In addition to the LA course, the School of Education has created a new two-credit course designed to give interested students a first teaching experience in a local high school classroom. The idea is that some of the LA's will get hooked on teaching through their LA experience, and will then go on to take this second course to see if teaching is something they really want to do.

Currently, the departments with LA's are Chemistry, which initiated the LA program at BU in the spring semester of 2011, Biology, and Physics. The latter two started a LA program in the fall semester of 2011. Each of these departments currently has between 12 and18 LA's per semester, either working in the lab sections (Biology) or in the discussion sections (Chemistry and Physics).

The Role of the Teacher-in-Residence (TIR)

The teacher-in-residence (TIR) is a key individual in all PhysTEC projects. Our first TIR, Juliet Jenkins, has been actively recruiting among the undergraduate physics students, making students aware that there is a national need for more physics teachers, and trying to tap into the joy of teaching that some of these students have, but which we have not tried to develop in the past. Ms. Jenkins has visited several different physics classes to talk about various ways in which students can have a teaching experience (such as becoming an LA, or doing tutoring through BU's tutoring center, or getting involved with BU's Wizards after-school program, which takes science demonstrations and activities to local schools). She has been working very closely with the members of Photon (BU's Society of Physics Students chapter), talking to them about teaching as a career and helping them to think about activities aimed at building teaching skills. Ms. Jenkins has also been working closely with Peter Garik on the PhysTEC activities that are centered in the School of Education, including both the LA pedagogy course and, especially, on the new course that includes classroom observations in local schools.

Ms. Jenkins presented a poster at the Fall 2011 conference of the New England sections of the APS and AAPT, held at UMass Amherst, describing PhysTEC, and providing details on the BU program, especially the role of the TIR. This is helping to spread awareness about PhysTEC in the region.

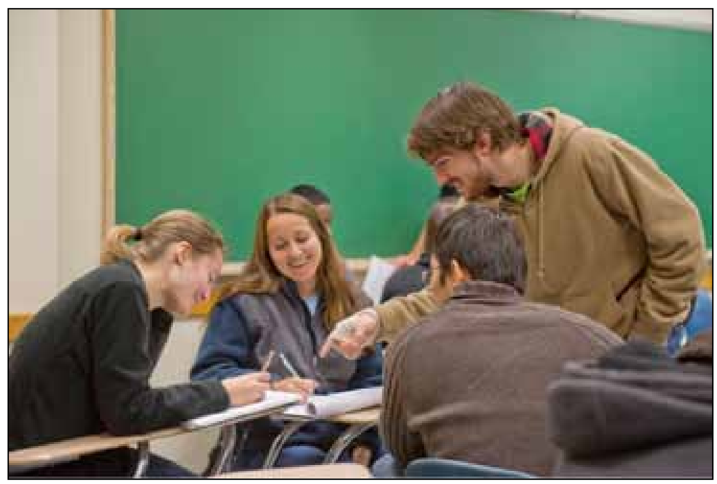
Another thrust of BU's program is to have our own faculty members reflect more on their own teaching, and to encourage them to value physics teaching as a profession, so they consider that to be a viable career option for our physics majors. To this end, Ms. Jenkins has been actively engaging in discussions with various members of the department, talking about teaching, or about LA's, and she was also instrumental in the organization of our first ever Physics Teaching Lunch, a lunchtime gathering in November, 2011, during which faculty members came together to discuss a particular aspect of our teaching. In our case, the first meeting focused on the pre-class quizzes we have introduced into our introductory physics classes, both to encourage students to come to class prepared, and to free up class time so that we can spend more time on interactive activities such as in-class quizzes and clicker questions.

Finally, we are also working to build a community of local physics teachers, hosting a few meetings every year during which teachers come in to give us advice on our PhysTEC efforts, and giving them an opportunity to share ideas and demonstrations related to what they are doing in their own classrooms. Ms. Jenkins was the main organizer of our first such meeting, in November 2011, which was attended by 15 area teachers and featured a great exchange of ideas among the group. We have had over 100 teachers take at least one of our ITOP courses for teachers over the past several years, and ITOP alumni represented the bulk of the attendees, but we were also pleased to see a few new faces, too.

Summary

We are developing several different projects consistent with the PhysTEC project and in support of the primary goal of increasing the number of licensed physics teachers who graduate from Boston University. Some of these efforts are aimed directly at undergraduates, such as the Learning Assistant program, while others are aimed at members of the physics faculty or at fostering collaboration between the university and local physics teachers. These efforts represent a significant commitment on the part of BU, both in terms of financial resources and in time committed by the project team, and we are highly appreciative of the PhysTEC support, which provides funding for a physics teacher-in-residence on campus. Our first TIR, Juliet Jenkins, has enthusiastically embraced her role, and is providing a lot of positive energy that is driving the project forward.

Andrew Duffy has been teaching introductory physics at Boston University since 1996. He is particularly interested in applying new technologies to teaching and learning, and is currently developing iPhone and iPad apps for physics.



Learning Assistant, Max Porter, working with a group of introductory physics students in a discussion section.

Physics Learning Communities, Teacher Scientist Alliances, and Local Physics Alliances: Professional Development whose Time has Come Again

Jacob Clark Blickenstaff, Teacher Education Programs Manager, APS

Typically, high school physics teachers are the only physics teachers on a high school campus, and may even be the only teachers of physical science, making the position very isolated. Though there may be a calculus teacher on campus, and perhaps another science teacher with some physics background, usually there is no one else around who teaches physics very often. Professional conversations about the teaching and learning of physics can be invigorating and sustaining when the day-to-day chores of taking attendance, grading homework, and checking lab equipment have taken their toll. In recent decades a number of efforts have been initiated across the country to try to link high school physics teachers with physicists in their region to engage in thoughtful conversations about content and pedagogy. A few examples include:

- In the 1990s, the APS ran the Teacher Scientist Alliance (TSA) program, which focused on elementary and middle school science teachers, and was aimed at linking physicists with classroom teachers.

- An archived version of the PTEC digital library site at Buffalo State (http://physicsed.buffalostate.edu/pubs/PTEC/PTED/) recalls the Local Physics Alliances (or LPAs) which supported the Modeling initiative at ASU (http://modeling.asu.edu/).

- The most recent trend has been the creation of Professional (or Physics) Learning Communities(PLCs) as a part of grant-funded reform efforts.

- Maintaining a cooperative relationship between university faculty and high school teachers requires significant commitment of time and energy, so the lifetime of these collaborations is often quite short.

As the Teacher Education Programs Manager for APS, I am working on what the next iteration of teacher professional development by APS will look like. I sent a very informal survey to the FEd list serve in November 2011, asking members to send me a note describing their efforts working with high school physics teachers. A number of the responses described projects along the lines of PLC, TSAI, or LPAs. I learned about some efforts that have been ongoing for many years (see the Syracuse group below), others that are built around large funded projects (see QuarkNet), and others that came into existence in response to a district-level mandate (see California Lutheran). Finally, the American Chemical Society is in the second year of at two-year pilot program that supports the formation of chemist/teacher teams which I will describe more fully below.

Syracuse-Central NY Physics Alliance

This group has been active since the early 1990s, and is still a going concern. Built around Saturday morning meetings held five times a year in the Syracuse University Physics Department, a community of high school physics teachers in central New York state gather to address issues of interest to the teachers. With the support of the local APS section, the department, and private funds, these sessions have served fifteen to thirty teachers at a time. While many of the sessions focus on make-and-take projects to add to the high school teachers' classroom apparatus, general pedagogy and summer professional development opportunities are also important topics. The group has even branched out into public outreach by setting up demonstrations in a local shopping mall. Two teachers who began their relationship with Syracuse through the Physics Alliance have gone on to participate in summer research at CERN.

QuarkNet

Two respondents to the email survey described QuarkNet (http://quarknet.fnal.gov/) as the driving force behind their efforts with high school teachers. The Quark Net project is a federally funded program that partners high school teachers and students with scientists working on experiments at facilities like Fermilab and CERN. Teachers gain experience as researchers on cutting edge physics projects, and are then able to connect this work to their classroom teaching. Perhaps just as important, QuarkNet teachers are part of a collection of 52 centers at universities and labs across the county where physicists and teachers develop supportive peer-group communities.

California Lutheran University

In contrast to a very large project like QuarkNet, some powerful interactions are happening on a small scale led by committed individuals. Bob Rumer, an instructor of physics at California Lutheran University, has been meeting with 7 high school physics teachers on a regular basis for the last 18 months. The teachers were initially brought together by a school district mandate and Bob was invited to join them. This meeting has evolved into a continuing discussion of physics teaching directed by the interests of the high school teachers. Bob has provided examples of lab experiments he does at the college level and teachers have seen the value of the group interactions even though they do not necessarily have the same equipment at their home institution. It is Bob belief that a key part of the success of this effort is that he follows the teachers' lead. Although the initial impetus for a meeting is external, the direction the group takes is decided by the teachers, not by an external mandate. Bob also noted that many of the teachers were unaware of national organizations like AAPT and APS and the free resources that both organizations provide. The physics department at California Lutheran has provided copies of Randall Knight's Five Easy Lessons to all the participants, which has guided a number of the group discussions.

American Chemical Society

Though the situation in chemistry is a bit different, the ACS has begun to address chemistry teacher professional development in a similar way. The 2011-12 school year is the second year of a two-year pilot program called ACS Science Coaches. Chemists in academia or industry, graduate students, and retired faculty are recruited to pair with middle or high school teachers to work on a project of the teacher's choosing. The teacher is given $500 to cover materials expenses related to the project. Teams are required to meet monthly and to communicate by email or telephone at least once per month, and a summative report is due at the end of the year. Approximately 150 pairs have participated over the two years of the pilot program, though the second cohort is in the middle of their projects as of this writing. Most teams have spent their funds on new laboratory equipment. The coach has participated in classroom activities with many partner teachers, but the project is entirely at the discretion of the team. At least one teacher asked the coach to assist in reorganizing the chemical store room and purchased up-to-date storage equipment with the funding.

Common thread: Teacher-directed

It is perhaps not surprising that the efforts that have remained in place for a significant period of time give science teachers real autonomy to decide what to explore and how to improve their own practice. Most physics teachers want to get better at what they do, and that is particularly challenging when working in isolation. Programs that bring teachers together with physics faculty can make a real difference in the content knowledge and teaching practice in high schools, but probably most effectively when the teacher decides what he or she wants to learn.

Jacob Clark Blickenstaff comes to the American Physical Society from a background as a high school physics teacher, teacher educator, and physics education faculty member. He works on the PhysTEC project as well as teacher professional development for APS.

NOTE from the Newsletter Editor – there are a large number of physics teacher 'Alliances' of various types operating around the country, many very informal and loosely connected with organizations such as AAPT or APS. We would welcome items about such Alliances and their successes in future editions of the Newsletter.

University of Arkansas Case Study: Teaching, Research, and Advising

Gabriel Popkin, Consultant, American Physical Society

In the past few years, physics departments have been closed or threatened with closure in states including Texas, Louisiana, Missouri, Maine, Tennessee, North Carolina, and Idaho. Most of these departments have been targeted because of the low numbers of undergraduate physics majors they graduate each year.

In response, APS has put together a set of resources to help physics faculty demonstrate value to their institutions and make the case for their departments. These resources include case studies of physics departments that have taken proactive steps to increase the number of students they graduate. The case study below and others can be found at www.aps.org/programs/education/undergrad/faculty/making-the-case.cfm

The University of Arkansas has made spectacular gains in its physics major graduation rates—from less than two majors per year in the mid-1990s to nearly 20 per year today. The program's success rests on its reformed introductory University Physics sequence, careful advising practices, and early teaching and research opportunities. The department also has a nationally recognized physics teacher preparation program, which is closely integrated with the overall undergraduate program.

Overview: Present and Past

The University of Arkansas is the flagship public university in the state of Arkansas, and serves over 20,000 students. The physics department comprises 20 faculty members, up from 14 in the mid-1990s, and grants around three PhDs and three master's degrees each year. The department now has a thriving undergraduate program, but this was not always the case.

In the mid-90s, the physics department graduated only a few majors per year, and students in an introductory physics course had actually gone on strike to express their dissatisfaction with the instruction. Recognizing a crisis and acknowledging that changes in their program were necessary, the department decided to hire Gay Stewart, a faculty member with a strong interest in physics education.

Starting with Course Reform

Gay Stewart and her husband John, also a physics education researcher, began by reforming University Physics II, the introductory electricity and magnetism course for both physics majors and engineers, which had been the source of many of the student complaints. The course was modified to tie theory and practice together more closely, and to make sure students were aware of the relevance of what they were learning. The Stewarts also developed a preparation program for teaching assistants, which quickly grew to include a program for undergraduate Learning Assistants. This ensured that the TAs and Learning Assistants were using good inquiry-based practices, and resulted in much higher student satisfaction, better student conceptual learning, and improved attitudes toward science by the end of the course.

After University Physics II, the Stewarts went on to reform University Physics I, the introductory mechanics course. They helped make modifications to other courses as well, and those course reforms are sustained with different instructors, although Gay emphasizes the importance of assigning these courses to full-time faculty members who care about good teaching, and can convey enthusiasm about physics. As a result of reforms and instructor selection, the University Physics sequence began functioning as a powerful recruiting tool, getting students excited about physics and drawing them into the department.

The physics program is now so highly regarded that some departments like Chemical Engineering actually recommend that some of their best students also major in physics. University Physics I has become a cornerstone course for the Freshman Engineering program, and many physics courses are recommended as technical electives across the College of Engineering.

Advising, Flexible Major Tracks, and Research Opportunities
Once an Arkansas student expresses interest in physics, that interest is carefully nurtured through proactive and personalized advising. The department tries to begin advising declared majors in their freshman year or sometimes before they reach campus, even though the university only requires students to have a department-specific advisor starting in the junior year. This allows advisors to identify students' interests early, and get them started on an appropriate course of study.

The Arkansas undergraduate physics programs includes a variety of major tracks, including a standard professional track, and ones focusing on optics, electronics, computational physics, biophysics, and astronomy. Beyond the defined tracks, however, advisors often work with individual students to develop a course of study tailored to that student's particular interests and needs. For instance, an advisor might help a non-traditional student pick up needed math courses, or work with a student to develop a "special emphasis area" to prepare for med school, law school, a teaching career, or other post-graduate options.

Early and proactive advising also enables students to get involved in research opportunities as early as their sophomore year. This in turn leads to more students gaining access to Research Experiences for Undergraduate (REU) programs, winning awards and fellowships, and being better prepared for graduate school. Equally important, it gives students who discover they don't like a particular area of research enough time to find a different course.

Arkansas Physics Becomes a Teacher Preparation Leader
In 2001, the University of Arkansas became one of the first funded sites of the Physics Teacher Education Coalition (PhysTEC) project, a teacher preparation project led by APS and the American Association of Physics Teachers. In 2001 the department had graduated one teacher in the previous decade; it now graduates five or more per year. The cornerstones of the program's success are the same as those that have been instrumental in boosting the department's majors: careful advising, flexible course requirements, and recruiting through good teaching. As Gay Stewart puts it:

"University of Arkansas' philosophy has been that you never know who is going to be a future teacher, so you should treat all students as if they might be, modeling good pedagogy in introductory physics classes. This has the beautiful side effect that if all students experience an intro class taught the way we would like future teachers to teach, you end up with more MAJORS! Further, the new teachers you have sent out start sending you new, well-prepared prospective majors."

Arkansas' physics teacher education program is now one of the top in the country in terms of physics teacher graduation rates, and it has been recognized as exemplary by the National Task Force on Teacher Education in Physics and the Association of Public and Land-grant Universities' (APLU's) Science and Mathematics Teacher Imperative (SMTI). Much more information about Arkansas' physics teacher preparation program is available at www.PhysTEC.org/institutions/arkansas

Support from the Administration and other Departments
The Arkansas physics program now has strong support from the university administration, and is often touted as one of the university's "model programs." Stewart notes that when administrative posts change, it can be a challenge to make sure the new people are informed about the program, and that visits from national groups like the Task Force and SMTI representatives have "helped new administrators appreciate the quality of our programs."

Other campus units have also recognized Physics' success, and are hoping to learn from it. The Department of Mathematical Sciences is now working on a project to emulate the physics program's course reform and teacher preparation activities through Learning Assistants and other activities. Engineering school faculty and administrators have also expressed appreciation for the service the physics department provides in educating their students, and chose to continue having their majors go through University Physics, even when they were given the option to teach introductory physics themselves. Stewart notes that her department's service to other programs on campus allows Physics to justify asking for more resources, such as faculty positions and TA lines for their courses.

The Present and Future: a Thriving Community, and Continued Growth
A final piece of the puzzle, says Stewart, is ensuring a healthy undergraduate climate. Arkansas students have their own space

where they can study or socialize, as well as a vibrant SPS chapter, which recently put on a Saturday afternoon physics demo show that drew over 300 people. Department picnics and social events further build community among students and faculty. "The students are the inspiration for everything we do," says Stewart.

Thanks to its thriving undergraduate program, the department's future looks bright. John Stewart has been hired in a tenure-track position, giving the department a second full-time faculty member specializing in education, with several others taking a side interest in educational issues. The department has also brought in more faculty in biophysics and astrophysics, hot topics for many students. Gay Stewart has been recently elected vice president of the American Association of Physics Teachers, and serves on the APS Executive Board, giving her program added recognition.

Further Reading

1. http://www.aps.org/units/fed/newsletters/summer2006/stewart.html
2. http://www.aps.org/units/fed/newsletters/fall2000/index.html

Gabriel Popkin is a freelance writer and a consultant for APS. He lives in Madison, Wisconsin.

Browsing the Journals

Carl Mungan <mungan@usna.edu>

- Harvey Leff has begun a five-part series of articles on demystifying entropy on page 28 of the January 2012 issue of *The Physics Teacher* (http://scitation.aip.org/tpt/). In addition, two articles particularly caught my eye in the December 2011 issue. Craig Bohren discusses convective and radiative cooling in "Why do objects cool more rapidly in water than in still air?" He points out that a person can survive a long time in still air at 7°C but not in water at the same temperature. Secondly, on page 567, an experiment is performed to measure the slipping angle of a ladder leaning against a wall when there is friction at both the floor and wall, unlike the usual textbook case that assumes a smooth wall. I have been interested in this same problem (see http://usna.edu/Users/physics/mungan/Scholarship/RotationalEquilibrium.pdf), but it is the clever technique used here to keep the two ends of the ladder perpendicular to the floor and wall that validates the theory.

- Under the editorship of David Jackson, the *American Journal of Physics* (http://scitation.aip.org/ajp/) is continuing to publish a diverse range of interesting problems. Check out Behroozi's article in the Nov. 2011 issue experimentally relating the internal pressure of soap bubbles to their radius and surface tension. In the Dec. issue, learn about video measurements of the *added mass* of a thrown beach ball, arising from the fact that the moving ball must accelerate some air around it. There is also a fabulous *brain twister* involving a falling block that is connected by a string and pulley to a second block sliding on a frictionless horizontal track. On page 24 of the Jan. 2012 issue are measurements of the muzzle velocity of a compressed air cannon; it turns out that primary disagreement with simple theory is not because of friction as the ball moves down the barrel, but because of the pressure drop as air flows through the valve between the pressure tank and the gun. Finally, I found Corti's note on the Gibbs paradox in the Feb. issue to be particularly enlightening in understanding the tricky issue of distinguishability of ideal gas particles.

- Most of us are probably familiar with the idea that one can tell the Earth is round because the mast of a ship progressively sinks below the horizon as it sails straight away from shore. Kibble puts some numbers on a photo of a distant bridge to calculate Earth's radius on page 685 of the November 2011 issue of *Physics Education*. The journal can be accessed at http://iopscience.iop.org/journals.

- The same webpage also gives a link to the *European Journal of Physics*. The November 2011 issue has an article by David Rowland and three letters by Butikov, by Burko, and by Repetto *et a*l. discussing the surprisingly complicated matter of the correct expression for the potential energy density of a transverse wave on a string. The issue is that one needs to take correct account of *longitudinal* motion of string segments, which must occur if the stretching is uniform along the string. I have collected together some related discussions from the past decade of the momentum carried by mechanical waves at http://usna.edu/Users/physics/mungan/Scholarship/WaveMomentum.html.

- The November 2011 issue of *Journal of Chemical Education* (http://pubs.acs.org/toc/jceda8/88/11) has an article by Fieberg and Girard suggesting a pie mnemonic for relating the various thermodynamic potentials such as enthalpy and Helmholtz free energy, along with the corresponding Maxwell relations.

- The Fall 2011 issue of the *Center for Excellence in Education* Newsletters interviews a number of physicists at http://www.cee.org/sites/default/files/newsletters/cee_fall_2011.pdf about the issue of *Physics First* in high schools.

Browsing the Web

Carl Mungan <mungan@usna.edu>

Last issue I began with a collection of webpages devoted to STEM (Science, Technology, Engineering, and Mathematics) education. Here are some more:

- Science Mentoring Research at http://ehrweb.aaas.org/sciMentoring/
- Pathways to Science at http://www.pathwaystoscience.org/
- Illinois I-STEM resources at http://www.istem.illinois.edu/
- STEM Planet at http://www.stemplanet.org/
- Teaching Institute for Excellence in STEM at http://www.tiesteach.org/
- Great Science for Girls at http://www.greatscienceforgirls.org/
- Verizon's Thinkfinity STEM page at http://www.thinkfinity.org/stem
- Afterschool Alliance's STEM page at http://www.afterschoolalliance.org/STEM.cfm
- New York's STEM Education at http://www.nysstemeducation.org/

- An easy-to-use list of HTML special characters is at http://www.edlazorvfx.com/ysu/html/ascii.html. I also recommend http://www.av8n.com/physics/decorated-symbols.htm for a discussion of how to apply overdots, vector arrows, and the like to HTML symbols.

- Some simple animations and explanations related to introductory physics topics are available at http://www.fearofphysics.com/.

- A repository of materials on applied math and science of particular interest to community and technical colleges is at http://amser.org/.

- If you have not seen the incredible before and after photos of the Japanese tsunami at http://blogs.sacbee.com/photos/2011/09/japan-marks-6-months-since-ear.html you should immediately go and look at them. They are an amazing testimony to the resilience of the human spirit.

- An illustrated discussion of the relationship between painting and optics can be browsed at http://www.webexhibits.org/colorart/.

- The Center for Science & Technology Policy Research at the University of Colorado in Boulder has a rich website at http://sciencepolicy.colorado.edu/.

- A peer-reviewed journal that publishes student research is online at http://www.jofsr.com/.

- The University of Delaware has a Problem-Based Learning webpage at http://www.udel.edu/inst/.

- The National Institute of Standards and Technology has a timeline about… wait for it… time measurements through the ages at http://www.nist.gov/pml/general/time/.

- One of my colleagues pointed out there are some provocative posts (among some rubbish) about getting rid of college lectures at http://science.slashdot.org/story/12/01/03/2040253/when-getting-rid-of-college-lectures-makes-sense.

- NASA has a page at http://science.nasa.gov/realtime/jtrack/3d/JTrack3D.html/ that enables one to track satellites in 3D.

- Finally, MIT has a large collection of physics demo resources at http://scripts.mit.edu/~tsg/www/.

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