

Forum on Education

American Physical Society

Spring 2010 Newsletter

Amber L. Stuver, Editor

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From the Chair

Peter J. Collings

During my year as Chair of the Forum on Education (FEEd), it has become quite obvious that one strong aspect of the FEEd's activities is the high degree of interaction with other units within the American Physical Society (APS) and with other organizations involved with physics education. This is quite natural, in that many groups associated with physics have a genuine interest in the education of both future physicists and the general public. The most obvious joint endeavors are co-sponsoring invited sessions at the March and April APS meetings. Roughly half of the invited sessions the FEEd organizes are jointly sponsored with other APS units. In addition, three FEEd officers are members of the APS Committee on Education (CoE), and the Chair of CoE is a non-voting member of the FEEd Executive Committee. As I mentioned in the last FEEd newsletter, the FEEd has formalized two activities with the American Association of Physics Teachers (AAPT) that have been going on for years: (1) organization (with another APS unit) of a plenary session at the AAPT summer meeting, and (2) AAPT organization of two invited sessions at the APS April meeting. In addition, the FEEd Bylaws stipulate that half of the At-Large members of the FEEd Executive Committee are also AAPT members, and that one non-voting member of the FEEd Executive Committee is a member of the AAPT Executive Board appointed by the President of the AAPT.

This newsletter issue represents yet another activity in cooperation with an APS unit, in this case the Forum on Graduate Student Affairs (FGSA). Educational outreach is highlighted in this issue, with the emphasis on the efforts of graduate students, postdoctoral fellows, and other young physics professionals. In addition, this issue features a regular column called the "Graduate Student Corner," which will be of interest to both graduate students and FEEd members interested in graduate education. Graduate students write most of the articles in this newsletter issue, and we hope that this will provide impetus for graduate students to submit newsletter articles in the future. This new direction for the FEEd would not be possible without the hard work of Amber Stuver of the LIGO Livingston Observatory, who is an APS/AAPT At-Large member of the FEEd Executive Committee, an APS Councilor, a member of the AAPT Committee on Graduate Education in Physics and a former FGSA Executive Committee member as an At-Large member. I want to publicly recognize Amber's important contributions.

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

New FEEd Executive Committee Members

The Forum on Education held its 2010 elections for members of the FEEd Executive Committee in November and December. The new Executive Committee members are:

Committee who are leaving the committee this year. These are: Ernest Malamud, who served in the Committee Chair positions from 2006 to 2010, Olivia Castellini, who served as the APS Member-

Candidate	Institution	Position	Term
Renee Diehl	Penn State Univ.	Vice Chair, Chair Elect, Chair, and Past Chair	2010 – 2014
Alice Churukian	UNC-Chapel Hill	APS Member-at-Large	2010 – 2013
Richard Peterson	Bethel Univ.	APS/AAPT Member-at-Large	2010 – 2013

The Executive Committee thanks all of the candidates in the election for their willingness to serve the APS and the Forum.

We would also like to recognize the members of the FEEd Executive

at-Large from 2007 to 2010, and Samuel Lightner, who served as the APS/AAPT Member-at-Large from 2007 – 2010. Their contributions to the FEEd are greatly appreciated.

APS Excellence in Physics Education Award

At the Washington, DC joint APS “April” Meeting/AAPT Winter Meeting, the APS Excellence in Physics Education Award will be presented to The Activity Based Physics Group: “*For twenty-three years of national and international leadership in the design, testing, validation, and dissemination of research-based introductory physics curricula, computer tools and apparatus that engage students in active learning based on the observation and analysis of real phenomena.*” There will be a special invited paper session at the Washington, DC meeting in recognition of this award.

Representing the group (below) is **Priscilla Laws** (left photo) of Dickinson College, **David Sokoloff** (center photo) of the University of Oregon, and **Ronald K. Thornton** (right photo) of Tufts University.

The following group members were also acknowledged: Patrick J. Cooney, Millersville University, Ret.; David P. Jackson, Dickinson College; E.F. Redish, University of Maryland; Robert Teese, Rochester Institute of Technology; Martin Baumberger, Chestnut Hill Academy; John Garrett, Science Education Consultant; Maxine Willis, Dickinson College; Karen Cummings, Southern Connecticut State University.

The Excellence in Physics Education Award was instituted through the efforts of members of the APS Forum on Education. This is the fourth time the award has been presented. The nomination and selection process for the Award is described at: <http://www.aps.org/programs/honors/awards/education.cfm>.

The deadline for submission of nominations for the 2011 prize is July 1, 2010.



Priscilla Laws



David Sokoloff



Ronald K. Thornton

New APS Fellows Nominated from the Forum on Education

In November, six APS members were named Fellows by the APS Council who were nominated from the Forum on Education.



Laurence S. Cain of Davidson College was cited: *For strong commitment to the advancement of undergraduate teaching and research, and for significant contributions to introductory physics curriculum and assessment at the national level.*



David J. Griffiths of Reed College was cited: *For advancing the upper level physics curriculum through the writing of leading textbooks and through his contributions to the American Journal of Physics in many editorial roles and as an author.*



Ruth W. Chabay of North Carolina State University was cited: *For contributions to the development of computer-based learning and tutorial systems, visualizations, and curricula that have modernized and improved how students learn physics.*



Theodore W. Hodapp of the American Physical Society was cited: *For improving physics education by helping set licensure standards for physics teachers, and by leading the PhysTEC project to develop strong liaisons between university physics departments and schools of education to increase the number of qualified high school physics teachers.*



Lynn Cominsky of Sonoma State University was cited: *For her seminal work to promote student and teacher education using NASA missions as inspiration.*



Gay B. Stewart of the University of Arkansas was cited: *For her work preparing teachers at the University of Arkansas, and for her leadership in the Physics Teacher Education Coalition and on the College Board Advanced Placement Physics Test Development Committee and the AP Physics Redesign Commission.*

We congratulate the new Fellows and thank them for their contributions to physics education.

The deadline for nominations for 2010 Fellows is 1 April 2010. Information about the nomination process is found at: <http://www.aps.org/programs/honors/fellowships/nominations.cfm>.

2010 Gordon Research Conference on Physics Research and Education

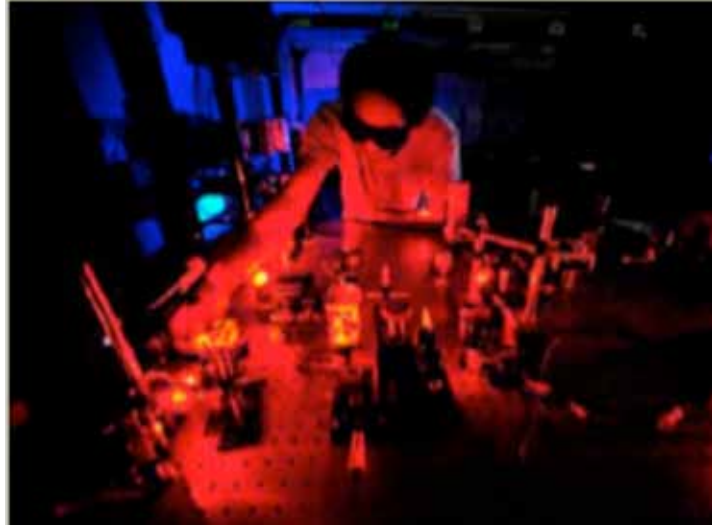
The sixth in a series of Gordon Research Conferences exploring the connections between Physics Research and Education will be held June 6 – 11, 2010 at Mount Holyoke College, South Hadley Massachusetts. This conference will focus on:

Experimental Research and Laboratories in Physics Education

Sessions:

- Undergraduate Research
- Upper-level Labs
- Experiments, Simulations and Modeling
- Advanced Lab
- Hands-on Experiments for Diverse Populations
- Innovative Labs and Approaches
- Frontiers in Experimental Physics
- Labs and Conceptual Learning

The confirmed speakers for the conference are: Joseph Amato, Mark Beck, John Belcher, John Brandenberger, Peter Collings, Sara Eno, Fred Goldberg, Jerry Gollub, Charlie Johnson, Pratibha Jolly, Matthew Lang, Priscilla Laws, Hideo Mabuchi, Mark Masters, Eric Mazur, Jan-Peter Meyn, Jim Nelson, Dick Peterson, Keivan Stassun, MacKenzie Stetzer, Nilgun Sungar, Dean Zollman, Alma Zook



Travel support for participants may be available.

Chairs: Chandrekha Singh & Kiko Galvez
Vice-chair Peter Shaffer

For more information go to <http://departments.colgate.edu/physics/grc/>

How to Increase the Number of Physics Majors

Stewart E. Brekke

The APS Executive Board and the American Association of Physics Teachers have gone on record as seeking to double the number of physics majors approaching 10,000 college students by the end of the decade. In order to attain this admirable goal I believe that the standard mathematically based algebra-trigonometry high school course must be made “user friendly,” not only for the upper 30% of normal high school populations who normally take high school physics, but also to the average student, minority student and female student who is often excluded from high school physics. It is the good experience in the high school physics course that generates many of the college physics majors. Therefore, we need to make these traditionally hard courses substantive, but also user friendly.

There is a great, untapped potential of minority students, Black and Hispanic, in the inner cities of this country who could be physics teachers and physicists if they could be positively tuned on to a career in physics. I have found over the years that many minority students can do the standard, mathematically-based high school course using drills and practice, especially in physics problem solving, with extra help from the high school physics teacher.

The environment for these minority students in the inner cities can be so devastating to young students of color that what appears to be simply a lack of motivation and achievement is really an indication of the amount of destruction that a repeatedly violent environment can work on what are really bright and capable minds. They may need extra help and well prepared lessons, not just standard high school physics texts to make up for years of poor teaching and motivation by the students themselves, especially the boys in the inner city.

Another group of high school students that could be tapped for the physics major in college is the average student in both majority and minority communities. In most high schools only the top 30% or so of the school population takes the standard mathematically based physics course and a few more take the chemistry course. A number of average students with hard work are good physics major candidates. Many students of average capacity would make excellent physics teachers, laboratory technicians and industrial science professionals thereby making good lives for themselves through these types of well paying jobs.

Traditionally, physics has been a male dominated subject. Unfortunately, in many minority high schools, males are often not the best students because gangs, violence, and negative peer pressure target them. Somehow, we must reach these at-risk minority males. However, the advanced mathematics and physics classes, especially at the honors level, are often populated by a majority of young women. These young women have to be courted to make college

physics, traditionally a male-dominated course, their major. These at-risk minority young women students could be excellent candidates for physics professionals such as teachers, professors, industrial and health scientists. However, the girls and these minority students, both girls and boys, need encouragement and direction because many of them have never thought of majoring in physics. By making all high school physics courses user friendly, substantive but not unnecessarily hard, physics teachers can generate many more successful college physics majors from the enormous pool of inner city and middle class, average and above average students, both male and female.

Many at-risk students do not always learn from examples in the text and/or from examples on the board. They learn from the teacher going around the room showing each individual student how to do a particular problem and then allowing the student to practice on two or more of the same type of problem. As time goes on these at-risk students get the idea of how to solve a mathematical type physics problem and with this type of empowerment they become interested in the real physics because they are successful in the mathematical type problem solving which is the basis of a career useful physics course. Many university physics and chemistry professors would be surprised at the variety and kind of high school students who can actually do a standard mathematically based college physics course from teenage mothers to gangbangers, and football players provided they are given a user friendly mathematical type course with help in high school and support in college.

In order to turn students of all types on to physics, so that they will make physics and chemistry their college major, the high school course must be made pleasurable in some way. In this manner the students will remember that they had a good experience in high school physics and may feel they will have the same good experience in college physics. B. F. Skinner once stated that good experiences produce pleasurable consequences. To keep those students in college physics as majors, college physics teaching must be made more user friendly. However, the high school course must be mathematically based so that when the student goes into higher education, he/she has a good foundation; the college courses in physics are more intensively mathematically based than the high school course.

During the cold war the number of physics majors was high. Unfortunately, those college courses in the 60's and 70's were not user friendly and a virtual “bloodbath of physics and engineering failures” took place. While there were many majors in physics and related subjects such as engineering, the number of actual graduates was far less in those majors, especially in the large state universities.

I found many at-risk students, average to honors, could easily do the standard mathematical physics course with varying degrees of help. I could thereby empower these students to be able to solve a standard high school physics problem and be prepared for a mathematical college freshman course. We need to make these high school (and even college) physics texts more user friendly. By employing the principles of learning instead of erroneously stressing so called “thinking”—a euphonic for actually making physics at all levels unnecessarily hard—in the teaching and texts, we can turn many students on to physics. Learning should be the emphasis in physics to keep and encourage physics majors, not unnecessarily emphasizing struggling with the problems but on solving them correctly.

Often, the problem solving aspect of the course (the main and most effective manner of teaching and learning physics) has become a dreaded endeavor for the student, from the most competent to average. Problems often have no example in the text, and most students cannot solve even basic physics problems without some kind of outside help. A vast multimillion dollar industry has arisen in which physics, engineering and other technical mathematical problem solvers (such as the wonderful Schaum’s College Outline Series) provide insights into the solution of physics problems which could easily be solved if an example problem is given in the text. These physics texts often give hard problems under the erroneous pretext of raising the thinking capacity of the student, undergraduate to graduate, when in reality the student rarely does any thinking of that type to solve the problem. Mostly, the students look for an example of how to do the problem in a physics problem solver or get someone, such as a friendly professor, to solve the problem. Unnecessary emphasis on solving hard prob-

lems turns many potential students in physics off. Today, a vast tutoring industry is also developing across the nation. A few years ago I took an advanced physics course and hired a tutor who I saw twice a week at \$20/hr to help me pass the course. I passed with an A, my time was maximized, and I learned quite a bit. In high school I interacted with a minority student of another teacher who spent six hours at home trying to solve a problem that I showed her how to do in two minutes. An example in the text would have saved this young minority student six hours of wasted effort which if repeated again and again would have certainly turned her off of mathematics: a field in which she could make a decent wage if she majored in it and given her access to equality.

In summary, we need to make high school and college physics more user friendly if we are to increase the number of physics majors. However, to increase the number of physics majors is not enough. We must actually graduate a larger number of those initial physics majors though better texts and teaching which employ the basic principles of learning, such as more examples of problems to be solved in the texts and the increased use of drills and practices of those problems. We must also target more minority students, Black and Hispanic, and we must target average students and young women in the high schools. To reach these traditionally at-risk students, average and women students in high school (where interest in physics begins) we must make these traditionally “hard” courses much more user friendly.

Stewart E. Brekke (Stewabruk@aol.com) MS in Ed, MA, retired from Chicago Public Schools where he taught high school physics and chemistry.

From the Editor: On Outreach, Education and Junior Physicists

Amber L. Stuver

The most surprising thing that graduate school taught me was how much I enjoyed being an educator. The feeling of accomplishment I had when I successfully conveyed information to another person is what kept me going through the rough spots of grad school. This led me to become involved in as many opportunities to teach as I could and to make physics education a priority in my career goals. Along the way, I have encountered many peers who feel the same and do excellent work to go out and share their love of science with the world—in and out of the classroom.

As mentioned by Peter Collins in the “From the Editor” article of this newsletter, I have been active in the Forum on Graduate Student Affairs (FGSA) and am working to connect us with other related groups; in particular the APS Forum on Education (FEd) and the American Association of Physics Teachers (AAPT). When I was presented with the opportunity to edit an edition of the FEd Newsletter, I immediately volunteered with the idea of publishing

an edition themed on outreach and public education with a special focus on work done by graduate students and junior physicists. This newsletter is the result of that effort.

Of the following nine articles, graduate students or junior physicists wrote six. The first two deal with the experience of graduate students in the NSF-funded GK-12 program which places STEM graduate students in kindergarten through 12th grade classrooms to gain experience in communicating science and to bring cutting edge science into classrooms. **Justin Mitchell’s** article is from a physics graduate student’s perspective and **Kristy Longsdorf’s** is from a chemistry graduate student’s perspective. **Kelly Herbinson** (a graduate student in creative non-fiction writing) and **Maggie Renken** (a graduate student in developmental psychology) discuss innovative outreach being done by graduate students to bring science into Wyoming classrooms. **Cristina Torres** discusses her experience in performing outreach to an under-represented group

while a graduate student at the University of Texas at Brownsville. **Stephanie Chasteen** describes the lessons she's learned about communicating science through her broad experiences. The remaining articles deal with outreach and education on larger scales and are written by more experienced physicists. **Bob Eisenstein** describes the Santa Fe Alliance for Science's mission to improve math and science education in Santa Fe Schools. **Marco Cavaglia** discusses organizing and implementing an education and public outreach group within a large scientific collaboration. Finally, **David Willey**, the "Mad Scientist" of *The Tonight Show* with Jay Leno, expounds upon his experiences performing outreach to large audiences and outlines useful lessons he's learned.

This newsletter also features a new regular column called the "Graduate Student Corner." This edition's "Corner" is written by Ivelisse Cabrera, the FGSA International Affairs Officer, on the recent CAM (Canada-America-Mexico) Physics Graduate Student Conference

that was held in Acapulco, Mexico on 22-24 October 2009.

I sincerely hope that you find this newsletter interesting both for the outreach it documents and for the small sampling of the outreach efforts being done by both junior and senior physicists alike. If you would like to share your outreach innovations or lessons learned, please feel free to contact me or the current editor of the FEd Newsletter about publishing it here. I also hope that this sampling of graduate student articles inspires many more graduate student submissions to the FEd Newsletter, on outreach or any other education related subject.

Amber Stuver (stuver@ligo-la.caltech.edu) is a postdoctoral scholar for Caltech at the LIGO Livingston Observatory. She also serves as the FGSA Councilor, is an APS/AAPT Member-at-Large on the FEd Executive Committee and serves on the AAPT Committee on Graduate Education in Physics.

Physics Education Outreach: A NSF GK-12 Fellow's Experience

Justin Mitchell

When I was an undergraduate physics student, my adviser asked me to talk about my research to a room full of grade-school children at a suburban magnet school. When I walked into the gymnasium, the first person I saw was my adviser's seven-year-old daughter. For most of the students, though, I was the first real scientist they had ever seen.

Luckily, my planetary science experiment was one that could be made interesting to non-scientists. A mock-up of our equipment helped me explain to the kids about how comets and planets form. I was a welcome break in the day of a busy first grader, with strange toys and distinctly non-grown-up hair. As I left, the teachers were gracious and the kids were excited by my lesson and demonstration.

"So this is outreach," I thought to myself as I drove back to campus. I had just communicated actual science to actual children in an actual public school, albeit an elite one.

After I entered graduate school at the University of Arkansas, I became a fellow of the NSF GK-12 Program. For those unfamiliar, GK-12 is an NSF sponsored program that brings graduate students from STEM fields into school classrooms from kindergarten to 12th grade. GK-12 programs at different universities operate in a variety of ways. In my case, graduate students were paired with individual teachers in 6th grade classrooms. We spent a month during the summer learning about middle-level pedagogy, inquiry-based teaching and local subject matter guidelines in science and math. We also met extensively with the teachers we would work

with for the next 9 months. I would spend the next academic year developing and teaching lessons with my partner teacher.

I'm not sure if any amount of training can prepare a person for 6th graders. Their energy is mind-boggling. Little from my year as a university teaching-assistant transferred to this new environment. Classroom management in a room full of sophomore engineering students is effortless compared to a room full of 6th graders. I quickly learned to create lessons that would direct their energy rather than try to contain it. My respect and understanding of my partner teacher's skills changed dramatically. Where before I may have been able to connect a lesson to a dozen different topics or examples, turning that understanding into a meaningful, salient experience on a shoestring budget was something I knew nothing about.

One of my first realizations was that to a 6th grader, nothing is real until you can put it in the next kid's hair. A textbook illustration of a crystal structure is good, but having students make models themselves is far better.

With this in mind, I built matching games to connect animals and their biomes, grew mustard plants to demonstrate stages of plant growth, graphed data on the school's sidewalks, built simple speakers, and flipped M&Ms to simulate radioactive decay. My goal was not only to allow students to learn with their hands, but to engage them to ask more frequent and more meaningful questions.

A second realization took longer to sink in: I was the only scientist

most of these students had ever met. This led me to say two important things over and over. The first is that I describe scientists as *we scientists*. My goal in saying this wasn't to impress anyone (6th graders are hard to impress); my students needed to see that real scientists are real people who have the same thoughts and questions they do. More importantly, the second thing I could say was that "if *you want* to know the answer to a question *you* do the following." The importance of this response is that it is actually an invitation. The implication is that there is an answer to each question, a straightforward way to find it, and most importantly, students are capable of finding it themselves.

A lesson that sticks with me is how rarely teachers are treated like the well-trained professionals they are. GK-12 was both my most formal and extensive training in pedagogy, and as a person who aspires to enter the academy I'm extremely grateful for that experience. Working with motivated, experienced and thoughtful teachers made a lasting impact on the way I teach and what I think about educators. I was able to experiment building lessons while supervised by a master teacher, could take great risks, fail

and learn why. I look forward to utilizing these professionals in my own outreach efforts in identifying and solving local educational difficulties.

The first class of 6th graders I taught are now beginning to think about their own college plans. Clearly, very few of them will become scientists, but they will need to understand how science works and how scientific information is created. Spending an hour with a scientist does little to communicate such an understanding. Spending a few days each week for an entire academic year may still not be enough. My outreach experience in GK-12 showed me that connecting with a scientist through sustained, focused outreach can at least help a young person appreciate science and what *we scientists* have to offer our communities.

Justin Mitchell (nanojustin@gmail.com) is a doctoral student at the University of Arkansas Department of Physics. His research is in theoretical molecular spectroscopy. He plans to graduate in the spring of 2010.

Returning to High School for a Few More Lessons

Kristy M. Longsdorf

With the alarm buzzing in my ear I roll over to find that the time is 7:30am. My first thought—"Oh no, I am going to be late for school!" So why is a graduate student rushing to get to high school on time? Is it some bad dream of memories past? This morning as I bustle about getting ready to leave, I am not donning on the lab coat today for research, but making a 20 minute commute to a local high school for participation in an outreach program. The NSF Graduate STEM Fellows in K-12 Education (GK-12) Program provides fellowships and training for graduate students in science, technology, engineering, and mathematics (STEM). The GK-12 program seeks to unite graduate students in the sciences with science teachers and their classrooms from grades K-12 in local school districts for the duration of an academic school year. The goal is to enhance primarily the graduate students' communication skills of science to a general audience and secondarily the educational content of the classes.

In the university setting surrounded by other graduate students and professors who are immersed in the culture of science and academia, we are often content to ramble on in our own jargon, filled with acronyms and sayings. When we communicate with the outside world, we are sometimes unaware that other audiences may not quite be grasping the concepts we are attempting to simplify. As a teaching assistant at the University of Delaware, I had some experience at adjusting my level of terminology for the undergraduate chemistry laboratories I led. However, now I would be working with high school students who have quite a different level of thinking and interest in science compared to undergraduates aiming for a degree in the sciences.

As a GK-12 participant, the chance to return to a high school to see the flip side (the teaching side that is) of what a general science class was responsible for knowing and how that material was transmitted gave me a different perspective on science in a classroom. It was humbling to realize how difficult it was to relate "simple" concepts that I have learned for the last ten years of my secondary education to students. For the first time I quickly learned that even when I thought the most general and non-scientific explanation possible was being used, it was still speaking above my audience. By working at being able to explain science at a 9th grade level to students, I was able to improve my communication skills in a way that graduate school never would have prepared me for.

The realization of how important relating students' lives to science concepts was another outcome of the GK-12 experience. There is always talk of how many of the products we use daily involve science, but those words themselves do not bring significant meaning to the student's mind regarding scientific concepts. However, taking the time to ask how science might influence a student's life allows them to see that it is more than just a CSI case solved in an untouchable and far away laboratory. It can be an exercise as basic as choosing a product they use and making a chart of how energy was transferred by different people and objects just to use that one product. Or it can be a more in-depth homework assignment, where students actually sit down with their parents and determine energy usage and what they would do if their energy consumption needed to be limited. Would they perhaps consider alternative energy sources or would other changes in their lifestyle be made? By bringing science to the student's level of reality and how it af-

fects their lives captures their attention and encourages them to be invested in the subject.

Students aren't the only benefactors of science outreach programs. While the GK-12 participants were educated on how to best present to students in a classroom, the teachers benefited from the graduate students presence as not only an extra set of hands, but by way of another set of ideas. Being a graduate student in a laboratory setting day in and day out, I was able to give suggestions for improvements on laboratory experiments. Also, I was able to offer my partner teachers more detail or background information to clarify a science principle being taught. The teachers I worked with were also thankful to have an outside voice, an "expert" in a given field, who could bring a different point of view to the classroom. This change of who is up in front of the class and talking about a topic is enough to change the interest level of some students. For example, after giving a PowerPoint presentation on the properties of water, I asked the class if there were any questions on the lecture. One student who had previously shown little interest in prior lectures said in a puzzled tone, "That was a lecture? But it was interesting...."

While participation in the GK-12 program was initially introduced to me as an option for an alternative method of funding, it has become so much more. This outreach experience has inspired me

to continue to be involved even after graduate school. As a speaker I am more confident in being able to relate science concepts and ideas to a broader audience. I truly value the daily efforts that teachers make to keep science interesting and relevant to their students despite the amount of material required to be covered in a given semester. As an instructor I have seen first hand the personal links that need to be formed to encourage students that they can understand and use science too. As a professional in chemistry I realize that scientists should be partnering with teachers to enhance the education of tomorrow. It is the responsibility of all scientists to teach in some capacity. Science is our career, our love, our passion; shouldn't we be taking at least some time to share that with the community?

Kristy M. Longsdorf (kristy@udel.edu) participated with the GK-12 program from 2007-2009 through the University of Delaware and New Castle County Vocational Technical School District. She received her B.S. in chemistry at Pennsylvania State University in 2001 where she was involved with the Women in Science, Engineering and Technology (WASET) program as well as participated in and organized outreach events as a member of both the Nittany Chemical Society (NCS) and the Nu Chapter of Alpha Chi Sigma (AXΣ) with schools in the State College area. Ms. Longsdorf is currently pursuing her Ph.D. in analytical chemistry at the University of Delaware.

The Science Posse: Innovative Outreach Connecting Graduate Fellows and K-12 Students

Kelly Herbinson and Maggie Renken

Wyoming is best known for its looming landscapes—the high plains, Rocky Mountains and grandiose Yellowstone National Park. It is also the least populous and tenth largest state, with just over 520,000 people living in 98,000 square miles. With approximately five people per square mile, science, technology, engineering and math (STEM) education outreach becomes an ominous task. Fortunately, the Science Posse, a team of interdisciplinary doctoral students at the University of Wyoming, is up to the challenge.

The Science Posse was established at the University of Wyoming in 2005, and for four years has introduced over 4,000 K-12 students throughout the state to science and math in fun and engaging ways [1]. Graduate fellows working in the program share a passion for research and education and have represented the fields of botany, chemistry, ecology, electrical engineering, geology, molecular biology, mathematics, neuroscience, paleontology, pharmacology, physiology, psychology, and zoology.

Fellows deliver classroom activities throughout the state, including:

- **Careers in Science Presentations** during which they discuss

their research, talking about the things they like and dislike, what the atmosphere is like, and what careers they can pursue later with the expertise they acquire.

- **Science Fair Collaborations** during which they assist students and teachers with science fair topics and development. They introduce students to the scientific method, discuss the qualities of a good research project, and provide ongoing support.
- **Science Demonstration Days** during which they perform authentic experiments and demonstrations designed to excite and awe students. (Popular lessons include dry ice experiments and sheep brain dissections.)

For more in depth, inquiry-based experiences, fellows have created two mystery units for students to solve:

- **CSI: Wyoming, Murder in Yellowstone** invites students to solve a crime using anatomy and dissection, forensic psychology, ballistics, forensic entomology, toxicology and DNA evidence to solve the crime.
- **CDC: Wyoming, The Twin Pines Mystery Illness** challenges students to work together to uncover the cause of a strange

illness. Students experiment with the engineering of energy sources, cryptography, bioaccumulation, diagnostic medicine, geology and hydrology to determine if the town's water has been contaminated by the nuclear power plant, the old gold mine, or the pig farm.

The Science Posse also welcomes students to the University of Wyoming campus for lab tours. Graduate fellows give visiting students a tour of their labs and discuss their research and their experiences as graduate students.

In addition to traveling throughout the state, fellows are paired with local teachers. This academic year, nine fellows have worked in teams with local teachers to collaborate on the development of inquiry-based science units that address ecological responsibility in relation to energy consumption and water quality.

Through these varied outreach activities, the program seeks to increase Wyoming students' understanding and appreciation for what science is and what scientists do using innovative, inquiry-based methods designed to spark curiosity and investigative thought. These endeavors ideally encourage students to take more math and science courses in high school and to consider STEM careers. The Posse also strives to increase teacher knowledge and awareness of developments in the process of modern science and advancements in science education techniques.

While K-12 students and educators may appear on the surface to be the main beneficiaries of the Science Posse, the program was designed with goals addressing benefits for everyone involved, and graduate fellows are at the heart of the program. In regard to the fellows then, the program aims to increase their ability to translate research into relevant and meaningful discourse. It also introduces them to the importance of public service while providing such service opportunities. Finally, graduate fellows are involved in interdisciplinary discourse throughout the year as they work together to create science lessons. Together, these components of the fellows' experience function to develop a generation of research scientists dedicated to and well-versed in communicating their research and its importance to the public.

Perhaps better articulated in the graduate fellows' own words, after a year of Science Posse involvement, one student reflected, "a great aspect of the Science Posse is that we get to present our find-

ings and model systems to a lay audience. This audience is particularly valuable because they often ask questions that you might never have to field in the typical confines of your academic area of expertise. As such, I think you get pushed to learn more about your subject area, albeit in a much more general sense, than you might normally." Another graduate fellow found that, "ultimately, [he had] gained a better understanding of how to effectively teach science, and this will help [him] in future work with both middle school and college students."

Unlike most STEM outreach programs, by combining a local partner teacher component with a massive intra-state outreach program, teachers are provided a variety of options for inspiring their students to pursue STEM education and careers. For graduate fellows, the Science Posse's unique outreach model instills flexibility in teaching and communication skills—something not always acquired teaching undergraduate courses alone. Although the state of Wyoming is expansive, the Science Posse continues to offer unrivaled support for Wyoming educators, scientific inspiration for Wyoming students, and unparalleled teaching skills for University of Wyoming STEM doctoral students [2].

References

[1] Since its inception, the Science Posse has been funded through a Science Education Partnership Award (SEPA) from the National Center for Research and the National Institute of Health, by the University of Wyoming, and by the National Science Foundation Graduate Education in K-12 grant program.

[2] For more information about the Science Posse, visit our website, www.scienceposse.org.

Kelly Herbinson (kherbins@uwyo.edu) is a masters student in creative non-fiction writing at the University of Wyoming interested in the creative communication of scientific concepts. She holds both a Bachelor's and Master's degree in Ecology and studied desert tortoises and ants before becoming a writer.

Maggie Renken (mdehart@uwyo.edu) is co-coordinator for the Science Posse and a doctoral student in developmental psychology at the University of Wyoming. Her research focuses on adolescent reasoning and science education with specific interest in misconceptions in the physical sciences.

A Graduate Student's Use of Education and Public Outreach as a Looking Glass into Her Culture

Cristina Torres

I believe it is a safe assumption to say that most professionals in science and education feel concerned with education and public outreach (EPO). When one thinks of EPO, our goals seem very straightforward: we strive to instill an appreciation for education and a desire to educate oneself on technological subjects. We each have a slightly different interpretation of what EPO means but my interpretation is probably very similar to the interpretation held by most individuals concerned with EPO. As people actively engaged in EPO we may be biased, as to EPO's importance, but the society at large also recognizes the importance of education. The recognition of EPO's importance is so widespread that we even see it discussed in the halls of city and national government.

Acknowledging the need for EPO in our society is obvious. The question we actually ask ourselves is "Since EPO is important, how should it be carried out?" It is very important to know where we want our EPO efforts to go and more importantly, "How do we reach those goals?" We all agree on a "goal" for EPO efforts, but deciding the optimal prescription to reach those goals is not trivial. Instead, we must acknowledge the inhomogeneous nature of our societal collective, and realize a "one size fits all approach" is not only difficult, but possibly detrimental to our long-term goals.

To reach potential EPO goals, a targeted approach is the optimal solution. We then need to decide, "Who or what are we targeting?" because EPO's target audiences are as diverse as the demographics in our society. Target groups can be very complex in composition and display behavior influenced by gender, religious belief structures, language, ethnicity, family structure, age, social stature, income bracket, etc. The ways in which we could classify potential target audiences seems endless. What should determine our ideal target audience and optimized prescriptions for reaching our audience has less to do with the audience and more to do with ourselves. The EPO movement is far from monolithic, and by looking inwards at ourselves, and using our inherent diversity we can determine what groups can be targeted most easily and effectively. An EPO group's internal demographics should guide its activities and tailoring techniques. The more an EPO group can be structured to reflect its local demographics the more an EPO group is likely to experience a boost in effectiveness.

During my experience as a graduate student involved with The University of Texas Physics and Astronomy EPO group, our internal demographics were an advantage. The University of Texas at Brownsville (UTB) is a primarily Hispanic serving institution, and is located in a border region whose Hispanic community comprises 91% of the local population [1]. This places UTB and its outreach efforts in a truly unique position when one considers that the concentration of Hispanics in Texas as a whole is only 32% [1]. As a Hispanic physics graduate student working in EPO,

my experiences served as a mirror into my own culture. UTB's group is engaged with activities like local science fairs, a traveling physics circus, public popular science talks, school visits, teacher workshops, and student science camps, all of which are used to stimulate our local community on a regular basis. Each time we engaged the community it gave me a unique opportunity to uncover more about how my community, the Hispanic community, related to the university and the technical world at large.

The Hispanic community is an under-represented (minority) group similar to African-American, Asian and many other minority groups. The fact that Hispanics are a minority group I believe is not an internalized reality in Brownsville, TX but rather an abstracted fact, because UTB is in the middle of a cultural microcosm. It is this microcosm which influenced my development from child to adult, and highlighted the fact that while all groups share similar traits each one is unique. Homogeneous environments like that in and around Brownsville, Texas magnify the effect and importance of cultural nuances more than one might think. What I witnessed during my time with UTB's EPO group was very illuminating; it showed me the barriers to higher education we face, some internal to my culture and others external to my culture that all minority groups deal with. I'd like to share a collection of my experiences as a Hispanic graduate student helping with EPO, giving my perspective on the positive and a few negative experiences while promoting scientific awareness in the Hispanic community.

Our local community, as I see it, reacted to our outreach efforts in a counter-intuitive way. I noticed that in many instances, the receptiveness level of an audience was very dependent on the ability of the audience to relate to us. During our events the levels of audience hospitality and engagement could be arbitrarily divided into two categories: one, EPO volunteers as part of the audience's "personal" community, and, two, EPO volunteers as social outsiders. If the audience seemed to "adopt" us our EPO impact was significantly boosted, but the amount of the boost is difficult to quantify. For example, we experienced a greater impact with our audience when, after a show, time permitted our physics circus performers to mingle extensively the audience.

The comments from the audience were typically about how the audience member could see their brother, sister, parent or sometimes themselves performing some element of our show. Integration of personal experiences via association to familial bonds and relationships seems to be a fairly standard trait in my community [2], one of which I became consciously aware after working on UTB's EPO activities. In more negative situations, a typical audience member who did not internalize the experience positively did not seem to relate the EPO volunteer to someone in their family hierarchy. In situations such as these our efforts were considered

akin to the role of a salesperson or recruiter, who was expected to have a hidden agenda or was just someone to endure. Tailoring activities so that they are as successful as possible required that the target audience be given an avenue to internalize the activity through an emotional connection to the EPO group. The science content proved to be less important than one might initially expect, and this was certainly truer the younger our target audiences were.

In situations where our target audience was teen or adult, the optimal approach changed somewhat from approaches we relied on for younger target groups. When working with older groups, the EPO efforts were less entertaining and more informative. Examples of these types of events were teacher training workshops, student academies, and science competitions like science fairs. For these event types, I believe the fact that we were mostly graduate students offered two concurrent benefits. It was possible for us to connect to both slightly younger audience members and older audience members simultaneously. In the case of a connection to a “younger” person, the same basic internalization and association of the EPO volunteer to someone in their family shaped the success of our efforts.

The primary difference here is that our targeted person needed to not only associate us to a respected person in the social hierarchy but also realize it was possible to move to a position of respect in their own local community as they age. This internalization allowed us to successfully break negative stereotypes of technically educated people as “nerdy”, “uncool”, “old”, and “socially isolated.” The last stereotype in particular is one that I feel is most important to break when doing outreach in a Hispanic community. In the second case where our interaction was with an “elder” person, a similar internalization of our interaction was required. In this case the elder person would be positively impacted by our interactions if they perceived us as “one of them,” a peer of sorts who is very approachable and willing to share knowledge. This again harks back to the idea of close-knit community, which is a common theme in the Hispanic community. For elder audiences the most important stereotype to break was this idea that technical/scientific people were “socially isolated” and that this isolation is the norm.

The last technique that I’ve had experience with is the “camp” or “academy” EPO activity. In this type of environment I think we use the least amount of target audience tailoring. In my interactions with students during summer academies, I found that carefully challenging the students built self-confidence. I feel confidence building in the Hispanic culture is important because I’ve witnessed and experienced a feeling of unfounded transient inferiority. This uneasiness seems to be common at least in my region among Hispanics and has been verified by experts researching education of the Hispanic community [2, 3]. In my summer academy groups, I believe my impact was maximized because my entire group of students could relate to me as a fellow Hispanic, possibly someone who once had similar fears and concerns as my students. In this environment students could internalize the experience posi-

tively by considering me to be a role model. My students realized I was integrated tightly into the Hispanic community, functioning in my own family structure and working to better myself. Seeing me in this light, they could project themselves onto a similar life path that satisfied Hispanic cultural expectations and societal responsibilities.

While working with the UTB EPO efforts I was able to gain an appreciation of the subtle ways that Hispanic culture permeates and influences all people in the culture. One way in which Hispanic culture influences its members stems from the fact that our culture tends to be functionally bilingual. While growing up I was not conscious of the influence from my bilingual family and surroundings. Imagine for a moment that concepts are regions in a memory hyperspace which is our brain. Now, imagine that words are mapping functions to those concept regions, and concept regions are not always mutually exclusive. Now, I want to introduce two innocuous words, cognates (words only phonetically similar), one in English and one in Spanish. I didn’t realize the impact this word pair had on me until I saw its impact in our Hispanic EPO audience members. The words are education and educacion, accent on the ‘o’. Influences from cognates like these have been researched when dealing with educating Hispanics [2]. Education is “... the act or process of training by a prescribed or customary course of study...” as stated in Webster’s dictionary. Educacion and education are cognates but have different meanings. According to the Oxford Spanish dictionary educacion could mean education, but it simultaneously refers to “upbringing” and “manners.” In the Hispanic culture educacion is more than a prescribed course of study resulting in more knowledge. For me, and most Hispanics, “education” defines a region in our concept hyperspace which is actually a subspace of the region spanned by the concept of “educacion.” I don’t know why, but I subconsciously interconnected/interchanged the concepts of educacion and education, and as a result education evolved into a very personal concept. Cognates like this are nefarious and for Hispanics can lead to strange feelings about educators, different academic subjects and feelings about our educational accomplishments versus social accomplishments. I witnessed unexpected behavior in our EPO target audiences which could be due to cross-linking of concepts in our minds as a result of simultaneously acquiring two languages. The effect of language on the way Hispanics value and pursue education could be written off as speculation, but education research seems to indicate this is an observed characteristic of multi-lingual minority groups and can’t be dismissed.

My experiences as a graduate student working with the UTB EPO efforts were very enlightening. For me personally, working with an almost exclusively Hispanic community offered me a looking glass into the influences that shaped my choice to go into physics and how I perceived the sciences at large while growing up. Doing outreach in our communities is very important, and for me, I think working with under-represented communities like the Hispanic community requires tailoring of programs and materials presented to the community. I also think that integrating responsible graduate and undergraduate students into various EPO projects is an excel-

lent technique to build bridges across generation divides present in most any EPO audience. I feel this is especially true in the Hispanic culture which is heavily reliant on interpersonal connectivity and a feeling of belonging/self-worth.

EPO in any context is very much a “service before self” operation. The amount of work required to perform effective EPO and continue making impacts in our local communities requires a serious commitment. This level of commitment can be maintained by science professionals and graduate students working cooperatively. While making quantifiable measurements of the impact of any single EPO activity is difficult, I’ve noticed subtle changes in our community as a result of repeatedly reaching out and stimulating the community. Measuring EPO progress is abstract and difficult, but perseverance over time will bring us a measurable result. Unfortunately we can’t estimate the outcome of our efforts, but we can optimize our EPO activities within the world we live by tailoring each EPO event for maximum effectiveness. Working in EPO is important, has taught me to know my audience, and has instilled in me an appreciation for the community I grew up in.

Speaking of Physics: The Art of Science Communication

Stephanie Chasteen

“If you want to understand the weird nature of neutrinos, do this experiment at home. Try to walk through a wall”

[Thump] “Ow!”

“Eh, maybe it’s not such a good experiment. The reason that you can’t walk through a wall is not that you’re too big. ...The reason you can’t walk through a wall is because your atoms, and the atoms of the wall, *interact* with each other. They speak the same language. They push on each other because they have electric charge. Neutrinos have almost none of the usual atomic qualities. ...So neutrinos have kind of a sad life. Once a neutrino has popped into existence it has almost no way to touch the physical world again.”

That’s David Kestenbaum’s one-minute synopsis of particle physics, setting the stage to talk about a new experiment to try to detect the ghostly little particles. He snags us with wit, a conversational tone, and something that we *can* relate to (the solidity of wood paneling) to bring us to an understanding of something quite foreign. It’s a delightful piece of radio – give it a listen at the link in the reference [1]. This is science communication at its best. It’s stuff like this that got me hooked.

What is this article about?

As a young physicist, I’ve had the immense good fortune to work with several expert communicators, like David Kestenbaum, to

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Cristina Torres (cristina.torres@ligo.org) is a first generation college graduate working for Caltech as a postdoctoral scholar on dual assignment with Louisiana State University and LIGO Livingston Observatory.

learn the best ways to bring science to diverse audiences. I realized in graduate school that I was more interested in helping people understand and appreciate physics, than in creating more physics myself. Those were back in the days of early global warming skepticism, and I was appalled at the general lack of trust and understanding of science. I wanted to do my part to change that. This article will tell you a bit about how I was able to get involved in science outreach, and the best practices that I’ve taken away from those experiences.

What have I done with my life?

There are many opportunities to be involved in science outreach. Even if it’s not a career goal, it is so important to be able to communicate clearly with people outside your discipline—because of the growing emphasis on interdisciplinary research, and the NSF Broader Impacts criteria. But me, I knew I wanted to create a career in outreach. Here’s how I did it:

1. **Science journalism.** I took a journalism course, attended science writing conferences, and wrote for the local newspaper, websites, and other venues.
2. **NPR’s Science Desk.** On the basis of my journalism clips, I was accepted into the AAAS Mass Media Fellowship, which places graduate students in the sciences into mass media outlets to learn to talk like normal folk.
3. **Other opportunities.** I networked like mad, and one opportunity led to another. I presented at a science book club, and

volunteered at science fairs. I did research for a public television program on cosmology. I did project management for a scientist/museum collaboration team.

4. **Postdoc 1: Exploratorium Museum of Science.** After my PhD, my first postdoc was at the Exploratorium, a world-famous museum of inquiry and hands-on learning. I learned to create and teach workshops for high school physics teachers, and created two podcast series.
5. **Postdoc 2: University of Colorado at Boulder.** Wanting more information about how people learn, I joined the physics education research group at Boulder. I focus on improving student learning and helping teachers use instructional technology more effectively.
6. **The center of my own universe.** I'm now a part-time consultant, doing a broad range of science education and communication projects. It's the best of all worlds—interesting projects that can have a real impact on people's understanding and appreciation of science. I also blog, at <http://blog.sciencegeekgirl.com>.

So what?

Certain themes keep coming up, in all these diverse venues. How to get your message across? Here is a smattering of what I've learned.

Hook people in

One of our Exploratorium teachers begins a unit thusly. He tells a kid, "You have an assignment. Fill this cup with water, and put an index card over the mouth of the cup. Invert the cup, holding the card with your hand. Put the cup over my head. Then let go of the card." Now, the whole class is rapt (and the student in question is a bit stressed out). This *provocación* or "hook" gets the kids interested—much more so than starting with "today we'll be talking about pressure" (yawn). I began this paragraph with a hook. David Kestenbaum snagged us with the weirdness of neutrinos, and a bit of humor. In college classrooms, an interesting question could begin the class period. A clearly organized class session or public lecture often falls flat because the teacher or speaker failed to be a good salesperson. The education literature supports this—motivation is key to learning. Why should I bother to learn something that I don't care about? We wouldn't have survived as a species long enough to even talk about learning science if we habitually wasted time on things that didn't matter. Make it matter.

Help people relate

Kestenbaum began talking about neutrinos (very unfamiliar) by talking about our bodies, and how they interact with plasterboard. It's important to explain new things in terms of something known. That's why we take undergraduate mechanics before we take graduate mechanics: a good instructor will guide us in learning ever-more complicated ideas by tying them first to what we can already do pretty well (that's called "scaffolding"). The same applies in public lectures, talking to school groups, or writing for the public. Ground it in the familiar. This is why it's key to have a sense of your audience—what do they know, where are they start-

ing? Analogies and metaphors, or connection to the real world, can help bridge this gap in understanding.

Get people actively involved

The activity where a student holds a water glass over his teacher's head is brilliant—it not only creates that hook, but it gets the student engaged in the lesson through activity. At the Exploratorium, we focused on hands-on activities—exploring the shadows cast by colored light bulbs, or shocking our fingers with charged pie plates. Not all "active" learning has to be physical however—in the college classroom we use interactive computer simulations (such as those at phet.colorado.edu) or devices that prompt students to articulate and debate ideas in class ("clickers"). All the research shows that—for the most part—people don't learn by passively listening to a lecture or watching a demonstration. That does not prompt the kind of brain activity required for the neuronal rewiring that constitutes learning. You have to ask them to debate, articulate, create, answer, explore, ponder, predict, and explain.

Language is colorful

...so use it that way. "Neutrinos have kind of a sad life," wrote Kestenbaum. We've all heard the mantra to "avoid jargon," but sometimes it's harder to do than it sounds. To some audiences, "conductor" is jargon. Using colloquial, conversational language is key—like you'd talk to your aunt, as long as she's not a particle theorist.

It's more complicated than that!

In public communication, we are generally aiming for a sense of understanding, rather than the type of rigor we are used to in scientific communications. It's almost physically painful, at first, to let go of the caveats and details that we are used to including when discussing science. My mentor at the Exploratorium had a tag phrase, a verbal footnote—"It's more complicated than that." This allowed him to give the simple explanation, but maintain the integrity of what he was saying. We know that people can only process so many new pieces of information at once—this is called "cognitive load." When your brain feels full in lecture, that's why. So, keep it simple. If you're going to lose your audience by giving extra detail, leave it out.

It's fascinating to me, as I write this article, how the four disparate forms of science outreach that I've engaged in—science journalism, public outreach, classroom education, and education research—share these common themes. The brain works in a certain way to process information, and best practices from all these arenas bear out that message. People (usually) don't fail to understand something because they're lazy—rather, they need you to present your ideas in a digestible form. The impacts of doing this right can be important to the world at large—and immensely satisfying to you as a professional.

Reference:

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Resources:

- AAAS Communicating Science – tools for scientists and engineers <http://communicatingscience.aaas.org/Pages/new-main.aspx>
- AAAS Mass Media Program <http://www.aaas.org/programs/education/MassMedia/program.shtml>
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- National Association of Science Writers: <http://nasw.org>
- Exploratorium Museum of Science: <http://exploratorium.edu>
- Stephanie Chasteen's website and blog: <http://sciencegeekgirl.com>

Stephanie Chasteen (stephanie@sciencegeekgirl.com) is a science education and communication consultant, and blogs at <http://blog.sciencegeekgirl.com>. She has a PhD in physics from the University of Santa Cruz, and is a part-time fellow in the Science Education Initiative in the physics department at the University of Colorado at Boulder

The Santa Fe Alliance for Science (SFAFS)

Bob Eisenstein

A large state of stunning but austere beauty, New Mexico is often called “the land of enchantment.” Next year Santa Fe will celebrate its founding by the Spanish, 400 years ago, as the capital of the Territory of New Mexico. It is the oldest capital city of the 50 states, presiding over a rich cultural and multilingual mixture of Native, Hispanic and Anglo Americans. Of all states New Mexico has the largest percentage population of Hispanic and Mexican Americans (42%) and is home to 22 indigenous native American pueblos (about 10% of the state population).

In spite of its natural beauty and cultural charm, there is concern here about what the future might hold for our people. New Mexico ranks 45th in median family income (\$43,508 in 2008) and our students persistently rank very poorly compared to those in other states in academic performance, especially in K-12 math and science. Our high school graduation rate has dipped below 60% and is declining. *Quality Counts*, the annual evaluation of all states by *Education Week* magazine, this year ranked New Mexico last in its “chance for success” index. It is difficult to attract STEM-oriented businesses to New Mexico because we lack a suitably trained workforce and good public schools. Businesses already here often have to recruit workers from outside New Mexico.

Fortunately the news is not all bad. Our state government is well aware of these issues and relatively speaking has been generous in funding K-12 education. New Mexico spends about \$9,525 per student, 29th in the U.S., a much larger number than one might expect based on our low median family income. In addition, largely because of the huge Federal investment at LANL and SNL and at military bases around the state, New Mexico has the 3rd highest per capita ratio of STEM professionals in the U.S.

Based on the belief that this large, highly talented pool of technical professionals could help improve K-12 math and science education in Santa Fe, the Santa Fe Alliance for Science (www.sfafs.org) was created in May, 2005. It follows similar activities established in the late 1980's by SNL in Albuquerque (the Sandia SciAd program) and by NASA and the White Sands Missile range in Las Cruces (the Science Education Alliance). These excellent activities are still going strong.

SFAFS is a non-profit 501(c)(3) organization. It comprises over 90 STEM volunteers working mostly in the Santa Fe public schools to help improve K-12 math and science education. Volunteer activities and level of engagement are quite varied and the organization has evolved in ways that we did not expect when we started. Our activities include:

- An extensive tutoring activity at the two major high schools, focusing on core math and science courses. We spend as much time tutoring in pre-algebra, algebra and geometry as we do in the sciences, reflecting the poor level of math preparation that students receive in elementary school. Last semester SFAFS volunteers contributed well over 200 hours of tutoring and over 400 student interactions. Tutoring is available at fixed hours several days each week. Tutors are offered an honorarium of \$20/contact hour, but few take it.
- A large-scale effort with elementary school science fairs, working with students to select projects and then serving as judges. Last year SFAFS was involved with 15 fairs and the district Science Expo. SFAFS impacted over 1100 students and teachers via this activity.
- An evening “Science Café for Young Thinkers” program featuring discussions with students on a wide variety of frontier science topics. We schedule about 8 of these per year and

average attendance is about 80 per event. Each Café presenter also appears on the KSFR Radio Café the day of the event.

- Volunteers teaching full physics and engineering courses in a local high school or the Santa Fe Community College.
- Visits to elementary and middle-school classrooms to talk about science. This activity has not been nearly as large as we expected, but the discussion topics have been interesting (e.g. what is life?, the atomic bomb, paleontology, cosmology and astronomy, and others)
- With the Santa Fe Institute, awarding an annual “Prize for Scientific Excellence” to the leading senior at each of the 11 local graduating high schools, and to one science teacher. Each award is \$1000.
- Beginning soon, a program of professional enrichment for teachers.

SFAFS has also worked at the Santa Fe Community College, at local charter schools, the Santa Fe Indian School, the Cochiti pueblo, with the Pojoaque Valley schools, and with New Mexico MESA.

Assessment of SFAFS activity remains a bit problematic. We know that SFAFS is quite popular but we don’t usually have measures of direct impact on student performance. That’s because our usual interaction with a student is not long-term so we don’t test scores, papers or course grades.

SFAFS has been fortunate to receive financial support from local businesses and anonymous donors. We’ve also received substantial support from the LANL Foundation and the NSF. This year our expenses will be about \$20,000. SFAFS has no salaried employees.

Let me identify a few “lessons learned.” Most important is that you can be successful establishing an activity like SFAFS, but it takes patience and therefore time. The key is to establish trust with teachers, principals and district leaders. This is based mostly on mutual respect and an appreciation of the difficulties. For STEM folks, it’s important to recognize that we are “content” experts and not “pedagogy” experts, and that modesty is a virtue. The key word is “partnership.” Also keep in mind that the high school of today—a very complex social organization with many responsibilities—bears almost no resemblance to what we experienced as teenagers. One soon learns that “blaming the schools” for our problems in education is naive at best. In fact, schools are a reasonably accurate reflections of our society as a whole.

SFAFS has enjoyed outstandingly good relations with the Santa Fe Public School district and the remarkable energy and commitment of its corps of volunteers. Without these things we would have gone nowhere. In closing, I record my profound thanks to all of these colleagues.

Bob Eisenstein (robert@sfafs.org) is the director of the Santa Fe Alliance for Science. He was born and raised in St. Louis, Missouri, and was educated at Oberlin College, Yale University (PhD) and the Weizmann Institute (Rehovot, Israel). He spent many years on the physics faculties of Carnegie Mellon University and the University of Illinois, where he often taught physics to freshmen and sophomore engineering students. He also spent more than a decade at the National Science Foundation, and for a brief time was president of the Santa Fe Institute. From Fall, 2007 until Fall, 2009 he chaired the New Mexico Math and Science Advisory Council. He and his wife Karolyn have two grown children. He can be reached at 505-990-5966.

Outreach of a Scientific Collaboration: Challenges and Rewards

Marco Cavaglià

In our rapidly evolving world, science is an integral part of our society. Every day, each of us is exposed to the most recent advances in science and technology through media and social interaction. People are eager to be informed about science, discuss it, hail new scientific discoveries or even condemn them: the time of elitist scientists holed up in their labs is over. In this context, science outreach holds a prominent place in any research program, this being especially true for large-scale scientific organizations which gain a lot of exposure in mass media. Projects such as CERN’s Large Hadron Collider, NASA’s Hubble Space Telescope, and NSF’s Laser Interferometer Gravitational-wave Observatory must maintain a public image of their endeavors which is informative, current, attractive, and readily accessible to the community at large. Although limited time and funding resources make this undertaking challenging, rewards can be substantial and well worth the effort.

In this brief letter, I would like to share with you some of my recent experiences as member of the Education and Public Outreach working group of the LIGO Scientific Collaboration. LIGO is one of the largest physics projects that the National Science Foundation has ever funded. Its goal is the detection of gravitational waves from cataclysmic astrophysical sources. Direct measurement of gravitational waves will open up a revolutionary new window on the Universe, which will probe some of the most violent and energetic phenomena in the cosmos—from black holes and supernovae to the Big Bang itself. As a frontier physics effort, a core mission of LIGO is also to inspire interest in astronomy and fundamental science among students and to educate the broader community. The grand scale of the LIGO interferometers, together with the innate public fascination with black holes, supernovae and other extreme astronomical phenomena provide an ideal framework for achieving these aims.

Developing a meaningful and effective outreach program in a scientific collaboration presents several challenges. Outreach activities must meet the standards and the public expectations of a major scientific experiment in the collective imagination; in a world where multisensory experience is essential to capture the attention of the public, old style events such as plain lectures or written contributions in the press are no longer effective to adequately convey scientific information to informal learners. People expect to “see and touch” the products of scientific research, as they see and touch the products of the latest technological innovations. Outreach programs must also involve the public in a non-passive way. In the era of blogs and social networks, people want to participate to the ongoing discussion, express their opinion and often offer their judgment. Science is not an exception to this trend; personal interaction with scientists and their instrumentation is essential to reach out to a general audience. A further challenge for outreach in a large-scale experiment is the need of a high level of coordination among collaboration members. Time is limited and outreach activities are, unfortunately, still a low priority task for the majority of faculty, graduate students and postdocs. Collaboration personnel working full-time on outreach is a luxury. Excellent ideas and programs may be scattered among research groups and often unknown to other members of the collaboration. This leads to unnecessary duplication of efforts, waste of resources and limited broader impact.

When an outreach program is successful, returns for scientists are invaluable. Apart from direct and indirect benefits in funding and recruiting, personal interactions with members of the public are very rewarding; I think that there is nothing more gratifying than helping a child or a non-scientist to understand a little more how our Universe works. There are several ways of building a successful outreach program. Internet-based activities, projects in the local community, and after-school and diversity programs with links to formal education all offer great potential for public education at all levels. In this context, interdisciplinary programs may appeal to an audience broader than people merely interested in science. Events blending science and music or visual arts are particularly suited to this purpose, being able to gather a crowd from humanistic disciplines which is usually not seen in more traditional science outreach events. A successful example of outreach program blending science and music is the ongoing partnership between LIGO and renowned contemporary composer and percussionist Andrea Centazzo, author of *Einstein's Cosmic Messengers* [1], a new multimedia show featuring Centazzo himself playing live music inspired by relativity and gravitational waves in sync with a projected multimedia video. Centazzo's concerts are preceded by a brief introduction to astronomical phenomena such as black holes and gravitational waves by a LIGO scientist. This partnership led to a series of free concerts at various LIGO member institutions around the country which attracted both music and science enthusiasts in a single event. The celebrations for the 2009 international year of astronomy, winding down as I write, offered another excellent opportunity for such interdisciplinary programs. The classical concert of renaissance music *Music of the Spheres*

by the Mockingbird Music Ensemble, preceded by physics demonstrations with ancient scientific instruments and complemented by historical readings of Galileo and Kepler, recently yielded a similar success at the University Museum in Oxford, MS. Nothing was more rewarding than seeing a mixed audience of college students, music enthusiasts, and more wonder why a double cone on an inclined plane seems to defy gravity.

Internet-based resources are important to reach to a large number of people in a short time, especially when the publication of a scientific result causes a spike in the public interest. LIGO, as most of the major scientific experiments, has a presence in social networks such as Facebook [2] and Twitter [3], and a news blog [4]. While these outreach programs fill the need for human contact with LIGO scientists in cyberspace, real contact with LIGO scientists on a one-to-one basis is essential to transmit enthusiasm for scientific research. Site-based programs allow the public to directly interact with LIGO researchers, but their reach is mostly limited to those regions in which the LIGO observatories are located, leaving the collaboration with the need to develop programs at national and international levels. In this case, the challenge is how to reach to a broad audience with minimal resources. The touring show on gravitational waves and LIGO science *Astronomy's New Messengers* addresses precisely this issue. Funded by the National Science Foundation, *Astronomy's New Messengers* consists of an approximately 200 sq. ft. exhibit traveling to junior colleges, universities, museums, and other public institutions through the U.S. This project is able to physically reach a broad audience of citizens from diverse socio-economic groups, different areas of the nation, and underserved groups. To maximize its impact, the exhibit's design reproduces the science and technology of the actual LIGO instruments in an eye-catching and entertaining way: text panels and large LCD screens with looping high-quality videos deliver key informational points, and a number of interactive components (including a computer game—the *Black Hole Hunter* [5]) engage visitors in discovering how LIGO operates and understand some of the foundations of gravitational wave astronomy.

In summary, innovation in outreach—be it through new technologies, interdisciplinarity, or more traditional media, is essential to capture the attention of the public in a competing world of diverse interests. Synergy between groups is also indispensable to get a meaningful outreach program off the ground in those scientific collaborations that cannot afford a dedicated team of professionals. Success can be achieved with rigorous planning, support from the leaders of the collaboration, and a lot of goodwill.

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Marco Cavaglia (*cavaglia@olemiss.edu*) is an Assistant Professor of Physics and Astronomy at the University of Mississippi and

Chair of the LIGO Science Collaboration (LSC) Education and Public Outreach (EPO) Working Group.

“So, This is Science?”

David Willey

The question that is the title of this article was asked by a twelve-year-old female student as my wife Raven and I were packing up our equipment after a show. I was happy to answer, “Yes, or at least it’s a small taste of what science is.”

I’ve been trying to provide that ‘amuse-bouche’ of science to as many people as I can for over 25 years now. It really all started for me at age fifteen, long before I left England when, as a bored science student and part time class clown, I transferred grammar schools. I left a school where the physics teacher talked at us to one where the teacher showed us many demonstrations while explaining the physics behind them. I was hooked; I studied physics at Aston University and education at Birmingham University, before moving to Columbus where I obtained a masters in physics from the Ohio State University. My first teaching position was with the University of Pittsburgh at Johnstown (U.P.J.) and some thirty odd years later, I’m happy to say I’m still there.

Sometime in the early 1980’s, the Natural Science Department had an open house. It was decided that I should perform some of the demonstrations that I put on in my classes, for the parents of prospective students. It all seemed to go well and we certainly had more interest shown in our physics program that year than had been exhibited during open houses without demonstrations. Plus I had a lot of fun doing it and gained some real satisfaction from the positive feedback received. At the time a friend of mine was working for a remand home for troubled boys and needed to come up with an activity that would take them out of the home and engage them in a project requiring sustained group cooperation and planning. By fortunate coincidence; at about the same time cable television came to our area of Pennsylvania and the company providing it had a TV studio that, by law, had to be made available to the general public. It was decided that with my help the young men from the home would make a quarter of an hour video of dramatic physics demonstrations set to their favorite rock music. The result aired several times on the local cable channel, albeit mostly at 3 a.m. but was deemed a success by all involved.

The program was also shown at more reasonable hours, and after one showing a local high school teacher called me saying that she had not only seen the show on TV, but also with her son (a prospective student) the open house demonstrations. She wished to know if I could visit her school and perform similar demonstrations for her class. I agreed and the show “How Does A Thing Like That Work?” was born. The head of my department agreed to let me use some of the department’s equipment. This show led to others and soon it seemed that at least one Friday each month I was loading equipment into my pickup truck and heading out to some

local high school.

A colleague in the Education Department at U.P.J. had received an Eisenhower grant and was arranging in house workshops for local teachers as part of a program called Math On Saturday/Science On Saturday (MOS/SOS). I presented demonstrations from the show at these workshops and part of the Eisenhower grant was used to fund ensuing visits to local schools and a presentation at the Pennsylvania Science Teachers Association’s annual conference.

Unfortunately lack of funding and internal politics caused the sad demise of the Eisenhower grant and the MOS/SOS program for our Education Department. I still had many requests for performances though and decided that “the show must go on;” so I replaced the school’s equipment with my own and started charging a fee to cover expenses. A few items were quite expensive (a tank for methane, a liquid nitrogen Dewar and a vacuum pump), but a lot of the props I either already had (such as a sledgehammer and shop vac) or they were relatively cheap everyday items (two liter soda bottles, balloons, helium, etc.). My wife took on the role of my assistant as I soon realized that relying on the help of the staff at the venue I was visiting, despite how willing they may be, was not a good idea. A young and strong gymnastics teacher, who had been volunteered to break the concrete block lying on top of me while I lay sandwiched between two beds of nails drove that point home, if you will excuse the pun. To no avail I told him that he did not need to hit the block overly hard, just enough to shatter it. He impressed the students watching, as I’m sure was his intent, and I bled front and back from a matrix of tiny puncture wounds. A tetanus shot set me fine, but that weekend we bought a couple of dozen blocks for my wife to practice with and since then there have been few others that I’ve trusted with the sledgehammer. I do have to admit that one of my favorite photos is of a nun in her black and white habit, breaking a block on me. This happened during a visit to one of the local catholic schools. She assured me that she was the one who split wood each year at their retreat, and she did indeed do a fine job; seems it’s not just rulers they are expert at wielding.

We received requests for an outdoor show and so one was developed. Larger, messier demonstrations were then possible and one that caught my eye was firewalking. I’d read an article by John Taylor in the March 1989 issue of the *Physics Teacher* magazine and just had to try it myself. It turned out to not be something that could easily be incorporated in the show. Instead, to make the same point, I picked up an orange hot piece of tile from the space shuttle – but still firewalking intrigued me. Background reading on the topic soon let me know that although there were good qualita-

tive explanations of the physics involved, there was little quantitative analysis. This led me to team up with a Norwegian physicist, Kjetil Kjernsmo of the University of Oslo, to try to develop a computer model of a foot undergoing a firewalk. To test the model, we needed data from both long and hot walks. A group of firewalkers from Seattle Washington that I had met over the internet wanted to break the world record for the hottest ever firewalk, 1,575°F at the time, and I agreed to take the data. On October 18, 1997, in Redmond, Washington, Michael McDermott took two steps, one per foot, on coals the surface temperature of which was 1813°F. Early in July of 1998, I organized a 165 foot firewalk at U.P.J. to break the world record for longest distance walked. The BBC sent a crew to film the event for the Discovery Channel, having contacted me after hearing about the other record breaking walk. John Stossel of ABC television also reported on the event for his special "Power of Belief," even walking himself on a shorter fire set up for him and his crew. The event was picked up on the A.P. wire and gained quite a lot of attention. One of the many media people who called was a producer for *The Tonight Show* with Jay Leno. He asked if I could perform a firewalk in their studio. I asked of what the floor was made, "wood" he answered. After a pregnant pause he asked if there were other things I did, and explained that they were looking for a "mad scientist" to be a recurring guest. I suggested walking on broken glass, the concrete block and bed of nails demonstration and dipping my hand in molten lead. He liked the ideas and we were on our way to Hollywood. I managed to fall on the bed of nails during that first show and bleed on the stage, but other than to my ego, no permanent damage was done and the director appeared to like that I just kept going despite the puncture wounds. In truth I didn't feel any pain until after, just embarrassment (adrenaline is a wonderful thing). Before Leno left *The Tonight Show* I was booked to appear twenty times, only one of which, a fire walk with Mel Gibson, Donald Trump and Prince, was cancelled. It rained heavily that day in Los Angeles and I am now glad it did. I'd asked for cherry wood to be provided, instead it was a truckload of almond wood that was delivered, a wood I'd never used before. Later I found out that almond burns even hotter than oak, the only wood I have walked on that has caused more than a small blister. Had we walked on the almond I strongly suspect that evening would not have gone well. That was the only time it rained when we visited L.A. and it could not have been on a more opportune day.

The Tonight Show introduced me to Chuck Harris, president of the Visual Arts Group, who soon became my manager for international bookings. Through him I have worked in London, Hamburg, Vancouver, Amsterdam, Beirut, Seoul and Singapore. My wife handles our booking within the U.S. and I have been fortunate to present at conventions, workshops and science museums throughout America. I'd estimate that over 50,000 people have seen the live show in one form or another. More TV work followed and I've appeared on national TV over 50 times as a science consultant, on such shows as *Daily Planet*, *Discover Magazine*, *Time Warp* and *Humanly Impossible*. Along the way there have been some memorable moments.

My wife and I were standing in the lobby of the Hilton Universal hotel in Hollywood on our third visit to the Tonight Show, waiting for our town car and to perhaps catch a glimpse of Lucy Lawless, a.k.a. Xena, Warrior Princess. I was dressed all in black except for my tie, as was then usual for me. An elderly and obviously wealthy lady standing close to us looked over and when she saw me a look of recognition, or so I thought, spread across her face. "Are you?" she questioned as she hesitantly approached, finger pointing at me. "Are you?" "Yes." I thought smugly, "I'm David Willey, I'm the Tonight Show's mad scientist." "Are you," she repeated, "my driver?" I was crushed, but it was exactly what I deserved and needed.

A science project I have much enjoyed being involved with is "Techfest," held each February in Dayton, Ohio. One year I was on stage trying to convince the audience that air bags in automobiles are a good idea by throwing a raw egg into a sheet, held by two audience members. My two volunteers were husband and wife. As I drew my arm back to throw the egg the lady's cell phone rang, immediately she dropped the sheet and answered it. I'm not sure who was most shocked, the audience, myself or her husband who barked at her, "That's the third time since we got here, turn the damned thing off!"

I truly enjoy working with children, but it has been my own personal experience that question and answer times at the end of a show are rarely worth the effort. The questions often have already been answered, "Doesn't the bed of nails hurt?" or start with "Can I have..." At times, though, they are unavoidable. We finished a show at a local high school twenty minutes before the buses were due to arrive and not wanting the students to have to return to their home rooms, or worse, be loose for that length of time, the principal asked if there was anything else we could do. I'd forgotten to throw spinning balls into the audience when demonstrating the Bernoulli effect, and so I spent a few minutes doing that, telling the students that whoever caught the expanded foam balls could keep them as a souvenir of the show. Apparently that did not take up enough time as I was asked to answer questions from the students. A radio mike was taken into the audience after warnings about everyone being polite and taking their turn had been issued by the principal. Students dutifully raised their hands, but before any of them had a chance to ask a question, a teenage boy in the fourth row yelled out loudly, "Why didn't I get any balls?" Without thinking I answered, "Don't know, sounds like a nasty birth defect to me." As the audience burst into laughter I immediately realized that what I'd opined was probably not the politically correct response and I looked over with trepidation to the principal. Much to my relief he was edging his way off the stage, obviously having a hard time controlling his laughter. After he told me that the student was a "real handful" and that it was a good thing that someone had finally put him in his place. It's funny how things work out.

This article is in no way meant to be a "how to" manual, for that I'd highly recommend that you get a copies of *Physics Demonstrations and The Wonders of Physics Lecture Kit* by Clint Sprott, but there are a few anecdotes that I'd like to pass along.

For the first couple of years I wore a shirt and tie with jeans when performing, much the same informal attire as when teaching my labs. The charge for the show was enough to cover expenses and a meal the day of the show. A colleague of mine at the time was heavily involved in procuring extracurricular activities for Pennsylvania high schools. He told me one day after watching me present, that if I wore better clothes I could easily charge 10 times as much as I was doing, and the long and short of it is, he was right. People value you as much as you value yourself. And for a lot of them, that's measured in dollars. With the extra money generated we have been able to purchase more equipment and improve our presentation. It also allows us to donate our services to worthy charities at no cost. Lesson to be learnt, don't sell yourself short.

We have presented the show to all ages, from six-year-olds in elementary schools, although we do prefer to deal with eight-year-olds or older, to the residents of an assisted living retirement community (no explosions for that audience). I've been asked several times if it is difficult to change the show so that the explanations best suit the average age of the audience, and my response is that I don't really change it that much. What I'm trying to do in the limited time I have is to give as simple an explanation as I can to go with the demonstration I'm performing, and if it works for an eight-year-old it will work for an eighteen- or an eighty-year-old; I see no point in making the explanations more complicated.

Even if I wanted to there is not enough time in a one hour show to thoroughly explain all that is involved behind the thirty or more demonstrations being done. My first goal as a scientist is, of course, to make sure that what I'm saying is to the best of my knowledge true. However, it is my belief that style, rather than content rules when competing for that rarest commodity, the young's attention. I'm trying to intrigue and motivate when I perform, more than I am trying to educate. I'd venture that Al Gore's *An Inconvenient Truth* did far more to increase public awareness, even though it did have scientific shortcomings in it, than did the more scientifically correct *Too Hot Not to Handle* HBO film by the same producer, Laurie David. Al was not 100% correct, but he was not boring either. Do your best to make it correct, but try just as hard to make it interesting. You can't teach anyone much without first getting their attention and then keeping it.

It is my experience that to be effective demonstrations have to be easy to see, so bigger is better. They should also be dramatic and have an element of surprise to them. Throughout the show I like to have demonstrations that have audience members helping me.

It takes approximately as long to take down most demonstrations as it does to set them up, which is also approximately as long as it takes to perform them. Hence our one-hour show really takes about 3 hours from set up to tear down. All demonstrations have been well practiced at home before being done before an audience. I prefer for the audience to be as close as possible, but on the days when it is going well, for safety, younger audiences especially sometimes have to be moved back. Some people work

well with a script, others, myself included, rarely say things the same way from one show to the next. I believe the spontaneity keeps it from being boring; it does mean though that sometimes I make mistakes. I tape copies of a list of the proposed demonstrations on the stage and tabletops, so I can see them but the audience cannot. The boiling point of liquid nitrogen is written on the Dewar in permanent marker. If during a show I forget to perform a planned demonstration, I usually just carry on and the audience never knows what they missed. Occasionally do I go back to the missed demonstration, but only if it is particularly impressive.

I try to set a good example and wear the appropriate protective clothing and safety glasses. There are the mandatory "Don't try this at home," warnings, but as they can have a contrary effect on some people (read: teenage boys). I make an effort to explain why and how these stunts are dangerous rather than just saying not to do them.

I have \$2,000,000 worth of insurance covering me when I perform. It wasn't always that way. Early on we had been hired to do an outdoor show for the local Kiwanis club. One of the demonstrations that we did involved sinking a two liter soda bottle, containing about a pint of liquid nitrogen in a 60 gallon plastic barrel filled with water. The barrel was behind a barricade of plastic warning tape and orange traffic cones. I dropped the weighted bottle into the water, ducked under the tape, and headed back for the stage. Upon getting there I turned around to look back at the barrel, only to find that it was surrounded by teenagers eagerly peering down into it. My cries of, "Get the away from there!" were totally ineffective. The bottle exploded sending about 40 gallons of water skyward. This, much better than I had, caused the juveniles to withdraw hastily, none it seemed any the worse for wear other than being startled. Most were highly amused and cheering and I breathed a sigh of relief. It transpired however that one of the young ladies close to the barrel was the daughter of a local accident attorney. A gentleman who it seemed had as his immediate goal in life to sue everyone involved, myself, the Kiwanis and the city of Johnstown. Had it not been for a friend having a video of his daughter playing happily with her friends, totally unharmed later that afternoon, I'm not sure what would have happened but I'm pretty sure I would not have liked it. When I do that demonstration these days someone is there guarding the barrel. Not everyone can be trusted to actually follow the directions printed on plastic tape, so it doesn't hurt to enlist one of the event organizers to play the "bad cop."

As I have found generally to be wise, I will let those of my wife, be the last words. A lady and her son approached us after a science fair at which we had performed. She said that the young man had something that he wanted to tell me. After prompting he asserted, "I want to be just like you when I grow up." Not a line my beloved was likely to let pass, "Oh, I'm so sorry," she consoled, "you can't do both."

David Willey (dwilley@pitt.edu) is an Instructor of Physics at the University of Pittsburgh at Johnstown and has a lifetime interest in dramatic science demonstrations and their presentation.

CAM 2009: Physics Knows No Borders...

Ivelisse Cabrera



CAM 2009 participants

From October 22-24, students from all across North America met in Acapulco, Guerrero, Mexico to participate in the 4th Annual Canada-America-Mexico Physics Graduate Students Conference.

The Canada-America-Mexico (CAM) Physics Graduate Students conference is a joint meeting of the Canadian, American and Mexican Physical Societies focusing on graduate students' education. The aim of this event is to provide an outstanding opportunity for students to develop professional skills, learn a broad range of physics topics, and initiate interactions across geographical borders. Furthermore, it fosters communication and exchange of ideas among students of various backgrounds and interests.

CAM 2009 was held from October 22-24 in Acapulco, Guerrero, Mexico. The conference was a success. There were 136 participants from all North America who had the opportunity to present their research work to fellow international students in a relaxed setting. Topics included particle physics; astrophysics and cosmology; nanostructures; fundamental physics phenomena; applied physics; superconductivity; and nuclear, atomic, and molecular physics. The conference was perfect for networking. Participants had fun during CAM and enjoyed the students' talks, the invited talks given by renowned scientists, and the panel discussion.

Panel Discussion Summary

Towards the end of the conference, a panel discussion titled: "New Frontiers in Physics: Interrelations of Physics and Other Disciplines (Medicine, Biology, Geosciences, Nanosciences, etc)" was held. Panel members included David Ernst (president of the Board of Directors for the National Society of Hispanic Physicists and

member of the American Physical Society Executive Board), Gordon W. F. Drake (director of International Affairs of the Canadian Association of Physicists and editor of the *Physical Review A*), Luis Felipe Rodriguez (president of the Mexican Physical Society), and Michael Steinitz (editor of the *Canadian Journal of Physics*).

Below are some of the points discussed:

- There is a desire to keep departments tied to fundamental fields (e.g., physics, chemistry), while allowing for multi or interdisciplinary activities and research. Universities should keep defined and separate boundaries between fields.
- It was suggested to include more interdepartmental courses during a student's undergraduate years to expose them to other disciplines at an early stage or their education.
- There is a current problem with high school physics teachers, where lack of resources prevents them from continuing research while teaching.

Final advice offered by panel members to graduate students:

- "Help prepare high school teachers or become a high school teacher."
- "Pick one thing/topic and become an expert on it."
- "Be unique. Read articles from other fields. Attend colloquia."

Work on your networking skills.

- *“Trust the system. Learn to communicate in English.”*

More information about CAM 2009 can be found at: <http://cam2009.smf.mx/>. A Facebook group has also been created for CAM 2009 at: <http://www.new.facebook.com/group.php?gid=161881349445&ref=ts>.

The CAM 2009 organizing committee would like to thank all participants for their high-quality presentations and active participation during all sessions of CAM 2009.

If you missed CAM 2009, you don't want to miss CAM 2011!

Ivelisse Cabrera (icabrera@pha.jhu.edu) is the FGSA International Student Affairs Officer and a graduate student in physics at the Johns Hopkins University.



From the Editor of the Teacher Preparation Section

John Stewart – University of Arkansas

This edition of the teacher preparation section features an article by Rob Thorne, the director of Cornell's PhysTEC site. Cornell is one of four new funded PhysTEC sites. The programs of the other three new sites have been presented in previous issues: North Carolina–Chapel Hill in the Summer 2008 newsletter, Florida International University in the Summer 2008 newsletter, and the University of Minnesota–Twin Cities in the Fall 2008 Newsletter. All four new funded sites build on the methodologies developed by the initial PhysTEC sites, adapting the techniques to their institutions. The article discusses the implementation of a Learning Assistants program at Cornell and the central role of the Teacher in Residence, core features of the PhysTEC model.

The article also comments on a new and promising source of highly qualified physics teachers, students in terminal physics masters

programs or students ending with a terminal physics masters. At the University of Arkansas, we have also found students ending with a terminal masters to be an excellent source of the new high school teachers. Many students enter graduate school with a poor understanding of the demands of physics as a profession. Some of these students find that the best experience they have in graduate school is teaching, particularly teaching in reformed, highly interactive courses. For these students, the transition to teaching as a career is very natural. Long-term tracking at Arkansas shows that the majority of the students who have made this transition are quite happy as teachers. I, note, that the Noyce Scholarship program has been very helpful in aiding the transition to teaching for some masters students. Joan Prival of the National Science Foundation discussed the most recent Noyce solicitation in the Summer 2009 newsletter.

PhysTEC at Cornell: A Progress Report

Robert E. Thorne

As the readers of these pages know well, the US has a severe shortage of high school physics teachers. The statistics are grim. Only one-third of high school students take high school physics. Only one-third of those who teach high school physics have a degree in physics or physics education. Teacher shortages are especially severe in urban and rural districts. Fifty-five percent of New York City schools, representing 23% of enrollment, do not offer physics.

Access to quality physics education is critical to our economic competitiveness and national security. Careers for which physics is a prerequisite—in the physical sciences, engineering and medicine, among many others—have historically provided an upward path for the socioeconomically disadvantaged. Equality of access to physics education is thus an issue of social justice. We cannot achieve our goals of greater socioeconomic, racial and gender diversity in STEM disciplines if our children do not emerge from high school with physics training and—even more important—with sufficient confidence and enthusiasm to pursue further physics study in college.

How did we get here? The factors are complex, but the historical

division of labor between US colleges and universities seems critical. Most teacher training occurs in second and third tier institutions, which tend to have relatively unselective admissions. High school students that are good in math and physics generally have good overall test scores, and are much more likely to end up at first tier institutions. But at these institutions, teacher training programs and high school teaching careers often have little visibility, and little cache with their undergraduate students, graduate students and faculty.

Again, the statistics are telling. In New York State in 2006, the top ten institutions for physics teacher production generated 52% of all certifications but only 16% of physics majors. The top ten institutions for physics majors graduated 61% of all majors but certified less than 4% of the physics teachers.

Major research universities like Cornell with large undergraduate enrollments in STEM disciplines must accept significant responsibility for the current crisis. We attract a disproportionate fraction of the physics-capable students, but produce very few physics teachers. In fact, most research universities are not even physics

teacher neutral: they train and certify fewer teachers each year than are required (given attrition rates from the profession) to ensure that the students who enroll in their introductory physics courses each year have had high school physics.

As a PhysTEC primary program institution since 2007, Cornell has significant potential as a source of future physics teachers. Roughly 1300 undergraduates per class take an introductory physics sequence, and several hundred graduate students work in physics and engineering-related areas. Our introductory physics courses provide excellent and diverse models of effective physics instruction, including state of the art lecture-based courses that have featured electronic in-class polling since 1971 and cooperative learning sessions and transferable-skill-focused weekly laboratories since the early 1990s, and mastery-based self-paced courses with online, video and podcast tutorials, self-guided lecture demonstrations and one-on-one instruction.

So what have we been doing to capitalize on this potential? To a large extent, we have followed the excellent rubric provided by PhysTEC, and have drawn heavily upon approaches and materials developed by past and present primary program institutions. Here I will focus on three components of our program: recruiting, early field experience and the physics teacher-in-residence.

Recruiting

Why do so few undergraduates at Cornell and its peer institutions pursue certification in physics teaching? High tuition, student loans and family expectations bias them toward careers that pay well. Professors, graduate teaching assistants and the institutional ethos bias them toward careers at the cutting edge of science and technology (even though most will not end up there) and to teaching careers at the university level. Institutional divisions isolate STEM undergraduates from Education departments and certification programs. The media convinces them that high school teaching careers are hard, poorly paid and not respected, a stereotype that their inadequately prepared high school physics teacher may have done little to dispel. The few students with serious interest in high school physics teaching often feel isolated, and receive little support from their peers or professors.

How can we convince more of our students to become high school teachers? Here are some principles and tactics.

Know your target audience. Surveys are an excellent way both to gauge attitudes and to stimulate interest. Each year we deploy a STEM Careers Interest Survey to all students enrolled in introductory physics courses. This survey asks students to think broadly about the factors relevant to choosing a career and about the kinds of careers they would like in their working life; it invites them to examine teaching careers; and it educates them about teacher education programs and available financial aid.

Give them the facts. In talks to undergraduates and on our PhysTEC website, we examine more than dozen career choice factors

and how high school physics teaching careers stack up. By most metrics, the answer is: very well.

Change the culture. We make regular presentations on the PhysTEC project to physics faculty and graduate students, reminding them why training more physics teachers is critical to our institution, profession, and country; inviting them to help in promoting teaching careers and in identifying and recruiting students with teaching interests; and pointing them to useful advising resources.

Grease the path. Most STEM majors know little about courses and programs relevant to teacher training. We use in-class announcements and emails to advertise teacher certification information sessions and Noyce fellowship opportunities to all students enrolled in introductory physics classes. Revised online and print materials for physics majors and graduate students place the Physics Department's stamp of approval on high school teaching careers, and give detailed suggestions for programs of study leading to teacher certification.

Cast a broad net. Over 90% of those who enroll in introductory physics do not intend to be physics or applied physics majors, but many would have excellent careers as high school teachers. Many of those who enter Master of Engineering programs would gain entrance to more meaningful careers by earning a Master of Arts in Teaching instead. Roughly 1/4 to 1/3 of those who enter Ph.D. programs in the physical sciences and engineering do not complete them, and this pool has yielded roughly half of the physics teachers Cornell has produced. Recruiting efforts should target all of these students. We are developing collaborations with advising and career services staff in Engineering and Biology so as to better inform and capture their students.

Early Field Experience

A centerpiece of the PhysTEC rubric is to engage students with the intellectual and practical challenges of teaching as early in their undergraduate careers as possible. In Spring 2008 we established an Undergraduate Teaching Assistant (UTA) program, drawing heavily on the program and materials developed at the University of Colorado by Valerie Otero. In our version, UTAs partner with graduate student TAs in facilitating cooperative problem solving sessions in our non-honors introductory courses. UTAs are an integral part of the in-



Figure 1: Undergraduate Teaching Assistants (UGAs) work with students in an introductory lecture.

structional team, and attend weekly course meetings with faculty and TAs. UTAs also enroll in and receive credit for a weekly 1-1/2 hour seminar “Teaching and Learning Physics”, which is taught/facilitated by our Physics Teacher in Residence. All undergraduates who have taken an introductory physics course are invited to apply to the UTA program, regardless of their intended major. We also solicit applications from students who are nominated by faculty, TAs and UTAs based upon their communication and teamwork skills as demonstrated in recitation and lab. An interest in a teaching career is the other important selection criterion. Students who wish to continue as a UTA for a second semester must enroll in an Education course.

The benefits of the UTA program both in generating interest in teaching careers and to our undergraduate physics program as a whole have become clear. For our third semester of the program we received 72 applications for 12 new positions, and all offers were accepted. Six students from the second semester enrolled in Education courses and have continued in the program, including one who has transferred from Engineering to Physics and is seeking certification. UTAs are enthusiastic about the experience and its impact on both their learning and teaching of physics. Undergraduates in the courses they serve appreciate the extra attention and the UTA’s often superior teaching skills. The program provides excellent PR for the Physics Department, especially to students from outside the department who enroll in our introductory courses. It helps build team spirit among those inside and outside physics who have interests in teaching, and gives them a way to identify themselves within the university.

How effective is our UTA program in helping to produce certified physics teachers? It is too early to tell. We do know that many Cornell science and engineering undergraduates express interest in teaching careers, and are anxious to gain teaching experience for the credentials and the growth it can provide them. But we also know that undergraduate interests evolve, especially in an environment that provides so many research and project team opportunities. We need to cast a broad net and then provide sustained encouragement and opportunities to maximize our teacher output.



Figure 2: Cornell TIR Marty Alderman

Teacher in Residence

The Physics Teacher in Residence plays a critical role in mentoring UTAs, in sustaining their enthusiasm for teaching, as an authority on high school physics teaching careers, and as a role model. In a research-focused environment where faculty are chronically over-committed and rarely available, the TIR also handles most of the day-to-day operation of the PhysTEC program, and serves as its public face to our undergraduate and graduate students.

We have been blessed with two outstanding Physics Teachers in Residence – Marty Alderman for 2007-2009 and Jim Overhiser (President-Elect of the Science Teachers Association of New York State) for 2009-2010. Both Marty and Jim have long been active in supporting teacher preparation and professional development.

Conclusion

Research universities must play a major role in addressing the national shortage of high school physics teachers. Many of our faculty engage in K-12 outreach activities. But the training of undergraduates to become educators is closer to our core mission and competencies, and few activities can match the impact of placing a highly qualified teacher in the classroom. By embracing high school physics teaching as a career option for our students, by bringing in talented high school teachers to serve as mentors and role models, and by partnering with our colleagues in Education, we can strengthen our undergraduate programs and help produce the teachers and educational leaders of tomorrow.



For more information and to access materials that we have used in our program, please visit <http://phystec.physics.cornell.edu>.

Robert Thorne is Professor of Physics at Cornell University, and co-directs Cornell’s PhysTEC project. His research interests include low dimensional electronic materials, physics problems in structural genomics, recovery of ancient inscriptions using X-ray methods, and biomass combustion. He has received three awards for innovation in introductory physics instruction for non-majors.

Browsing the Journals

Carl E. Mungan



- The November 2009 issue of *The Physics Teacher* (<http://scitation.aip.org/tpt/>) has an unusually large number of articles with insightful physics experiments and theory, including discussion of cosmic ray detection, inverse-square forces, the Coanda effect, back emf, static equilibrium, general relativity, capillary rise, terminal velocity, the Coriolis force, and boomerangs, among many other topics.
- I enjoyed the Quick Study entitled “The surprising motion of ski moguls” on page 68 of the November 2009 issue of *Physics Today* (<http://www.physicstoday.org/>). It clearly explained how moguls form (with what characteristic spacing and amplitude) and why they slowly migrate uphill by about 8 cm per day. Get out your skis and test some physics in action!
- A French trio present a pedagogically instructive mechanical model for a Carnot engine on page 106 of the January 2010 issue of the *American Journal of Physics* (<http://scitation.aip.org/ajp/>). The hot reservoir consists of a partially filled egg carton of balls located vertically higher than another egg carton comprising the cold reservoir. The mean and standard deviation of the gravitational potential energy and configurational entropy are easily calculated, and therefore also the effective reservoir temperatures and the engine efficiency.
- Recently in our department there has been discussion of how to best experimentally investigate and model damped oscillations of a mass on a spring. So it was with great interest that I noticed an article on page 121 of the January 2010 issue of the *European Journal of Physics* (<http://www.iop.org/EJ/journal/EJP>). Three physicists from Colombia present data for a sphere oscillating in aqueous glycerin solutions of different concentrations and container sizes. They show that it is necessary to introduce corrections to the standard Stokes model in order to fit the data.
- The November 2009 newsletter of the *International Commission on Physics Education* (<http://web.phys.ksu.edu/ICPE/Newsletters/n58.pdf>) includes an article entitled “Recent Developments in Physics Education in Canada.”
- A set of MathCad symbolic mathematics programs and associated documentation for various topics of relevance to thermodynamics and statistical mechanics are included in the December 2009 issue of the *Journal of Chemical Education*, as can be accessed online starting at <http://www.jce.divched.org/Journal/Issues/2009/Dec/abs1466.html>.
- David Griffiths (recently retired from Reed College) has an article with his thoughts about teaching physics entitled “Illuminating physics for students” in the September 2009 issue of *Physics World* (<http://physicsworld.com/>).

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

Web Watch

Carl E. Mungan



- The Royal Society of the United Kingdom has assembled a scientific timeline from 1650 to the present called Trailblazing at <http://trailblazing.royalsociety.org/> which presents key scientific publications in historical context.
- Several new services attempt to network or rank authors of scientific publications. Consider joining the American Institute of Physics' UniPHY network at <http://www.aipuniphy.org/> or Academia's version of Facebook at <http://www.academia.edu/>. Also type your own name into the author ranking of APS journals at <http://www.physauthorsrank.org/>. If you are searching for textbooks for a course, try <http://www.facultyonline.com/>.

- I like much of Todd Timberlake's curricular materials about entropy at <http://facultyweb.berry.edu/ttimberlake/entropy/>. Grant Mason has some great review material, online quizzes, and links to free books dealing with intermediate electricity & magnetism on his webpage at <http://einstein1.byu.edu/~mason/emsite/EM-TOC.html#TOC>.

- Check out the Shockwave simulations at <http://www.physicclassroom.com/shwave/>. For example, have students try the Race Track and see if they can control their acceleration and keep their car on the roadway!

- The Optical Society of America is now spotlighting featured ar-

ticles on optics topics at <http://www.opticsinfobase.org/spotlight/>. Similarly for highlights of recent developments in chemistry, read the Alchemist at <http://www.chemweb.com/alchemist-current>.

- Some colleagues recently told me about the Euler-Cromer method, a substantial improvement on the standard Euler method for numerically integrating a second-order differential equation (such as Newton's second law) in a spreadsheet. Read a nice summary of the idea at <http://www.physics.udel.edu/~jim/Ordinary%20Differential%20Equations/Euler-Cromer%20Method.htm>.

- Here are some useful tools for scientific authoring: the Physics and Astronomy Classification Scheme (PACS) is online at <http://www.aip.org/pacs/>; a comprehensive list of journal abbreviations can be found at <http://www.library.ubc.ca/scieng/coden.html>; the Chicago Manual of Style is available at <http://www.chicagomanualofstyle.org/>; one of many book search engines is <http://www.bookfinder.com/>; a list of differences in spelling between British, Canadian, and American words can be reviewed at <http://www3.telus.net/linguisticsissues/BritishCanadianAmerican.htm>; and an online dictionary of computer-related terms and acronyms is <http://foldoc.org/>.

- Looking for some physics puzzlers on the web? Try Donald Simanek's list at <http://www.lhup.edu/~dsimanek/scenario/insight.htm> or Henry Greenside's <http://www.phy.duke.edu/~hsg/physics-challenges/challenges.html> or Yacov Kantor's set at <http://star.tau.ac.il/QUIZ/> or the blog at <http://collectionofphysicsproblems.blogspot.com/>.

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

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