Forum on Education
American Physical Society

Fall 2012 Newsletter

Beth Lindsey, Editor

IN THIS ISSUE

From the Chair

Renee Diehl

As most of you know, the APS has a new strategic plan, and a significant part of it is about enhancing physics education at all levels and across the world. Our increasingly technological lives, shifting demographics in the United States, and the globalization of science are all factors compelling us, as physicists and educators, to think of new ideas for physics education that will advance our robust and healthy society.

The main job of the Forum on Education is to inform APS members of new ideas and developments in physics education and training, and this is done mainly through the creation of programming for the March and April APS meetings. The FEd typically organizes 5-10 invited and focus sessions at each meeting, along with occasional workshops, which span a wide range of educational interests. These include physics education at all levels, informal education and outreach, preparation for careers and physics education research (PER). This big organizing job is handled by the FEd Program Committee, consisting of ten members having very diverse interests in education, and being chaired this year by Paul Cottle of Florida State University. In this newsletter, Paul provides a preview of the FEd sessions that you can expect to see at the March and April meetings in 2013.

An exciting new development for the Forum is a proposal by Jonathan and Barbara Reichert to endow a new APS award for advanced laboratory instruction. The Forum is currently working to craft a proposal for this award, that if approved, will reward the hard work and dedication of those who toil to create, teach, maintain and improve stimulating experiments in advanced physics courses. Most of us have memories, fond or not, of the advanced experiments that we performed as undergraduates. Those of us who have ever taught an advanced lab course have a true appreciation for the sheer energy and dedication it takes to do a good job. There is no question that the best of these instructors should be recognized for their ingenuity and perseverance. The award, if approved, will be awarded annually to an individual or a team, and consists of a certificate and $5K, plus an invitation to speak at an APS meeting. Check the FEd website for updates.

Renee Diehl is Professor of Physics and Associate Department Head for Equity and Diversity in the Physics Department of Penn State University. She is Chair of the APS Forum on Education and carries out research in the area of surface physics, with an emphasis on surfaces having complex structures and weak interactions. She also leads a GK-12 Program called CarbonEARTH that seeks to improve STEM literacy and communication at the K-12 and graduate levels.

FEd-sponsored invited sessions for the 2013 March and April Meetings

Paul Cottle

The program of FEd-sponsored invited sessions at the 2013 national meetings will cover a great deal of ground, ranging from recent results in Physics Education Research to national policy documents on education, the challenges of building diversity in our field, and discussions of how professors bring the excitement of their research to their classrooms and the broader community.

At the March Meeting in Baltimore, one session will focus on the challenges of introducing students in urban environments to physics and other STEM fields and will take advantage of the work being done in the Baltimore region and elsewhere. The speakers at this session, which is being chaired by Mel Sabella of Chicago State University, include Richard Steinberg of the City College of New York, Cody Sandifer of Towson University, Nicole Gillespie of the Knowles Science Teaching Foundation, Anne Spence of the University of Maryland–Baltimore County, and Gale Seiler of McGill University.

A second Baltimore session will examine the issue of bringing more women and members of underrepresented minorities into the physics community. The first speaker will be Philip Rous, Provost of the University of Maryland–Baltimore County, which is a leader in recruiting minority students into science and engineering fields. He will be followed by Peter Muhoro, who is Project Manager for the APS Minority Bridge Program; Paul Gueye of Hampton University who is also the President of the National Society of Black Physicists; Senta Victoria Greene, who is Executive Dean of the Vanderbilt University College of Arts and Sciences and (as of this writing) Chair of the APS Committee on the Status of Women in Physics; and Roxanne Hughes, Director of the Center for Integrating Research and Learning at the National High Magnetic Field Laboratory at Florida State University.

A series of important reports being released by federal agencies is the subject of a third Baltimore session. Talisma Rahman (National Center for Education Statistics) and Gary Phillips (American Institutes for Research) will speak about the NAEP-TIMSS linking study which will allow the comparison of academic performance in each American state to the performance levels of other nations. Paula Heron (University of Washington) and Donald Langenberg (University of Maryland) will discuss the NRC decadal report on Physics Education Research. Finally, Kenneth Heller (University of Minnesota) will address the NRC report on Discipline-based Education Research.

The final March invited session will consist of talks by five Cottrell Scholars on the topic of integrating research and teaching excellence. The speakers will be Jairo Sinova (Texas A&M University), Jennifer Ross (University of Massachusetts–Amherst), Richard Taylor (University of Oregon), Mark Tuominen (University of Massachusetts–Amherst) and Erica Carlson (Purdue University).

The Forum is also sponsoring a March focus session that will follow up on the workshop “Building a Thriving Undergraduate Program” that was hosted by the APS in June. The invited keynote talk for the session will be given by Gubbi Sudhakaran of the University of Wisconsin–La Crosse. It is hoped that workshop attendees and others will present their own program-building ideas during the contributed part of the session.

The FEd invited sessions in April will include a session on “Transforming Teaching and Learning in Upper Division Physics” with speakers Heather Lewandowski and Steve Pollock of the University of Colorado–Boulder (a third speaker has not yet been confirmed). A second April session will discuss public outreach by the high energy physics community and will include Marjorie Bardeen (Fermilab), Steve Shropshire (Idaho State University) and Mitch Wayne (Notre Dame).

Finally, the Forum will host a session celebrating the winners of the 2012 Excellence in Physics Education Award: Gary Gladding, Mats Selen and Timothy Stelzer of the Physics Department at the University of Illinois–Urbana-Champaign. They received the award for their “smartPhysics” program.

Paul Cottle is a Professor of Physics at Florida State University. He is currently the Chair-Elect of the APS Forum on Education Executive Committee.

Upcoming Elections

Michael Fauerbach

On behalf of the nominating committee, I would like to thank everybody who nominated candidates for the upcoming elections, as well as the candidates and those that considered running, but unfortunately were unable to. The ballot will come out shortly and I encourage you to read the candidate statements and biographies carefully. You will notice that we have an excellent slate of candidates who are highly qualified for the positions they are running for. Please make sure to vote and please remind other members of the Forum in your department to vote as well. Active participation in Forum sponsored sessions at meetings as well as strong member participation in the election show that the Forum on Education is an active and vital part of the APS.

Michael Fauerbach is a Professor of Physics and Astronomy at Florida Gulf Coast University. He is the Vice Chair of the Forum on Education, and serves as chair of the Nominating Committee.

Physical Review Special Topics – Physics Education Research: A brief history and future directions

Charles Henderson, Western Michigan University, Senior Editor
Robert Beichner, North Carolina State University, Founding Editor

The purpose of this article is to provide an overview of the journal *Physical Review Special Topics–Physics Education Research* (*PRST-PER*). This will begin with a history of why *PRST-PER* was created in 2005, a picture of how the journal has grown since then, and then conclude with a vision of the future of the journal.

Overview of PRST-PER
Physical Review Special Topics–Physics Education Research (*PRST-PER*) is the archival research journal for the field of Physics Education Research (PER). The journal covers the full range of experimental and theoretical research related to the teaching and/or learning of physics. Unlike other journals that publish physics education research, *PRST-PER* is the only journal that has physics education researchers as its primary audience. As part of the American Physical Society's *Physical Review* series, *PRST-PER* shares in and contributes to the reputation of the *Physical Review* journals as among the leading international journals in Physics.

PRST-PER is an online-only journal published under the terms of the Creative Commons Attribution 3.0 License. This allows authors and others the right to copy, distribute, transmit, and adapt the work, provided that proper credit is given. In addition, because authors pay article-processing charges, the journal can be distributed without charge, thus making it easily accessible to researchers throughout the world.

> "APS was very interested in giving the Physics Education Research community a designated and selective journal home within the *Physical Review*. . . . The field isn't richly funded in every country, so making PRST-PER open access allowed physics education researchers around the world to get to these high-quality articles without a subscription barrier. We knew it was essential as well to work with the American Association of Physics Teachers and the APS Forum on Education to find scholarship options for authors who weren't able to pay the article-processing charges that permit open access." -Gene Sprouse, APS Editor in Chief.

Origins of PRST-PER
With the Spring 1999 adoption of a "Statement of Research in Physics Education," (http://www.aps.org/policy/statements/99_2.cfm) the American Physical Society (APS) Council recognized a growing interest in PER and supported its inclusion in physics departments. As the field's acceptance expanded, a major stumbling block was the difficulty in finding suitable publication venues. There were a few journals that might publish research on the teaching and learning of physics, but there was no one publication with that as its main focus. This was recognized as impeding the growth of the field because faculty could not make a strong case for promotion or tenure. Conversations between Bob Beichner, Ramon Lopez, Joe Redish and others about the need for a PER-specific journal led Beichner to write a proposal to the National Science Foundation (NSF) to create a web-based publication, along with an internet "homebase" for the PER community. With support from Ted Hodapp (then an NSF Program Officer) and others at NSF, the project was funded and led to the creation of the APS journal as well as the PER-Central.org website. In addition to NSF funds, the project was supported by the APS, the American Association of Physics Teachers (AAPT), and the APS Forum on

Education (FEd). (Support was provided to cover article-processing charges for authors able to document need for such support.) Although there was some initial resistance to the journal, three early events helped to alleviate most concerns: 1) APS agreed to have the new PER journal under the *Physical Review* imprimatur; 2) several senior members from the PER community came out in public support of the journal; and 3) a high profile Editorial Board was named for the journal, chaired by Carl Wieman. *PRST-PER* began publication in 2005 with Beichner as the founding Editor and David Maloney as the Associate Editor. Sanjay Rebello replaced Maloney as Associate Editor in 2008. In 2011 Beichner announced that he wished to step down as Senior Editor. He was replaced by Charles Henderson in 2012.

Current Status of PRST-PER

Since its beginning, *PRST-PER* has grown significantly. In this section we will discuss four important aspects of *PRST-PER*: finances, number of submissions (and acceptance rate), time to acceptance, and Impact Factor.

1. Finances

PRST-PER is currently funded in two important ways. The APS continues to provide approximately half the operating expenses of the publication. The other half is provided by article-processing charges. These charges are paid by authors or their institutions prior to publication of an accepted article. The Physics Education Research Topical Group (PERTG) of AAPT has also recently agreed to provide $10,000 annually to be used to support authors who are not able to pay the article-processing charges. As the journal grows, it is expected that the article processing charges will eventually cover all of the operating expenses.

> "Improving physics education will continue to be a priority for APS, and hence we expect to support PRST-PER in appropriate ways until its operating expenses are covered by article-processing charges. This is a sound and valuable investment in the future of physics."
> -Joseph Serene, APS Treasurer/Publisher.

2. Number of submissions

The number of submissions to *PRST-PER* continues to increase (see Figure 1). In 2011 there were 102 manuscripts submitted. Of those, 48 have been accepted for publication. The acceptance rate for manuscripts has remained fairly constant at approximately 45% throughout the journal's lifetime.

3. Time in Review

One important goal of any scientific journal is to publish important scientific results as quickly as possible. *PRST-PER* continues to work on decreasing the time from article submission to acceptance. As Figure 2 shows, 2011 was the best year yet, with a total time to acceptance of 165 days. Most of the time to acceptance occurs while the article is with the referees or with the authors (for making revisions). Keep in mind that the author and referee times include all rounds of reviewing and revision.

4. Impact Factor

All articles published in *PRST-PER* are indexed on the Web of Science. The Impact Factor is a metric that identifies the number of times, on average, that an article published in the previous two years was cited (by another indexed journal) in a particular year. For example, the 2011 Impact Factor of 0.902 means that, on average, articles published in 2009 and 2010 were each cited a bit less than once in 2011. As Figure 3 shows, the Impact Factor for

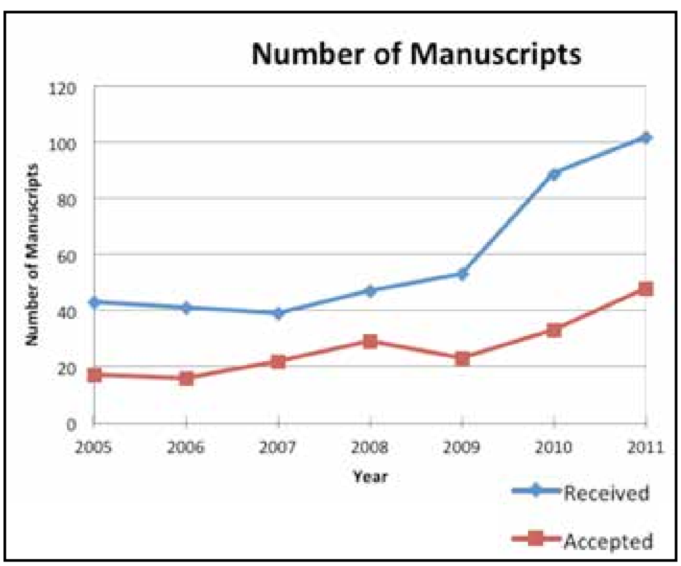


Figure 1: Number of manuscripts received and accepted. Note that the number of manuscripts accepted is based on the year that the manuscript was received (even though the manuscript may have been accepted in the following year).

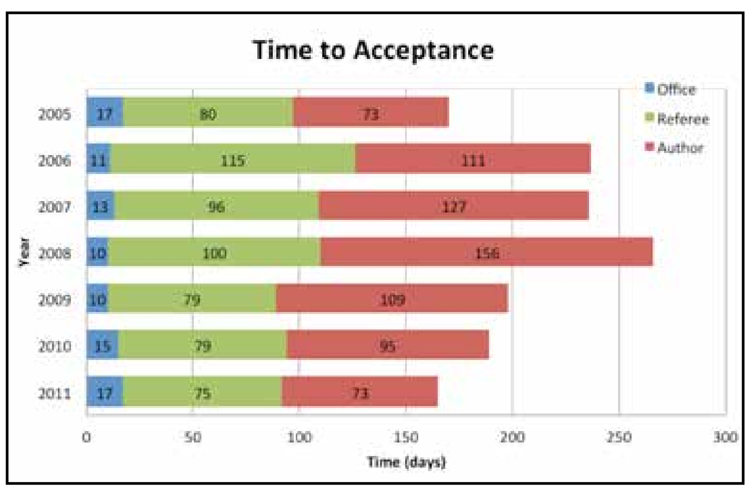


Figure 2: Time from submission to acceptance. Office: time for processing and routing the manuscript as well as time with the editors. Referee: time that the article is with referees for review. Author: time with the author for making revisions.

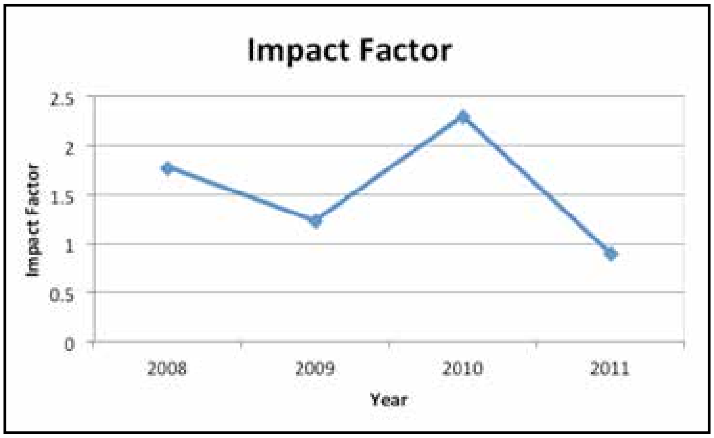


Figure 3: Impact Factor of *PRST-PER* for each of the four years available

PRST-PER fluctuates around a four-year average of 1.56. An Impact Factor of 1.00 is sometimes considered as a threshold for a high-quality journal.

Future Directions of PRST-PER

As shown in Figure 1, *PRST-PER* is currently experiencing rapid growth in terms of the number of submissions. This is an indicator that authors in the PER community see the journal as a high quality publication venue for their research. It is also notable that the percentage of articles submitted by authors outside of the US is now approximately 50% (up from approximately 25% during the first few years of the journal). This is an indicator that the journal is increasing its international visibility.

Although the trajectory of the journal is positive, there is still much to be done to ensure that this trajectory continues. As the journal grows and matures, it is important to maintain and in some cases formalize lines of communication between the journal and the stakeholder groups. Towards this end the journal plans to strengthen ties between the FEd and the AAPT Physics Education Research Topical Group (PERTG). The journal has also developed plans to increase the feedback that referees receive about editorial decisions and to more closely involve the Editorial Board in decision making. Finally, the journal is seeking to strengthen the international vitality of *PRST-PER* through an increased participation of authors and readers with diverse international perspectives on the teaching and learning of physics.

In order to increase the visibility and utility of the journal both within the PER community and outside, *PRST-PER* is also in the process of finalizing plans to develop theme issues of the journal. A theme issue will be a set of related articles that seeks to articulate the current state of PER knowledge related to the given theme. The articles will be tied together with an editorial by a Guest Editor that summarizes this knowledge. Thus, it is expected that this set of articles will be of significant value to the PER community as well as a place for those outside the PER community to get an overview of what PER can contribute to various areas of knowledge.

Of course, *PRST-PER* can only be successful with the help of people like you. If you are not currently in the reviewer pool for *PRST-PER*, please send a short note to the Editor (prstper@aps.org) with your contact information and areas of expertise. If you receive a request to review a manuscript, remember that the quality and timeliness of your review directly shapes the quality and timeliness of the final article. Finally, in order for PRST-PER to be the archival research journal for the field of PER, it is important for all research-based knowledge in physics education to be represented. When you see high-quality research in physics education that has not yet been published, encourage the researcher to develop an article and submit it to *PRST-PER*. And of course, please continue your investment in PER by publishing and sharing results through the *PRST-PER* platform.

Charles Henderson is an Associate Professor of Physics and Science Education at Western Michigan University. He currently serves as the Senior Editor of PRST-PER*.*

Robert Beichner served as the Founding Editor of PRST-PER*. He is an Alumni Distinguished Undergraduate Professor of Physics at North Carolina State University, and heads the North Carolina State University STEM Education Initiative. He is the recipient of the 2011 McGraw Prize in Education.*

Section on Teacher Preparation

Teacher Preparation Section

John Stewart, University of Arkansas

This edition of the Teacher Preparation Section features articles about two of the most important initiatives to improve the quality and quantity of STEM teachers: PhysTEC and UTeach. Jon Anderson, former Teacher-In-Residence at the University of Minnesota's PhysTEC site, will provide an overview of the role and contributions of TIRs across the PhysTEC project. These master teachers provide support and a practical knowledge of teaching that is vital to the development of a physics teacher preparation program and to the support of teachers post-graduation.

Mary Harris, Jennifer McDonald, John Quintanilla, and Cindy Woods of the University of North Texas will discuss their UTeach replication site. I had the pleasure of attending a presentation on Teach North Texas (TNT) at the annual UTeach meeting and was particularly impressed by the thoughtfulness, energy, and passion that has gone into the program. TNT's recruiting program is particularly innovative and effective. With a projected graduation rate of 50 highly qualified STEM teachers per year, TNT will dramatically impact the education of thousands of students in northern Texas.

Our final article discusses a long-standing professional development initiative for physics teachers, QuarkNet. The program, now fifteen years old and a recent recipient of continued funding, was featured in the July 2000 edition of the APS Forum on Education newsletter. The program allows in-service teachers to participate in particle physics research as part of the professional development required for continued licensure. The program also focuses on developing an active community of physics teachers. Recruiting and preparing highly qualified teachers is only part of the solution for the shortage of science teachers; it is also critical to retain working teachers. Active professional networks that provide a sense of community and support are an important part of keeping enthusiastic teachers in the classroom.

What Can a TIR Do For Your Teacher Preparation Program?

Jon Anderson

Introduction

With the recent death of Neil Armstrong and the landing of the Curiosity rover on Mars, the United States is reminded of the countless accomplishments of NASA. The space race inspired national investment and innovation to improve the quality of math and science teachers. Consequently, the courses these teachers taught and the students in these courses benefitted greatly. Once again, our nation is facing a critical shortage of qualified science teachers, specifically physics and physical science teachers. As colleges and universities around the country take steps to respond to this need, a number of strategies and approaches are being employed. In this article, I will discuss one important aspect of many successful teacher education programs, namely the role of the Teacher-in-Residence (TIR).

History and Background

The Physics Teacher Education Coalition (PhysTEC) has identified a TIR as one of the key components that is shared by successful teacher preparation programs across the country. The PhysTEC project is led by the American Physical Society (APS) and the American Association of Physics Teachers (AAPT), with support from the American Institute of Physics (AIP). The mission of PhysTEC is to improve and promote the education of future physics and physical science teachers. It was started in 2001 and to date has funded 27 institutions that are engaged in innovative and effective methods of physics teacher recruitment and training.

Initially, it was believed that the TIR position would be a one year appointment of an accomplished in-service physics teacher who would return to their school after their time as TIR. This person was to be housed in the physics department at the PhysTEC site and work closely with the the project PI. Although this model of the position in many ways holds true today, there are numerous variations on this model.

Today, the "typical" TIR can be characterized as a teacher from a high school that is reasonably close to the funded institution and someone who is a recognized master teacher and leader. Most commonly, this teacher is released either full-time or part-time from their school district to the PhysTEC site. Commonly, a portion of the PhysTEC funding is used to pay for this teacher's release from their district. In return, the district receives recognition as the home district of the TIR. The district is usually able to hire a less expensive replacement teacher for the time that the TIR is released. When the TIR returns to their home district, they return revitalized, more connected to the PhysTEC site, and more knowledgeable in Physics Education Research (PER). Since the start of the project, there have been 53 TIRs. Of this total number,

- 23 were/are female, 30 were/are male.
- 42 were/are in TIR positions full-time, 11 were/are in TIR positions part-time.
- 42 were/are in-service teachers, 11 were/are retired teachers.
- Teaching experience ranges from two years to over 40 years.
- 38 were/are in TIR positions for one year, 15 were/are in TIR positions two or more years.

The majority of the TIRs do fit the "typical" model but it is clear that there are many variations as well. These variations are in response to the different needs of the PhysTEC sites, the evolving responsibilities associated with the TIR position, and the demographics of the area served by a PhysTEC site. To illustrate this variation in the TIR position, consider the following three former TIRs:

- *Diane Crenshaw:* Diane earned her physics degree from Mount Holyoke College in Massachusetts. After graduation she moved to Miami to teach physics for two years in an urban high school as part of the "Teach for America" program. Upon completion of her teaching tenure, Diane was lured away to work as the full-time TIR for one year at Florida International University. Currently, she is working on a PhD in an education field at Columbia University.

- *Alma Robinson:* Alma is both a Virginia Tech graduate and the first TIR at Virginia Tech. While completing her Master's degree in Education, she worked as the Outreach Director for the Virginia Tech Physics Outreach program. Alma then spent the next eight years teaching all levels of physics before starting as the TIR at VT in 2011. Upon completion of this, her second year as TIR, Alma plans to return to teaching physics.

- *Jim Selway*: Jim started as the TIR at Towson University in January of 2011 and continued until August of 2012. Prior to his TIR position, Jim taught physics in the Baltimore public school system for 38 years as well as several years in the community college system. Towson has hired a new TIR for 2012-12 and Jim is continuing at Towson as a volunteer TIR –a first for PhysTEC!

Each of these TIRs left their own unique stamp on both their institution and on the PhysTEC Project. Each also took a different path both to and from the position.

A Day in the Life of a TIR

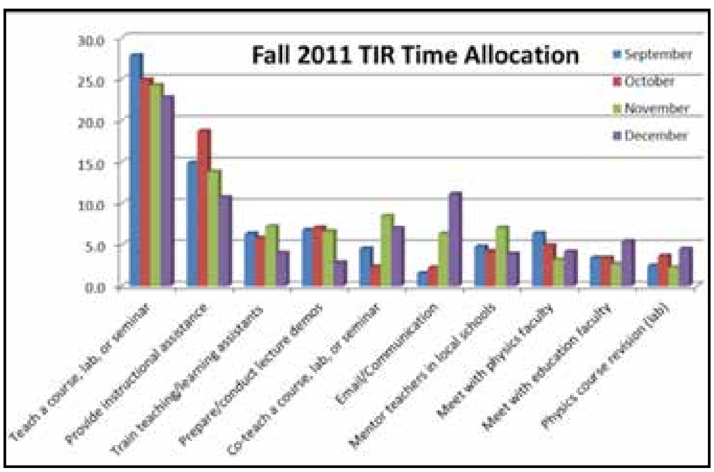
Here again, it is difficult to define "typical" TIR job responsibilities. They are as varied as the TIR's background and as the needs of the site at which they are working. However, PhysTEC has identified many different roles that TIRs fill in teacher preparation programs. Some of these roles are:

- Recruiter
- Advisor
- Instructor

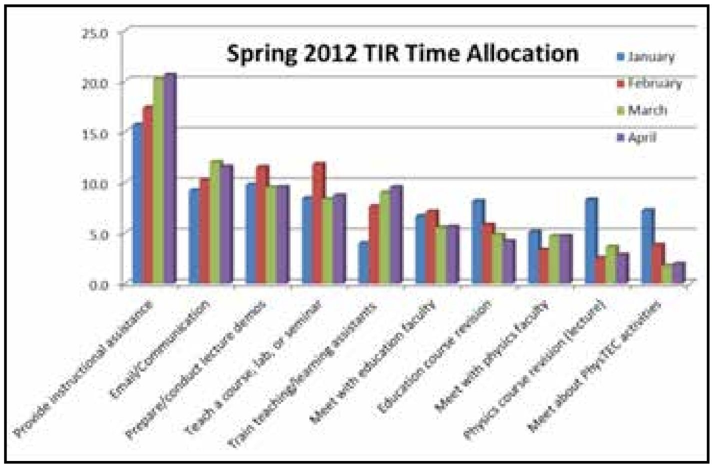
- Course and curriculum developer
- LA/TA leader
- Mentor
- Professional Community Leader
- Program Coordinator
- Professional Development Facilitator
- Ambassador to School of Education
- Ambassador to School Districts

This is not intended to be a comprehensive list, and several of these will be discussed in more detail later in this article. I will start by showing how the 2011-12 TIRs spent their time.

Beginning with the Fall 2011 semester, there were nine TIRs. Four were working full-time and five part-time at their position. Of these nine, five were new TIRs and four were returning for their second year. The majority of this group attended the "PhysTEC TIR & VMT Meeting" on July 29, 2011 in Omaha, Nebraska. This annual meeting occurs prior to the start of the AAPT Summer Meeting and is an opportunity for new TIRs to interact with veteran TIRs as well as PhysTEC Project personnel. It is a "launch pad" of ideas and details for new TIRs and their chance to get a much better sense of the responsibilities of their new role. Additionally, the TIRs participated in three video conferences that were scheduled throughout the academic year. The TIRs log their hours spent in various activities and submit monthly time logs of these hours. The two graphs shown below represent how the TIRs cumulatively spent their time in the Fall 2011 semester and the Spring 2012 semester. Please note that the y-axis represents the percentage of total hours spent in a given activity.



It is interesting to note that a closer look at the time spent in the five teaching-related categories ("Teach a course, lab, or seminar," "Co-teach a course, lab, or seminar," "Provide instructional assistance," "Prepare/conduct lecture demonstrations," and "Train teaching/learning assistants") accounted for an average of 50% of their time. Of the many strengths that the teachers bring to their TIR position, it appears that their experience and expertise as teachers is recognized and relied upon by the PhysTEC sites.



Because of their connections to the physics teaching community in the area surrounding their site, TIRs are also able to act as liaisons between the PhysTEC sites and the local schools. This ambassadorial role is beneficial both to the site and the schools. It connects the site with a larger pool of physics teachers that can be drawn upon for professional development opportunities, outreach activities, placement of student teachers, and the assembling of Teacher Advisory Groups. Additionally, it provides the area physics teachers with these same benefits as well as more direct access to the PhysTEC site and the people associated with it.

TIRs also serve as mentors to pre-service and in-service physics teachers. In fact, they have been involved in mentoring over 800 prospective and new teachers since PhysTEC's inception. This significant and far-reaching aspect of their position occurs in both a formal mentoring situation as well as informal situations. Because TIRs are fresh out of the physics classroom, they bring a sort of credibility and expertise that can't be duplicated and is recognized and sought out by prospective teachers. Often, the mentor/mentee relationship that develops continues after a TIR's tenure is complete. Personally, when I was starting my career, I was fortunate to work with an excellent physics teacher who continued to mentor me for many years. These types of relationships exist between TIRs and their mentees and continue to this day.

Furthermore, four former TIRs now continue in a more formal mentoring role as Visiting Master Teachers (VMT) at the six PhysTEC legacy sites that are served by the PhysTEC Noyce Scholarship awards. These VMTs maintain regular contact with pre-service and in-service physics teachers who were also awarded a PhysTEC Robert Noyce Teacher Scholarship. This PhysTEC supported mentor/mentee relationship insures that soon-to-be and new physics teachers have the ongoing support and resources that are provided by an experienced and knowledgeable master physics teacher.

The TIRs have also produced a wide variety of materials that have and continue to leave a mark on their site. Some of these materials include recruiting posters, recruiting videos, informational presentations and posters, monthly newsletters, Teacher Advisory Groups, talks at local, regional, and national conferences, reformed courses, new courses, outreach activities, lecture demonstrations, Learning Assistant programs, and classroom observation/volunteer options to name a few. Collectively, these materials enhance the physics teacher preparation program at these sites.

In the TIRs' Own Words

A comprehensive questionnaire of former and current TIRs was recently completed and the responses were compiled. This questionnaire produced several interesting results. First, the TIRs were asked to think about how they spent their time and about what amount of time they spent in these activities. The top five roles performed by TIRs (based upon frequency of response) were:

1. Recruiter
2. Instructor
3. Advisor
4. Mentor
5. LA/TA Leader

The top three activities in which the TIRs engaged (based upon time spent in activity) were:

1. Instructor
2. Mentor
3. Recruiter & LA/TA Leader

The most common response to the question: *There are a number of areas of knowledge and expertise that a TIR might contribute to the teacher preparation process that regular university faculty might not be able to contribute, either not as well or perhaps not at all. Please cite some examples of such areas that seem to you to be particularly notable or important.* was: "TIRs have a significant knowledge of classroom teaching/management and high school culture." Quoting one former TIR, "I think that the TIR brings an awareness of how a high school works and what are the daily challenges a teacher faces. In a sense they are the liaison between theory and practice," while another said: "Everything that is directly related to the culture and practice of HS teaching is better done by TIRs."

To the question: *If you were responsible for hiring TIRs, what specific qualities would you look for?* the most frequent responses were: "Energetic/enthusiastic, Passion for teaching, Significant teaching experience & content knowledge, Good communicator, Leadership, and Flexible".

The question: *From your standpoint as an experienced classroom teacher, what are some of the key areas of knowledge and expertise that pre-service teachers need to learn in order to make a successful start in teaching? Please be specific and cite examples.* drew the following responses: "Physics content knowledge, Pedagogical content knowledge, and Classroom management/student motivation".

Finally, in response to: *Are there some activities that are better done by TIRs and other activities better done by university faculty?* the TIRs responded that the they are better at "Sharing teaching knowledge, experience & pedagogy, recruiting, and advising/mentoring" while the faculty are better at "course reform, department engagement, and research strategies/opportunities".

Although I have provided only a generalized snapshot of the TIR responses, my hope is that it is clear that they share common perspectives and common responsibilities in spite of the fact that they are meeting many different needs at many different sites. One former TIR summed it up with the following words "This opportunity was one of the greatest in my life. After having had 38 wonderful years as a high school physics teacher, the TIR position gave me the chance to pay back by recruiting future physics teachers and training them at the university level."

Conclusion

The role of the TIR continues to evolve, and this is a good thing! It is also necessary as meeting the needs of the sites they serve and addressing the changing demographics of the next generation of physics teachers demands flexibility. It is also important that TIRs help lead the charge as universities continue to address the critical shortage of qualified physics and physical science teachers that our nation is facing. So, "What can a TIR do for your teacher preparation program?"

1. TIRs are experienced teachers. They bring this recent experience, a clear and honest perspective, and a first-hand knowledge of what physics teachers need to know and do in classrooms in the area that is served by the PhysTEC site.

2. TIRs are master teachers. Their expertise can be tapped to teach pedagogy courses, train Learning Assistants, assist in the reform of existing courses, and provide input in the design of new courses.

3. TIRs are connected. These connections to local organizations of physics teachers, schools, and state departments of education prove to be a valuable resource to the PhysTEC site and to the pre-service and in-service teachers associated with this site.

4. TIRs are mentors. Based upon 1, 2, and 3 above, they are in an excellent position to provide a mentoring experience that is both rich and comprehensive. Furthermore, the teachers that serve as TIRs bring a commitment to the profession of teaching physics that is pervasive in all they do, including their role as mentor.

5. TIRs are resourceful. They will develop and produce a host of materials related to the profession of teaching physics that will be available for the site's use long after the TIR's tenure has ended.

6. TIRs are recruiters. Please see 1-5 above for the reasons why.

Ultimately, it is reason #6 that potentially has the most long-term impact on a teacher preparation program. If the goal is to produce more physics teachers to meet the critical need that exists, then this end product has to start with recruiting. Once the recruitment→engagement→pre-service→in-service teacher pipeline is established, a teacher preparation program is poised to continually address the need for more physics teachers.

Jon Anderson has taught physics at Centennial High School near Minneapolis since 1988. He was the TIR at the University of MN PhysTEC site from 2007-2009, continues to work as a consultant for the PhysTEC project, and has been a QuarkNet Fellow since 2007.

Recruiting and Preparing Science and Math Teachers at the University of North Texas

Mary Harris: TNT Co-Director and Professor, Department of Teacher Education and Administration, Jennifer McDonald: TNT Program Advisor, John Quintanilla: TNT Co-Director and Professor, Department of Mathematics, Cindy Woods: TNT Master Teacher

Science and mathematics are fields from which there is a high rate of teacher attrition. Demand for teachers within these high needs fields is growing, with greatest need in schools with diverse populations of low-income students. Compounding the problem, the landmark *Rising Above the Gathering Storm* (National Research Council, 2007) reports that "middle and high school mathematics and science teachers are more likely than not to teach outside of their own fields of study" (p. 113). The deficiencies found in teaching science and mathematics at the middle and high school levels can be attributed to three primary causes: lack of science and mathematics educator preparation programs that provide strong subject content and pedagogical knowledge for pre-service teachers, lack of support during the first years of employment, and failure of universities to recruit into science and mathematics teacher education programs (National Research Council, 2010).

In response to the state and national imperative for the United States to reemerge as world leader in science, technology, engineering, and mathematics (STEM), the University of North Texas (UNT) implemented the Teach North Texas (TNT) program, a replication of the pioneering UTeach program at the University of Texas at Austin. Combining classroom teaching experiences throughout the pedagogical course sequence, opportunities for professional development and induction, and financial support for its students, TNT has been increasingly successful in raising the quantity and quality of competent and innovative teachers within these high-need fields.

TNT now boasts almost 300 students, including 16 students seeking Physics or Physics and Mathematics secondary teaching certification. Equally impressive, TNT students are an academically talented group, with higher average GPAs and SAT Math scores than college and university averages. We expect to produce approximately 50 graduates annually in the coming years.

So, how are we doing it? Our success is an intricate interweaving of five key components: collaboration, curriculum, staffing, targeted recruiting and retention practices, and community.

Collaboration

Prior to the inception of TNT, our university of over 28,000 undergraduate students produced an annual average of only 8 secondary mathematics and science teachers *combined*, and a majority of these graduates considered their generalist education courses to be greatly disconnected from teaching in the STEM fields. Our university leaders saw the need for change and pledged cooperation and support for the creation of a teacher education program specifically geared toward mathematics and science.

The TNT program is firmly rooted in a collaborative vision of excellence. The College of Education (COE) and College of Arts & Sciences (CAS) worked together to implement TNT; and continued support of each college's dean, our provost, and our president have enabled TNT to grow and sustain a remarkably successful mathematics and science teacher education program.

TNT also collaborates with five local school districts, since all field experiences require the cooperation of district officials and human resources departments. We maintain an extensive network of local Mentor Teachers who open up their classrooms to TNT students for observation and teaching practice. Without their cooperation and feedback, the extensive training we provide students would not be possible.

Curriculum

TNT's unique curriculum instantly sets our program apart from others. It begins with an invitation for university students who have a declared interest in science or mathematics to explore teaching through a minimal-investment one-credit-hour course. Enrollment in this introductory course does not automatically require completion of the entire TNT program. However, those students who discover a passion for teaching complete a 21-credit hour minor along with their STEM content majors. These students join an educational community solely dedicated to their growth as future middle school and high school science or mathematics teachers. TNT's dedication does not stop upon graduation; we continue to support our graduates with an induction program throughout the first and second years of their teaching careers.

The TNT minor is a sequence of courses created by COE and CAS that are specifically designed to prepare future science and mathematics teachers for the middle and high school classrooms. Throughout the program, students are trained to use the inquiry-based 5E lesson plan model (engage, explore, explain, elaborate, evaluate). Inquiry-based teaching pushes TNT students toward a deeper, more thoughtful understanding of lesson planning and challenges their prior assumptions about how a class "should" be taught. Utilization of the 5E model leads to innovative and creative lessons that ensure student engagement and content understanding.

TNT stresses early and continuous field experiences both to recruit students into the program and to ensure that the teachers we produce are well qualified to teach when they enter the workforce. Few degree programs provide so many opportunities for students to interact with, learn from, and emulate practitioners in the field. TNT requires students to observe and teach at the elementary, middle school, and high school levels. As much as possible, TNT students are placed in classrooms comprised of ethnically and linguistically diverse students and in locations where a majority meet the criteria for free and reduced price lunches. This ensures that TNT students recognize and experience the cultural and emotional developmental needs of diverse populations in and out of high-need schools.

Throughout the TNT minor, students develop and practice inquiry-based lessons and use results of student assessment to improve teaching. Initially, for their very first field experience, students think through the questioning strategies necessary to deliver a proven lesson effectively using a kit of materials. As TNT students gain teaching expertise, they are increasingly challenged to utilize knowledge acquired by creating original lesson plans. By the second semester of the minor course sequence, our students are developing and teaching their own lesson plans, and by the fourth semester, they are developing and teaching lessons planned for the high school level.

Furthermore, TNT students use their own teaching as the subject of action research or inquiry. They videotape and study their teaching and study the results of student pre- and post-assessments. This enables our pre-service teachers to create probing questions that link student responses directly to their understanding of the material. This type of self-critical practice characterizes excellence and innovation in mathematics and science teaching.

Staffing

As a joint program of COE and CAS, TNT is led by co-directors from both colleges, both reporting to their respective deans. TNT functions as a small department within CAS but offers a minor comprised of courses from both colleges. Both of the co-directors are released half-time by their departments to lead TNT, and they make requests for funding, development, and research support through both of their colleges.

The co-directors lead a team of seven Master Teachers, who are experienced STEM teachers who possess, at minimum, a master's degree. Master Teachers are readily available as students prepare their lessons, and, as much as possible, they travel to schools to observe and critique TNT students as they teach. Master Teachers hold the rank of Lecturer, teach multiple TNT courses, and obtain approvals for students' field experiences with COE and school district officials. The external relationships developed by Master Teachers help the program navigate such obstacles as processing criminal background checks, facilitating appropriate placements for apprentice (student) teaching, and communicating opportunities for employment.

TNT also employs three staff members. With a dedicated Program Advisor, we try to provide a one-stop shopping model of advising our students. Our advisor works with CAS faculty and staff advisors regarding recruiting, enrollment, and degree requirements. The advisor works with COE staff on procedures for formal admission to the teacher education program, admission into apprentice teaching, and teacher certification by the state. The Program Advisor also assists with financial aid issues and scholarship applications and directs Talon Teach, the TNT student organization. Our administrative services officer ensures our unit's compliance with university protocols with purchasing, payroll, and other similar issues. Finally, our materials manager serves as the program's quartermaster, tracking and maintaining our large inventory of pedagogical materials that TNT students peruse and borrow as they teach their lessons.

TNT highly depends on existing COE faculty specializing in science and mathematics education as well as CAS faculty who have a high interest in educational issues. Course teams made up of tenured/tenure-track faculty from COE and/or CAS, Master Teachers, and graduate students meet several times each year and as often as once a week. We organize at least one annual meeting of the entire teaching faculty around program evaluation. At these meetings, data documenting student learning and other evidences of program success or need for improvement are considered, and plans are made for changes to the courses and program and for evaluation of the impact of changes.

Recruitment

In Fall 2012, TNT successfully attracted and enrolled 113 new students. TNT utilizes a combination of guerrilla and conventional marketing strategies with a primary focus on the engagement of students, faculty, and staff to increase enrollment and retention. Recruitment tools include marketing materials, electronic marketing, and word of mouth. The combination of direct recruiting efforts and the maintenance of program visibility have yielded success semester after semester.

The recruitment tactic with the greatest return is presence at all University Orientation sessions. At least one student and the Program Advisor attend all Orientation fairs and are present during one-on-one academic major advising sessions prior to new and transfer student registration. They promote TNT with short program highlights as invited by the hosting faculty advisor. TNT is advertised as a “you can do it all” degree plan. Emphasis is placed on earning a full STEM major along with teacher certification in a “two for one” slogan. Co-presentation by the Program Advisor and a current science student has led to a large increase in science (including physics) enrollment. Follow-up via e-mail reminds students of how to enroll and provides contact information in case of additional questions.

Electronic communication and marketing materials ensure program visibility and engage students, faculty, and staff. Powerful recruiting tools include targeted e-mail solicitation to science and mathematics students, strategically placed fliers with student quotes and photos, and student-produced banners outside of the TNT classrooms. Promotional items such as t-shirts, pens and pencils, notepads, key-chains, and bumper stickers, build program recognition. Faculty, staff, and students are active on the website, Facebook, and Twitter.

Word of mouth has created positive TNT program recognition across campus and within surrounding communities. TNT partners with not only campus administrators but also student advisors from other academic areas, teachers and school administrators in surrounding school districts, and UNT faculty. Consistent recognition of the efforts these partners make for TNT and its students garners continued support from these contributors. Enough cannot be said about the importance of partnerships. Numerous students are referred directly to our program not only by faculty and staff advisors, but also by community program affiliates.

Community

Students quickly learn that TNT is much more than a sequence of courses; it is a community of students, instructors, and staff with a common commitment to STEM teaching and learning. Be it through lounging in the student workroom on a beanbag chair, studying at the worktables with peers for an upcoming exam, receiving lesson-planning assistance from a Master Teacher, or cracking jokes with the Program Advisor after an advising session, our students are engulfed in a supportive environment that is dedicated not only to academic success but also to personal fulfillment. TNT has experienced success in retaining the students recruited by creating an environment in which students want to participate. This is done by using the best resource available: human interaction. TNT faculty and staff, administrators, instructors, colleagues, campus advisors, and most importantly, students all facilitate human interaction. Collaboration and communication, appreciation, and a sense of belonging come with membership in TNT. How we work with the many different people who make up TNT directly impacts the program’s success.

References

1. National Research Council, (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* Washington, DC: The National Academies Press.

2. National Research Council, (2010). *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. Washington, DC: The National Academies Press.

TNT Physics major Gene Costa performs an experiment illustrating buoyancy with a group of high school students. Gene states: “If students are engaged, their learning process becomes much more authentic. I’m committed to showing students that science is not a sterile subject and that only a willingness to think with a natural, childlike curiosity is required. Teach North Texas has imparted in me the ability to teach through hands-on experience, and I’m prepared to meet the needs of different students in my classroom.”

TNT Physics major Johnny Long works with a force-motion track during an experiment with local high school students. Johnny states: “I would never have considered the teaching field if I hadn’t found a program like TNT that actually makes great teachers. I’ve learned that playing with science is fun, and that teaching science is both rewarding and fun.

QuarkNet in the Teen Years

Jon Anderson
Shane Wood

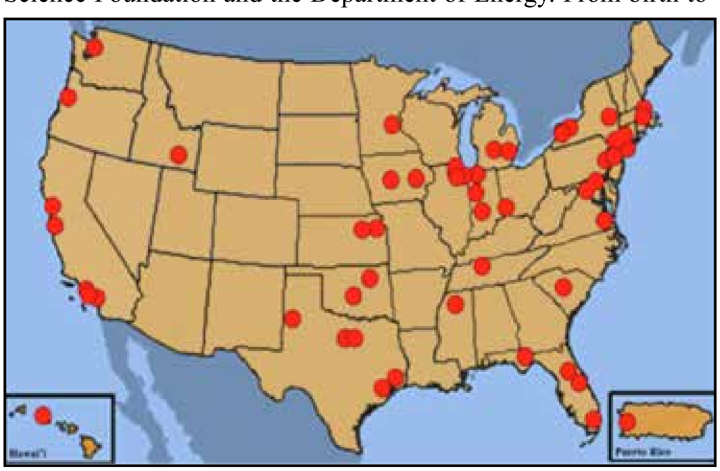
I. Introduction

Professional development is a two-word phrase that doesn't always inspire enthusiastic response or participation from high school teachers. Unfortunately, this is based on experience. The opportunity to participate in meaningful, applicable, and up-to-date opportunities for professional development in one's teaching area is often difficult to locate and/or be selected to participate. Furthermore, teachers are constrained by a work schedule that is both unique to the profession and complicates the effort to seek out such opportunities. Yet, *x* number of professional development hours are required annually for every teacher to maintain and renew their teaching license. Consequently, participating in professional development often becomes more chore than opportunity and is often a "packaged", stand-alone workshop that offers little to no continuing support.

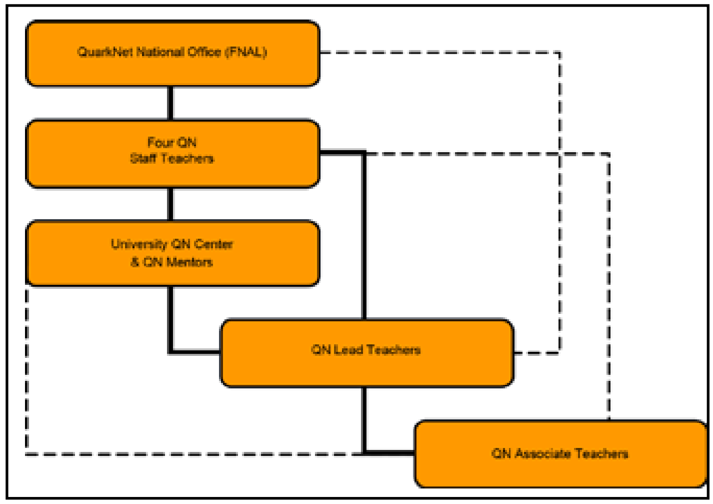
Physics teachers are fortunate when it comes to professional development due to the many well-supported and diverse opportunities available to them. Workshops and sessions at AAPT Summer Meetings, Research Explorations for Teachers programs at universities, physics modeling workshops, topic-specific workshops, NASA sponsored workshops, and state and local organizations of physics teachers are just a few of the options available to physics teachers in their quest for professional development. Additionally, these opportunities tend to attract motivated and knowledgeable participants and this further enhances the experience. Consequently for physics teachers, participating in professional development is usually more opportunity than chore. Two of the hallmarks of meaningful professional development opportunities are longevity and the networks of participants that develop. It is these two areas that truly set the QuarkNet collaboration apart from so many others.

II. QuarkNet History and Structure

QuarkNet was born in 1999 and is jointly funded by the National Science Foundation and the Department of Energy. From birth to



QuarkNet Center Locations across the United States



QuarkNet Organizational Structure

its pre-teen years, QuarkNet centers were established at universities that had physicists collaborating on the CDF or D0 experiments at the Fermi National Accelerator Laboratory's Tevatron accelerator. In fact, Fermilab is still the epicenter of the QuarkNet collaboration. It has since expanded to include physicists participating in the ATLAS and CMS experiments at the Large Hadron Collider at CERN.

Now in its teen years, QuarkNet has established over 50 centers at universities across the nation and Puerto Rico as is shown on the map. It is at these centers that the participating physicists take on the role of QuarkNet Mentor. It is also at these centers that the QuarkNet workshops are held. Workshops at the centers take on a variety of different structures and we will discuss some of these later in this article.

In addition to the QuarkNet Mentor(s), each QuarkNet center selects and employs two Lead Teachers who are chosen from local schools. After training, the teachers and their mentors work together to plan the QuarkNet workshops that are held at the centers. The organizational chart that is shown above gives a generalized overview of the QuarkNet collaboration. The four Staff Teachers are employed full-time by the collaboration and provide various types of leadership and support for the QuarkNet Centers. Additionally, the dashed lines are drawn to indicate that collaboration occurs between the different layers and to illustrate that the organization does not operate in a hierarchical manner. The ongoing discussion and collaboration that this organizational structure promotes is truly one of its strengths.

During the first year for a new QuarkNet center, the lead teachers engage in a paid, eight-week summer research appointment working with their QuarkNet mentor to gain a better understanding of the concepts and research involved. The first week of this appointment is spent at Fermilab as participants in Boot Camp. This is an activity that will be discussed in more detail later in this article. The lead teachers then take the knowledge and experience that they gained from the research appointment and incorporate it into their curriculum as well as beginning the planning process for subsequent summer workshops.

III. QuarkNet Professional Development Opportunities

The QuarkNet collaboration and the activities that are developed for professional development are driven by four goals.

1. QuarkNet teachers provide opportunities for students to increase their scientific proficiency, especially in particle physics.
2. QuarkNet teachers create environments for students to interpret, evaluate and provide explanations for phenomena in the natural world.
3. Students of QuarkNet teachers show evidence that they understand how scientific knowledge is developed and engage in scientific practices and discourse.
4. QuarkNet teachers participate in sustained professional development.

The QuarkNet professional development opportunities that support these goals are numerous. Some of the most important are discussed below.

A. Particle Physics Boot Camp

As the name implies, the annual particle physics "Boot Camp" is a chance for new lead teachers and other QuarkNet teachers to immerse themselves in a week-long, intensive particle physics experience at Fermilab. Participants experience a guided inquiry data analysis activity in which they gain a better understanding of what happens in collider detectors. Several of the physics concepts that the teachers apply in their analyses are among the very concepts that are taught in high school physics, including the use of vectors, conservation of energy and conservation of momentum. Teams work collaboratively, guided by QuarkNet staff members and other QuarkNet teachers (QuarkNet Fellows). The week concludes with participants presenting results in a poster session at Fermilab. The Boot Camp week also includes many facility tours, physicist talks, and time for teachers to discuss and reflect on pedagogy.

B. High School Teachers (HST) at CERN

Each summer, a number of QuarkNet teachers are chosen from the United States to attend the High School Teachers program at CERN. This international program takes place for three weeks each summer, and includes physics teachers from around the world. Goals of this program include the promotion of physics and particle physics education in high schools, to expose teachers to particle physics research, to create, update and modify particle physics-related activities to be used in the classroom, and to provide a setting that encourages the exchange of ideas and experiences among an international collection of teachers. Curricular contributions from each year's participants continually update the wide array of particle physics teaching materials housed at the HST website. HST teaching materials produced over the years include lessons and activities focused around accelerators, detectors, bubble chambers, particle physics experiments, and physics in general.

C. QuarkNet Fellows

The QuarkNet Fellows Program began in 2007 in order to develop leadership in a select number of QuarkNet teachers who could work with QuarkNet staff in order to provide professional development activities for QuarkNet centers. Fellows develop and lead workshops, create activities to be used with teachers and students, attend and present at national, regional, and local conferences. Particle physics Boot Camp, the US Masterclass, cosmic ray workshops, and LHC data workshops are among the many facets of QuarkNet in which the Fellows play a key role.

A graduate student demonstrates a cloud chamber for students participating in a Masterclass day at the University of Minnesota.

D. Ongoing Local Professional Development

In addition to some of the national and international programs and initiatives mentioned above, networks of QuarkNet teachers are active each year at the 50+ local QuarkNet centers scattered across the United States. QuarkNet Mentors and Lead Teachers, in collaboration with QuarkNet staff members coordinate a wide variety of professional development activities at each center. Examples include cosmic ray and LHC data workshops led by QuarkNet Fellows and staff, talks by particle physicists regarding the latest developments in particle physics research, building equipment that can be used in the classroom (including cloud chambers and cosmic ray detectors), time for discussion regarding state and local standards, facility tours, demonstration shows, among many other activities and events. Each year, many centers bring on new teachers to the network, while providing continuing opportunities for the experienced QuarkNet teachers.

IV. QuarkNet Mentor and Teacher-Led Opportunities for Students

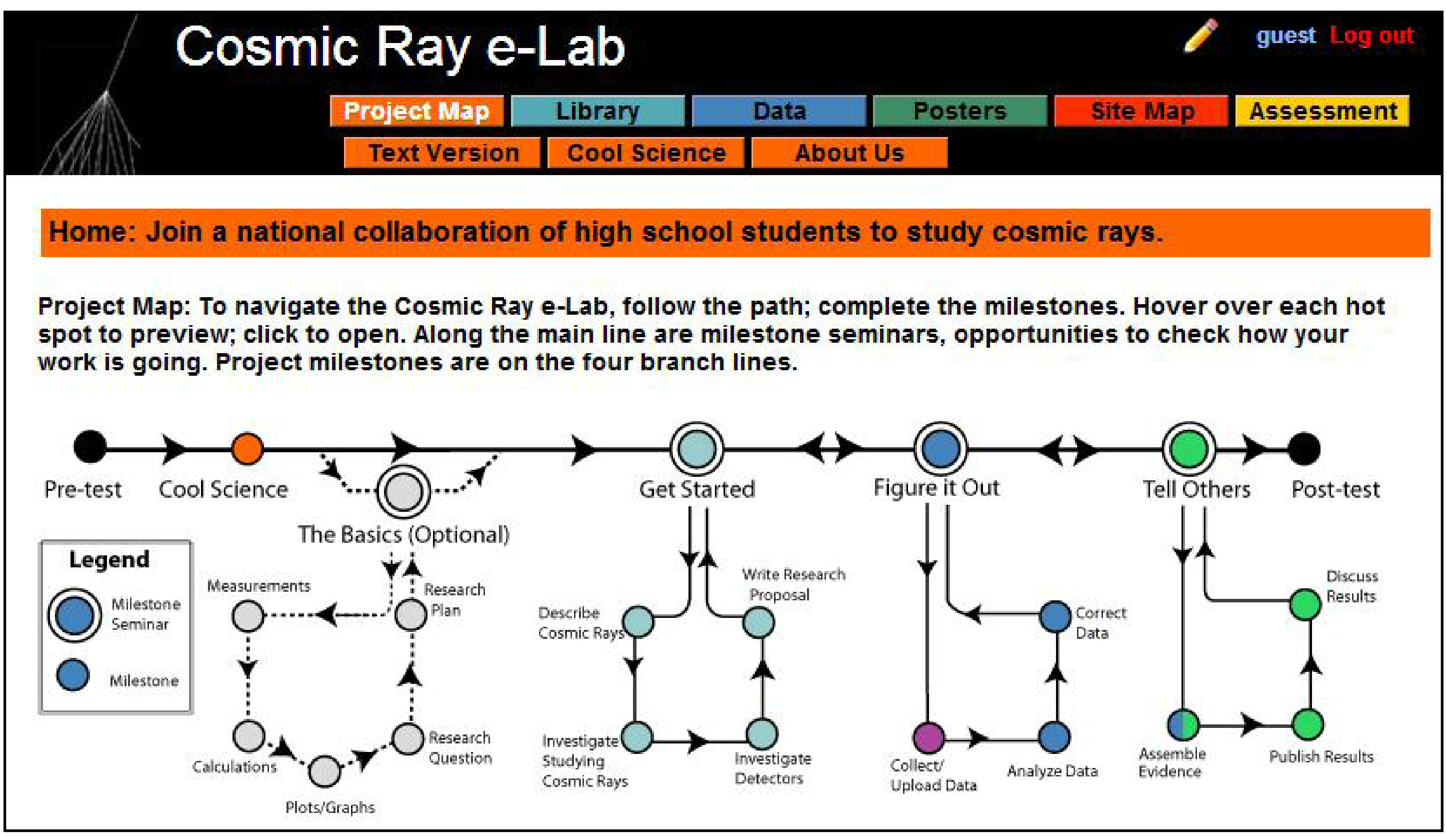
A. The Particle Physics Masterclass

Each year since 2007, QuarkNet has organized the US Masterclasses in which high school physics students have the opportunity to work for a day with QuarkNet teachers and mentors at local QuarkNet centers. The day includes particle physics talks, facility tours, lunch with a physicist, demonstrations (including cloud chambers, e/m apparatus, etc.), Q&A sessions, and culminates with students at each center analyzing 1000 events from various particle physics experiments (including data from the ATLAS and CMS detectors at CERN). Modeled after the world of professional physicists, students communicate results with one another through videoconferences, where results are summarized, questions are asked, and implications discussed. Prior to the Masterclass day, QuarkNet teachers must "set the stage" for participating students by working through three-plus hours of preparation materials. Masterclass provides opportunities for students to apply physics concepts learned in physics class (conservation laws, etc.) to modern physics research, to build their knowledge of particle physics concepts, and to deepen their understanding of the nature of science.

QuarkNet teachers study a particle detector (cloud chamber) up close during a QuarkNet meeting.

B. Interactions in Understanding the Universe (I2U2) e-Labs

QuarkNet teachers and their students now utilize various "e-Labs" in order to conduct authentic research experiences and to participate in scientific collaborations that extend beyond the classroom. The e-Labs are created and maintained by the organization I2U2 (Interactions in Understanding the Universe), and provide a common framework and resources for student-led, teacher-guided investigations. Students access e-Labs through a web-browser where they are guided through various milestones that include planning research, collecting/analyzing data, and publishing results in an online poster format. Students record progress and obtain teacher guidance through the use of an online logbook that allows for teacher feedback. Students currently have access to three types of e-Labs, including CMS



The opening web page indicating a research path for students to take in a Cosmic Ray e-Lab

Participants in a Masterclass communicate through a videoconference.

(CERN's Compact Muon Solenoid), LIGO (Laser Interferometer Gravitational-wave Observatory) and cosmic ray e-Labs. Much of the data uploaded for the cosmic ray e-Labs originates from QuarkNet-issued, student-assembled cosmic ray detectors located at high schools scattered around the country.

C. Summer Teacher/Student Research Program

Since 2004, QuarkNet has supported a summer student research program in which teams of four high school students work with a QuarkNet teacher on one of a variety of research topics. To date, research has been associated with variety of experiments, including CERN's ATLAS and CMS detectors, and cosmic ray muon detectors located in classrooms. The program runs for six weeks each year out of several QuarkNet centers around the country.

V. QuarkNet at the University of Minnesota

The QuarkNet center at the University of Minnesota (U of MN) got its start in 2002 with the support of QuarkNet Mentors Dr. Kenneth Heller and Dr. Priscilla Cushman. Dr. Daniel Cronin-Hennessey has since replaced Dr. Cushman as one of the mentors. In 2002, the authors were hired as Lead Teachers. Our initial training and research appointments started with one week of Boot Camp at Fermilab. This was followed by participating in research with the mentors at the University of Minnesota and at CERN. It was an exciting summer with a steep learning curve! As per the QuarkNet model, we spent the next academic year implementing what we had learned as well as planning for the three week workshop for Minnesota physics teachers to be held in the summer of 2003. Since that initial QuarkNet workshop, we have been conducting five to six day workshops every summer. Our workshop model is focused on exposing and introducing physics and physical science teachers from Minnesota to particle physics background material, particle physics-related curriculum, and to the larger QuarkNet collaboration. We have had over 100 teachers participate in our workshops and they bring a wide variety of backgrounds to our center.

- The teaching experience of participants has ranged from recent graduates of licensure programs to master teachers with 34 years in the classroom.
- Some participants have extensive physics background and coursework while others have had only one or two courses in physics.
- Some participants teach in rural schools while some teach in urban high schools.
- Some participants teach only physics classes while others are THE science teacher, teaching physics, chemistry, and biology.

Our workshops are a mix of "Particle Physics 101", working with particle physics-related labs and curriculum, lunch talks by U of MN particle physicists, introduction to the Masterclass, and tours of particle physics research facilities. We have toured research laboratories on the U of MN campus, the NOnA experiment detector module factory, the MINOS experiment, and Fermilab.

Being a physics teacher is often a lonely pursuit. It is not unusual to be the only physics teacher at a school so collaboration with peers is rare. Perhaps the most significant accomplishment of our QuarkNet center is that we have been able to facilitate the creation of a community of physics teachers. These teachers are connected to one another, they are connected to QuarkNet, they have taken advantage of additional QuarkNet professional development opportunities, they are more knowledgeable about particle physics topics and activities, they have engaged countless students in the inquiry process that is physics research, and they have successfully advanced the scientific literacy of their students through their connections to this larger community. This accomplishment is not unique to our center; other QuarkNet centers have been equally successful.

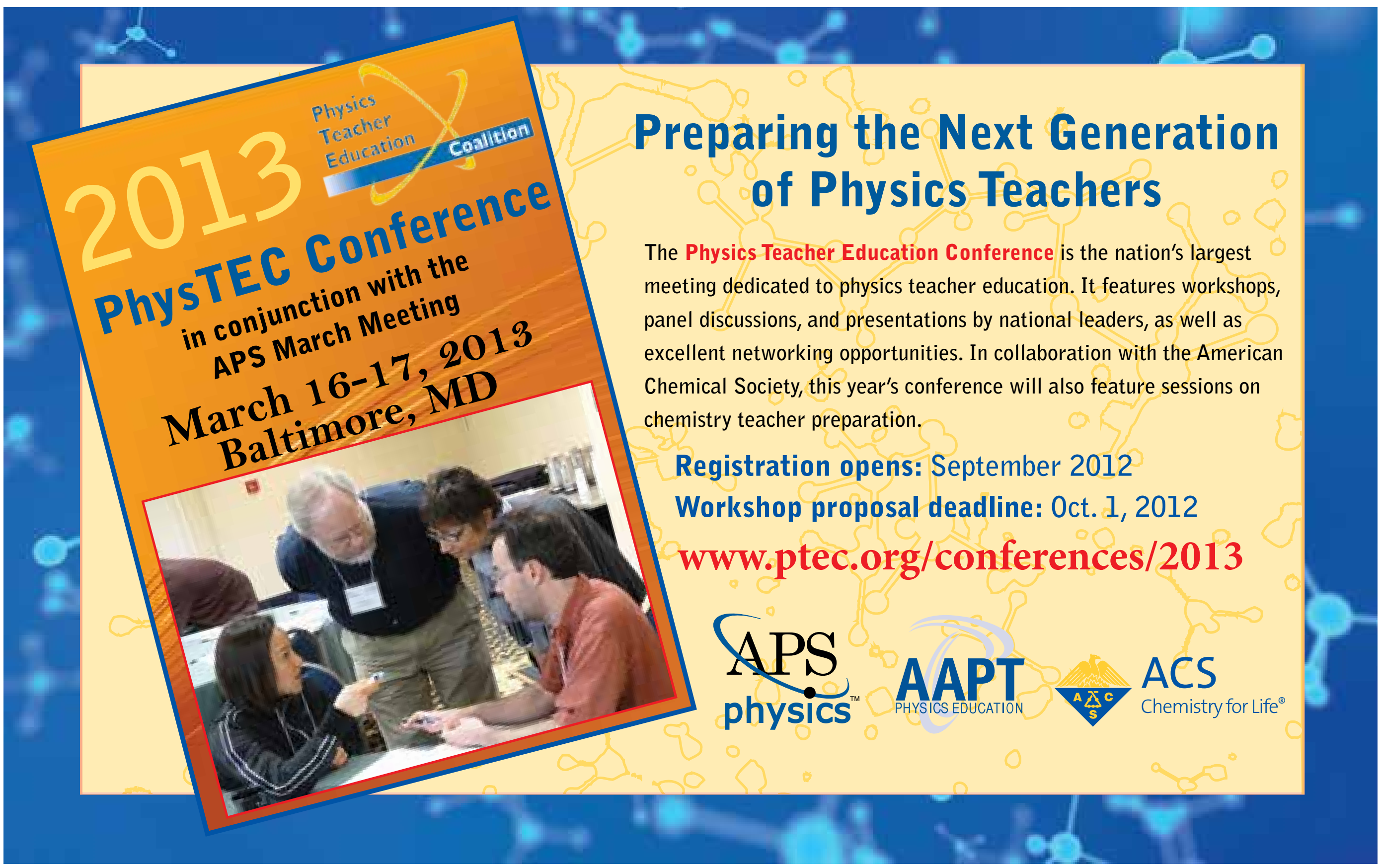
VI. Conclusion

QuarkNet is now 14. As it starts its 15th year, it starts with another five years of funding. This funding will allow it to continue to grow, mature, and reach adulthood as a vital component of and contributing member to the physics teaching professional development society. This is unusual in the realm of professional development opportunities.

In the last 14 years, there have been numerous people and institutions involved in the raising of QuarkNet. All of these have had their own impacts on QuarkNet and all have had a hand in easing the growing pains that are inevitable in this process. Along the way, QuarkNet has been able to learn, to adapt, and to become a stronger collaboration as a result of the type of input that has been provided. It is this continual growth that has allowed the QuarkNet collaboration to provide up-to-date and classroom-ready curricular materials and background information as key parts of workshops at QuarkNet centers across the country. Because of this growth, the Masterclass continues to improve and continues to immerse a broader populace in the excitement and challenge of basic research, scientific literacy continues to grow, the QuarkNet centers continue to evolve based on the resources of the centers and the needs of the teachers they serve. Unique collaborations of physicists, postdocs, technical staff, graduate and undergraduate students, high school teachers and high school students continue to be formed. Perhaps most importantly, the high school teachers being served and the students with whom they do and will work continue to be the biggest beneficiaries of QuarkNet.

Jon Anderson has taught physics at Centennial High School near Minneapolis since 1988. He was the TIR at the University of MN PhysTEC site from 2007-2009, continues to work as a consultant for the PhysTEC project, and has been a QuarkNet Fellow since 2007.

Shane Wood has been a science teacher at Irondale High School near Minneapolis, MN since 2001. He has been involved in QuarkNet since 2002, and a QuarkNet Fellow since 2007.



Next Generation Science Standards and Physics Teaching

Scott Bonham, Western Kentucky University

The development and implementation of the Next Generation Science Standards (NGSS) will have a potentially significant impact on K-12 physics instruction and beyond. NGSS is a collaborative effort to develop new state-level standards for K-12 science education,[1] building on previous standards and research on learning, and following up the recent wide adoption of the Common Core Standards in Mathematics and Literacy.[2] The development of NGSS is being carried out in a two stage process: the development of the conceptual framework by the National Research Council, and the writing of the standards themselves, organized by the non-profit educational foundation Achieve, Inc.[1] As of June 2012, feedback on draft standards has been collected from various sources and a review of revised standards is expected in Fall 2012. Twenty-six states are currently involved as Lead State Partners, which will seriously consider adopting the final standards.[3]

The vision laid out in the NRC report *A Framework for K-12 Science Education*[1] would improve science education in a number of important ways. First, is calls for more depth and less breadth, consistent with findings of research.[4] Towards this end, two to four core ideas in each discipline have been identified which will guide what is and is not included. Second, there is an intentional building on the core ideas from early ages; for example, the concepts of forces, energy and waves would first be introduced in elementary school and then built upon in middle and high school. Third, there is a much greater emphasis on the process of science and connecting ideas; the framework envisions scientific knowledge as three dimensional, with practices and crosscutting concepts as well as the discipline-specific concepts (see Figure 1). Specific performance expectations in the standards themselves are organized so that each performance item contains a practice, a core idea and a cross-cutting concept with explicit links and explanations, as well as links to other standards in science, math and literacy. Fourth, the standards recognize the interrelationship of technology with science, and explicitly include engineering/applied science within the framework. Fifth, there is an explicit concern about college and career readiness, asking what students need to know to be ready for college or the workforce.

The vision laid out in the framework would lead to significant improvements in K-12 science education. However, there is much that needs to happen for this vision to be realized. First, all involved in science education need to ensure that the standards themselves are well written and provide high but achievable expectations for all K-12 students in learning science in general and physics specifically. The first public draft released by Achieve in May of 2012 was commendable in many ways, but also included expectations that were poorly developed and with other problems. Achieve promised that all the feedback they received will be used to improve upon the first draft, but it is incumbent on our community to do all we can to ensure that does in fact happen. There will be at least one more round of feedback on the revised standards in the fall of 2012, which will be collected from departments of education in lead state partners, professional societies like APS and AAPT, and the general public through the NGSS website. Second, the implementation of the standards will require significant changes in K-12 education, professional development, curricular materials, and post-secondary instruction in support and as a result of new standards.[1] This will include ensuring K-12 teachers from elementary school up have sufficient content understanding, particularly in areas of new emphasis like waves and engineering. The emphasis on practices will require a shift in instructional

Figure 1

Scientific & Engineering Practices	Core Ideas (partial)	Crosscutting Concepts
•Asking questions (for science) and defining problems (for engineering) •Developing and using models •Planning and carrying out investigations •Analyzing and interpreting data •Using mathematics and computational thinking •Constructing explanations (for science) and designing solutions (for engineering) •Engaging in argument from evidence •Obtaining, evaluating, and communicating information	**Physical Science** PS 1: Matter and its interactions PS 2: Motion and stability: Forces and interactions PS 3: Energy PS 4: Waves and their applications in technologies for information transfer **Engineering, Technology, and the Applications of Science** ETS 1: Engineering design ETS 2: Links among engineering, technology, science, and society	•Patterns •Cause and effect: Mechanism and explanation •Scale, proportion, and quantity •Systems and system models •Energy and matter: Flows, cycles, and conservation •Structure and function •Stability and change

methods from telling to activities that better reflect the process of doing science, which will need to be modeled for future teachers in both science and teacher preparation courses. There will need to be significant development or modification of curricular materials such as textbooks and science kits to fit the new standards. The development of state-level assessments that well reflect student understanding of not only concepts but scientific processes and cross-cutting concepts will be a key part of ensuring that what happens in the classroom reflects the new standards. There will also need to be significant research to support all of this.

While NGSS will most directly impact K-12 instruction, it is important that those at the post-secondary level be aware of and involved in the development and implementation. First, we have the knowledge of both the content and process that should be reflected in the standards, as well as in teacher preparation, curriculum, and assessments. Second, teacher preparation programs will need to look closely and make changes as needed to ensure that future teachers have the foundations they need. Third, if NGSS is successfully implemented, it will change preparation and expectation of what happens in a science class of the students coming into introductory post-secondary science classes. This may require restructuring of those classes and possibly introducing remedial classes the way they exist in math and English. The Next Generation Science Standards represents an opportunity to improve science instruction in our country, but realizing that potential will require significant effort of all those involved in science education.

References

1. National Research Council, *A Framework for K-12 Science Education*, Washington, D.C., National Academy Press, 2012.
2. Common Core State Standards, In the States, 2012, http://www.corestandards.org/in-the-states.
3. Next Generation Science Standards, Lead State Partners, 2012, http://www.nextgenscience.org/lead-state-partners.
4. See for example, Marc S. Schwartz, Philip Sadler, Gerhard Sonnert and Robert H. Tai, *Science Education*, 93 (2008) pp. 798–826.

Scott Bonham is Associate Professor in the Department of Physics and Astronomy at Western Kentucky University. He served among over a hundred college and workforce development personnel brought together in June 2012 for a panel review of NGSS focusing on college and career readiness. He has served several years as a university representative on a state-level science standards taskforce for the state of Kentucky.

NRC Study Seeks to Articulate Best Practices in the Learning, Teaching, and Assessment of Physics

James Lancaster

The National Research Council (NRC) is nearing completion of a study on undergraduate physics education (UPE). The central charge to the committee is that it

> … produce a report that identifies the goals and challenges facing undergraduate physics education and identifies how best practices for undergraduate physics education can be implemented on a widespread and sustained basis. In so doing, the committee will assess the status of physics education research (PER), and will discuss how PER can assist in accomplishing the goal of improving undergraduate physics education best practices and education policy.
> (Statement of Task)

The committee's charge further directs that it focus its attention on students in three categories: those students in fields such as engineering and life sciences who need a physics background for their vocations, physics majors who typically then proceed to graduate school or into the workforce, and those students who will be teaching physics and physical sciences in K-12.

The committee undertaking this challenge was formed in early 2011 and is chaired by Donald Langenberg, chancellor emeritus of the University System of Maryland. The committee has 16 members and includes a mix of expertise and backgrounds. A large portion of the committee consists of individuals actively engaged in physics education research (PER). Other members are physics professors with an interest in and expertise in teaching but who are not heavily involved in PER. Still others have different backgrounds that were also considered important for the study. The goal was to include on the committee as many voices as practical from those communities who would be impacted by a successful study and so members include a high school science teacher, a member with expertise in the area of two-year college instruction, as well as several university administrators.

During the course of the study, the committee held five face-to-face meetings. The first meeting was held in March 2011 in Washington D.C., where the committee heard from representatives of the study's sponsors: the NSF's Education and Interdisciplinary Research Program in the Directorate for Mathematical and Physical Sciences' Physics Division, and the NSF's Division of Undergraduate Education in the Directorate for Education and Human Resources. The sponsors shared with the committee their goals for the study and engaged in discussions with the committee on what they envisioned would be useful outcomes. At its next two meetings, held over the spring and summer of 2011, the committee continued to collect information, hearing from speakers who addressed a number of topics pertinent to the committee's charge such as the training and education needs for students who want to teach physics and general science at the K-12 levels, the status of PER for upper division courses, and efforts to develop on-line resources for those interested in undergraduate physics education issues. During and between those meetings, the committee began to develop the report's structure and language. The committee's fourth and fifth meetings, held in the fall of 2011 and winter of 2012, principally were working meetings at which the report was further developed and written.

The committee's efforts are close-to-complete. It has produced a report that is now in the NRC's review process. One of the steps undertaken by the NRC to ensure that its reports meet appropriate standards of objectivity and satisfy the committee's charge is that each report must undergo an independent review by a panel of experts who were not involved in the study process or in the preparation of the report. All of the reviewers' comments will be responded to by the committee in developing the final version of the report. Once the report is deemed to have met the concerns and issues raised by the reviewers it will be publicly released. Current expectations are that the report will be available for public release by the end of 2012. More information about the study can be found at http://sites.nationalacademies.org/BPA/BPA_059078.

James Lancaster is the Director of the Board on Physics and Astronomy of the National Research Council.

The PER User's Guide: A Web Resource for Physics Educators

Sam McKagan, Editor, PER User's Guide - American Association of Physics Teachers

Physics education research (PER) is widely recognized as a leader in discipline-based science education research. Researchers in the field of PER have made enormous advances in understanding how students learn physics most effectively and in developing teaching methods that dramatically improve student learning.[1] However, research on faculty change has found that even educators who know about PER and are highly motivated to improve their teaching have trouble finding the information they need to implement PER-based teaching methods effectively.[2] The PER User's Guide (http://perusersguide.org) is a growing web resource designed to address this problem by translating, summarizing, and organizing the results of PER in an accessible and useful way for busy educators. The American Association of Physics Teachers (AAPT) has developed a pilot site with NSF funding in conjunction with the ComPADRE digital library (http://compadre.org), with the PER Leadership and Organizing Council (PERLOC) serving as the advisory board.

The content of the PER User's Guide has been developed by the editor based on classroom observations, interviews with developers and adopters of PER-based teaching methods, surveys, and literature reviews. One important result that has come out of this work is that curriculum developers have many hidden assumptions based on their own environments and goals, and thus are not always able to effectively communicate the essential features of their curricula to adopters. Successful adopters, on the other hand, because they have had to struggle with enacting someone else's vision in a new environment, are often able to articulate these hidden assumptions and to offer much more detailed and clear advice for other adopters. This result suggests that the current practice of leaving dissemination to curriculum developers is not the best way to increase effective implementation. The PER User's Guide is playing an important role in dissemination by collecting the wisdom of successful adopters that has traditionally been left untapped.

Some of the features available on the PER User's Guide include:

- A guide to PER-based teaching methods which includes brief overviews to more than 50 PER-based teaching methods and a wizard for filtering teaching methods based on criteria such as the instructional environment, the instructor's goals, and various types of research validation
- General information about PER, including links to PER resources, podcasts, blogs, and videos of presentations by experts in PER
- Answers to Frequently Asked Questions about PER
- A guide to what makes PER-based teaching methods work
- An article on the "top 10" results of PER that every physics instructor should know

User testing with physics faculty has shown that the site is easy to navigate and provides many resources that faculty need, and has highlighted many areas for further development and expansion.

In addition to providing basic overviews of PER-based teaching methods for instructors who are still trying to decide which method to use, we are developing detailed implementation guides to provide comprehensive guidance for instructors who are already working on implementing a particular method. Each detailed implementation guide will contain approximately 20 pages of text, graphics, and multimedia, demonstrating the method through detailed suggestions for implementation, ways to address common challenges and questions, a summary of the research base behind the method, classroom videos, reviews by other adopters, case studies of successful adopters, and ways to connect with other adopters.

The next step in the development of the PER User's Guide, funded by a new NSF grant, will be the development of assessment resources. The PER community has produced dozens of research-validated assessment tools to evaluate the effectiveness of different teaching methods for many different physics topics. These assessment tools have had a major impact on physics education reform: The Force Concept Inventory (FCI)[3] a test of basic concepts of forces and acceleration, has been given to thousands of students throughout the country and the results show that PER-based teaching methods lead to dramatic improvements in students' conceptual understanding of mechanics. These results have inspired many physics instructors to try the FCI with their own students and to radically change their teaching methods based on the results. Similar assessments exist in nearly every topic in physics, but it is often difficult for instructors to access these assessments or to interpret the results. We will address this problem by creating a database of assessment tools and results where instructors can access assessment tools, find descriptions of how to use them and the research behind them, and submit student scores to a national database so that other instructors can see typical scores that they can use to evaluate and interpret results from their own classes. This will provide a basis for comparison between instructors and pedagogies that will enable instructors to assess the effectiveness of their instruction on a variety of topics, promoting the adoption of more effective teaching methods. In addition, we will provide overviews for faculty on a variety of research-based assessments in their classrooms. These overviews will cover a range of types of assessment, including summative, formative, and programmatic.

Future goals for the PER User's Guide include:

- Editorial Board review of all content and ensure that the site contains high quality material that accurately reflects the views of the PER community
- Development of detailed implementation guides to more of the 50+ PER-based teaching methods on the site

- Development of comprehensive guides to the research behind all teaching methods on the site including summaries of the most important research results and a searchable database of references for each method, with tags indicating what type of research has been done, what student skills has this method been demonstrated to improve, at what levels, and in what settings
- Redesign of the site based on the results of user testing
- Video demonstrations of popular teaching methods, a Virtual New Faculty Workshop library containing videos of all the presentations at the Workshop for New Faculty in Physics and Astronomy
- Guides to research by physics topic
- An online curriculum database
- Online faculty learning communities
- Expanding the site to include content targeting K-12 teachers
- Expanding the site to include content for educators in developing countries
- Research on the impact of the PER User's Guide on faculty practice
- Consulting services for physics departments that are interested in implementing PER-based teaching methods and need help determining which methods are most appropriate to their environment and how to implement them effectively.

(Endnotes)

1. R.R. Hake, "Interactive-engagement v.s traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys*. 66, 64-74 (1998); L.C. McDermott and E.F. Redish, "Resource Letter: PER-1: Physics Education Research," *Am. J. Phy*s. 67, 755 (1999) and refs therein; E.F. Redish, *Teaching Physics with the Physics Suite* (Wiley, New York, 2003) and refs therein.

2. C. Henderson and M. Dancy, "Barriers to the Use of Research-Based Instructional Strategies: The Influence of Both Individual and Situational Characteristics," *Phys. Rev. ST*: PER 3 (2), 020102 (2007).

3. D. Hestenes, M. Wells, and G. Swackhamer, "Force Concept Inventory," *Phys. Teach*., 30, 141 (1992).

Sarah "Sam" McKagan is the Editor of the PER User's Guide for the American Association of Physics Teachers. She is also a PER consultant for several projects, including the Energy Project at Seattle Pacific University, PhET Interactive Science Simulations at the University of Colorado at Boulder, and a modern physics lab development project at Augsburg College.

The Chicago State University Science Teaching and Learning Laboratory

Mel Sabella, msabella@csu.edu

Chicago State University (CSU) is taking action to make the teaching and learning of science both more welcoming and more effective for students underrepresented in the STEM disciplines. CSU has made a substantial commitment to the teaching of science by renovating two classrooms each year in the sciences. This past year, CSU President Wayne D. Watson called on the department of Chemistry and Physics and College of Arts and Sciences Dean David Kanis to build one of the most advanced physical science classrooms in the country. The department looked at a variety of innovative models in physics instruction at institutions that included North Carolina State University, the University of Oregon and the Massachusetts Institute of Technology.

President Watson's commitment of just over 1.5 million dollars to promote the use of modern innovative instructional techniques for the teaching and learning of undergraduate science addresses both the importance of increasing diversity in the number of STEM majors in undergraduate and PhD Programs and addresses the national need to increase the number of highly qualified Physics and Chemistry Teachers in the country. Both these issues have been receiving increasing attention by the public and national organizations in physics and chemistry are taking the lead in both understanding and addressing these issues. Less than 6% of the PhDs in physics are awarded to students of color. The percentage in chemistry is also low, at 10%.[1] Both the American Physical Society and the American Chemical Society recognize the important role that universities who serve large minority communities can play in efforts to increase diversity.

The renovations to the physical science classrooms provide an example of CSU's support for the teaching and learning of science. The classes that are held in these rooms utilize the latest techniques

Kristina and Angela, two physics majors, explore an interactive simulation of a ripple tank on one of the Starboards.

in reform-based instruction and include the majority of physics courses, a number of physical science courses and many chemistry course lectures. The Chicago State University Physics program has completely revised their introductory physics sequence as a result of four grants from the National Science Foundation Course, Curriculum, and Laboratory Improvement Program (NSF-CCLI). These reform efforts have led to both content and attitudinal gains for our students and have led to the recognition of the types of resources that underrepresented students bring to science classrooms.[2] The new classrooms are allowing the Physics Program to realize the full potential of the reform efforts and utilize new and exciting teaching and education research techniques.

A view of the classroom showing five of the eight Starboards and students sitting in groups of six around tables that foster collaboration.

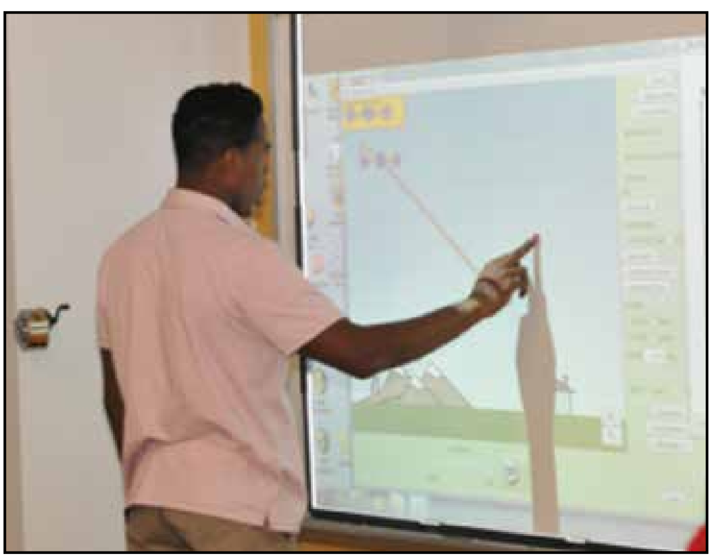
CSU draws its students from the community on the southside of Chicago. The school is about 90% African and 70% female, both populations underrepresented in the disciplines of chemistry and physics. These instructional innovations, guided by the departments' research in Physics Education have led to a new model of instruction that fosters the development of an active scientific community and builds on the strengths of the urban physics learner while addressing the specific challenges students have in physics throughout the country. The design of the new classrooms was led by faculty in the Chemistry and Physics Department, working closely with architecture firm AECOM and AV contractors Whitlock, one of the largest companies in the country that specialize in this type of technology-rich environment. Each classroom is designed for group collaboration and active learning, with four hexagonal tables in each room that allow students to work in eight groups of three or four groups of six. Whiteboards have been placed on all four walls, with one wall a removable partition that is itself a floor to ceiling whiteboard. Each room is also equipped with eight independent Starboards that each utilize a section of the whiteboards.[3] These Starboards can work independently, with each having different content. For example students can work on a

Tasha (left), a CSU physics major, describes a lesson she is preparing for a high school class to Kara, a Chicago Public Schools teacher, as part of the CSU PhysTEC Program.

physics problem, or they can develop a Mathematica workbook, or they can interact with a physics PhET simulation.[4]

An instructor can send any video source to any display destination so that results can be easily shared. For instance, an instructor can say, “I’m interested in what group three came up with for their solution. I would like each group to comment and critique their solution.” Group 3’s work can then be shared on all the starboards in the room for discussion. In addition, an advanced video codec allows the possibility of combining screens into a seamless image that stretches across up to six starboards. This technology is quite new for the instructional setting but lends itself to very exciting possibilities.

Because of the University’s strong commitment to education and education research, with three faculty members in the department of Chemistry and Physics focusing on this work, it was important that the classrooms support this effort. Each of our two classrooms has four video cameras in the ceiling and four wireless microphones that can we used to capture students working on different types of tasks. This data is then used to revise curriculum, identify specific difficulties and resources that our students have and document the use of effective instructional tools. Assessment is an important part of the CSU mission and allowing the possibility of capturing a rich set of qualitative data is an extremely powerful tool in developing a deep understanding of student knowledge and how we can better serve our students.



Joel, a CSU engineering studies student, uses a PhET simulation to explore kinetic and potential energy.

In a given semester, about twenty courses are taught in the new classrooms in physics, physical science, and chemistry, with about 350 students participating in these classes. These physics courses serve students in Biology, Chemistry, Physics, Engineering, and Education. It is our hope that the new classrooms will make physics instruction more accessible to this diverse student population. Chemistry faculty are also using the rooms for interactive lectures and recitations. Because the rooms promote inquiry-based science instruction, these classrooms are ideal settings for the preparation of science teachers. CSU is currently serving education students at all levels through the use of innovative instructional materials. Elementary and middle school education majors are enrolled in two courses that integrate best practices in the classroom. One course utilizes the Physics and Everyday Thinking (PET) Curriculum, a nationally known curriculum for the preparation of preservice teachers.[5] In addition to serving the needs of education majors the new classrooms will have a profound effect on our students pursuing secondary education. CSU is making significant changes to its physics secondary education program as a result of support from the APS PhysTEC Program.[6]

Each year students from Ashburn Middle School in Chicago engage in a science lesson developed by CSU preservice science teachers as part of CSU’s NSF Noyce Program. This year about 40 students participated in Biology, Chemistry, and Physics experiments that focused on light and optics.

The students in our secondary education program all go through the introductory courses that are now being taught in the new

Ishtar and Barbara engage a group of middle school students engage in a lesson on light and optics.

classrooms. Many have found that teachers teach the way they have themselves been taught, which makes the use of the new classrooms an essential element in the training of teachers.

Physics programs often struggle with low enrollment. Through CSU's NSF-CCLI Programs, the Noyce Program (which provides financial and intellectual support for students preparing to be HS science teachers), the PhysTEC Program, and through the innovative instruction made possible by the new classrooms, CSU hopes to increase the number of majors in physics and address the severe lack of representation of students of color in this field. The situation is dire. Recently, The Texas Higher Education Coordinating Board (THECB) has decided to close all programs that produce less than five graduates a year. "If all the other states were to adopt Texas' approach … 526 of the roughly 760 physics departments in the US would be shuttered. All but 2 of the 34 HBCU physics programs would be closed. A third of underrepresented minorities and women studying physics would have their programs eliminated."[7] Investing in physics is more important than ever.

*pictures 1-4 by Essential Photography, Chicago.

Mel Sabella is a Professor of Physics and Chair of the Department of Chemistry and Physics at Chicago State University. His research is focused on identifying the needs and resources of students underrepresented in the STEM disciplines.

(Endnotes)

1. http://www.aps.org/programs/education/statistics/minority-degrees.cfm
2. "Using the resources of the student at the urban, comprehensive university to develop an effective instructional environment," Sabella, M. S., Coble, K., and Bowen S. P., 2008 *Physics Education Research Conference Proceedings* (AIP, NY).
3. http://www.hitachisolutions-us.com/starboard/
4. See http://phet.colorado.edu
5. http://petproject.sdsu.edu/
6. http://www.phystec.org
7. Policy News Article from the *National Society of Black Physicists* (September 2011). See http://www.nsbp.org/en/art/312/

Call for Manuscript Proposals: Effective Practices in Preservice Physics Teacher Education

Eric Brewe and Cody Sandifer

The Physics Teacher Education Coalition, the American Physical Society, and the American Association of Physics Teachers announce a call for manuscript proposals for a new peer-reviewed book entitled *Effective Practices in Preservice Physics Teacher Education: Recruitment, Retention, and Preparation*. Co-edited by Dr. Eric Brewe and Dr. Cody Sandifer, this book seeks to provide a practical guide to innovative, state-of-the-art programs, and will include papers in the following areas: Recruitment and Retention; Early Teaching Experiences; Preparation in Physics Knowledge, Scientific Practices, and Physics Teaching; The Collaborative Nature of Teacher Preparation; Mentoring and Community-Building; and Case Studies of Successful Preservice Teacher Education Programs.

Manuscript proposals are due February 1, 2013. Full manuscripts will be due in September 2013, and book publication is scheduled for 2015.

For more information, the book editors can be contacted at EffectivePracticesBook@aps.org. The full call for manuscript proposals can found at: http://www.ptec.org/effectivepracticesbook.

Eric Brewe is an Assistant Professor of Physics at Florida International University.

Cody Sandifer is a Professor of Science Education at Towson University.

Browsing the Journals

Carl Mungan <mungan@usna.edu>

- Some effective demonstrations have been presented in recent issues of *The Physics Teacher* (http://scitation.aip.org/tpt/). Check out the use of a water-filled balloon to discuss buoyant force on page 428 of the October 2012 issue, and the counterintuitive behavior of series versus parallel springs on page 359 of the September 2012 issue.

- A compact proof that M_{12} must equal M_{21} for the mutual inductances of two coupled circuits is provided by Dake Wang on page 840 of the September 2012 issue of the *American Journal of Physics* (http://scitation.aip.org/ajp/). I also enjoyed learning about the paradox of a floating candle that does not get extinguished on page 657 of the August 2012 issue, and the energy efficiency of the various systems in a car on page 588 of the July 2012 issue. The discussion on page 519 of the June 2012 issue of why shear is omitted from our standard discussions of divergence, gradient, and curl also intrigued me.

- Connect a smaller spherical balloon to a larger one with a tube. It is not always the case that the smaller one will get smaller and the bigger one get bigger. See the experimental results and discussion on page 392 of the July 2012 issue of *Physics Education*. An aluminum soda can pull tab is floated on the surface of a glass of water. An electrostatically charged rod is brought near the tab. Does the tab move toward the rod, away from it, or stay still? See page 644 of the September 2012 issue for the surprising answer. Also check out the discussion of the volume of conical glasses and oval spoons on pages 502–504 of the July 2012 issue: half full is nowhere near half height! The journal can be accessed at http://iopscience.iop.org/journals.

- The same webpage also gives a link to the *European Journal of Physics*. On page 1111 of the September 2012 issue, there is a discussion of particles sliding off the surfaces of arbitrarily shaped surfaces (not necessarily hemispherical as in the usual textbook case), with or without kinetic friction. Also see the discussion of the classic problem of whether or not one should run in the rain to keep as dry as possible on page 1321, and an analysis of the tumbling toast problem on page 1407 of the same issue. Finally, there is a good review of theoretical models and comparison to experimental measurements for falling U-shaped or piled-up chain systems on page 1007 of the July 2012 issue.

- The June 2012 issue of the *Journal of Chemical Education* (http://pubs.acs.org/toc/jceda8/89/7) has a short but provocative discussion of how to define elements in contrast to compounds on page 832, and an article about how lightsticks work on page 910. Peter Loyson argues on page 1095 of the August issue (http://pubs.acs.org/toc/jceda8/89/9) that Galileo did not invent the Galilean thermometer. I was also sufficiently intrigued by the discussion of the laws of thermodynamics applied to open systems on page 968 of the July issue (http://pubs.acs.org/toc/jceda8/89/8) to write my own analysis at http://usna.edu/Users/physics/mungan/Scholarship/OpenSystems.pdf.

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Web Watch

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- North Carolina State University has a well-organized list of physics demonstrations with descriptions, photographs, and videos at http://demoroom.physics.ncsu.edu/html/.
- An excellent set of science and engineering student resources for technical presentations, correspondence, and other written documents can be found at http://www.writing.engr.psu.edu/.
- NASA has a webpage at http://www.nasa.gov/audience/foreducators/postsecondary/index.html devoted to higher education.
- A discussion of the ancient Antikythera astronomical clock and working replicas of it are online at http://www.universetoday.com/95733/the-antikythera-time-machine/.
- NaRiKa corporation specializes in Genecon (hand-cranked generator) electrostatic experiments and has many videos of them starting at http://global.narika.jp/product.
- The Physics Front is a large collection of resources for teaching middle and high school physical science at http://www.thephysicsfront.org/.
- A blog related to STEM issues is available at http://blogs.heacademy.ac.uk/stem/.
- If you are not part of the PHYS-L listserver community, I highly recommend it. It has moved to a new address on the web at http://www.phys-l.org/.
- Undergraduate physics students at the University of Leicester publish articles in their online Physics Special Topics journal at https://physics.le.ac.uk/journals/index.php/pst/.
- The National Renewable Energy Laboratory (NREL) in Golden, CO describes their educational programs at http://www.nrel.gov/education/.
- A middle-school physics student wanted to share with you a page he found about why our ears pop when we fly at http://www.cheapflights.com/promos/in-flight-barotrauma/.
- You may enjoying browsing the webpages of the Max Planck Institute for the History of Science at www.mpiwg-berlin.mpg.de/en/resources/.
- The Math and Science Partnership Network is supported by NSF to assist with No Child Left Behind efforts in K-12 technical education at http://hub.mspnet.org/.
- The Nuffield Foundation for Science and Mathematics Education and the IOP have a website called Practical Physics at http://www.nuffieldfoundation.org/practical-physics for secondary and college physics experiments.
- These days one hears a lot about cloud applications. A project library for image processing is at http://pointclouds.org/.
- A reader of this column drew my attention to the list of resources devoted to spaceflight and geomagnetism at http://www.phy6.org/readfirst.htm.

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