

Executive Summary

This report documents the activities of the PhysTEC project during its eighth year (August 1, 2008 to July 31, 2009). The mission of PhysTEC is to improve and promote the education of future physics and physical science teachers. Specifically, the project aims to

- Demonstrate success in and provide models for
 - Increasing the number of highly qualified high school physics teachers;
 - Improving the quality of K-8 physical science teacher education;
- Advocate for improving teacher education within the physics community, and spread best practice ideas through a coalition of institutions committed to this work;
- Work directly with physics departments to engage them in educating teachers, targeting areas of critical need.

PhysTEC is a partnership among the American Physical Society (APS), the American Association of Physics Teachers (AAPT), and the American Institute of Physics (AIP). The project continues to enjoy broad support from all three sponsoring organizations, and has received generous contributions from the APS's 21st Century Campaign.

PhysTEC-funded institutions have achieved a number of significant successes, including:

- Greatly increasing the number of physics and physical science teachers graduating from their programs, as much as tenfold in some cases;
- Providing prospective teachers with early teaching experiences;
- Using master teachers to provide critical mentoring support to new graduates and develop bridges between physics departments, education schools, and local K-12 school districts;
- Transforming science and teaching methods courses for future teachers;
- Securing allocation of institutional resources to sustain program components;
- Disseminating results through publications and presentations at conferences and workshops.

The project also includes the Physics Teacher Education Coalition (PTEC), which currently includes 137 institutions dedicated to improving their physics teacher preparation programs. The project organizes an annual national conference for PTEC members, as well as smaller regional and topical workshops. In addition, the project has teamed up with ComPADRE, the NSF-funded digital library, to produce the PTEC website, which houses a collection of electronic resources in teacher preparation.

The project is disseminating its results to the physics community in a variety of ways, including a newsletter, websites, articles in a number of venues, activities at prominent national meetings, and quarterly project updates. The project has also launched two additional major research and dissemination efforts: the National Task Force on Teacher Education in Physics, and a book of collected papers on teacher preparation. Project leaders are also seeking to magnify the project's impact through collaborations with other organizations, including an NSF-funded Math and Science Partnership project led by the Association of Public and Land-Grant Universities (APLU) to engage research universities in recruiting and educating science teachers.

1. Results

The PhysTEC project can report significant findings and results. PhysTEC sites—institutions with significant project support that have developed model teacher education programs ([see Section 2](#))—represent about 1.5% of the institutions that offer physics majors, yet graduate approximately 8% of all new high school teachers of physics.¹ The number of teachers graduating each year from PhysTEC institutions has greatly increased since the project began, in some cases by a factor of ten. The project has current employment information for 90% of these teachers, of which over three-quarters are teaching in a K-12 school. PhysTEC sites have also improved the preparation of about 500 elementary teachers per year through implementation of research-based curricula in physical science courses that these teachers take. Sites have developed and refined models of recruiting, course transformation, early teaching experiences, induction, and mentoring. Teachers-in-Residence and Teacher Advisory Groups have created authentic collaborations among physics departments, education schools, and local school districts. While direct assessment of teacher quality is very complex, the project can report that PhysTEC teachers take introductory physics courses transformed under the project that implement research-based “interactive engagement” techniques shown to improve student conceptual understanding. Further, scores on validated conceptual exams given in these courses were roughly a factor of two greater than published results for courses using traditional lecture methods.² In addition, assessments of pedagogical skill³ were consistent with results expected for teachers who use interactive methods called for in national teaching standards.

1.1 Secondary Teacher Preparation

Because of the great need for highly qualified secondary physics and physical science teachers in the U.S., the PhysTEC project focuses primarily on recruiting and preparing more of these teachers. Of all sciences taught at the secondary level, physics has the greatest shortage of qualified teachers. Only 33% of the 23,000 high school physics teachers in the U.S. completed a physics or physics education major.⁴ The severe shortage of qualified high school physics teachers is confirmed by superintendents and principals who rate physics teachers as the most difficult of any science or mathematics professional to recruit.⁵ The shortage of physics teachers is only getting more critical as the percentage of students taking physics in high school is increasing by approximately 1% per year.⁶ In addition, many states such as Texas⁷ have adopted laws requiring students to take four years of science. Legislation of this type, while addressing

¹ M. Neuschatz, M. McFarling, and S. White. *Reaching the Critical Mass*. American Institute of Physics (AIP), 2008. Available online at <http://www.aip.org/statistics/trends/hstrends.html>.

² R. R. Hake, “Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses,” *Am. J. Phys.* **66**, 64-74 (1998).

³ D. Sawada, M. Piburn, E. Judson, J. Turley, K. Falconer, R. Benford, I. Bloom. “Measuring reform practices in science and mathematics classrooms: The Reformed Teaching Observation Protocol,” *School Science and Mathematics*, **102** (6), 245-253 (2002).

⁴ Neuschatz et al.

⁵ “*Educator Supply and Demand in the United States*,” American Association of Employment in Education, Columbus, OH (2004).

⁶ Neuschatz et al.

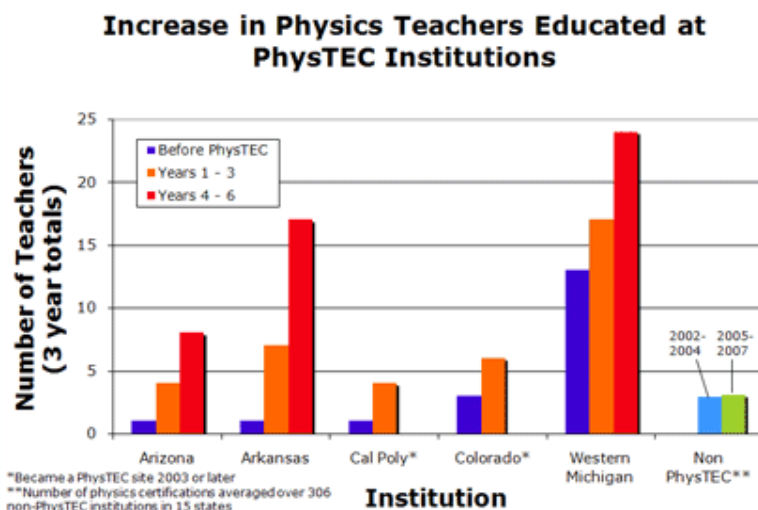
⁷ Texas House Bill 1, 79th Legislature, 3rd Called Session, (2006).

the need for a technologically literate workforce and citizenry, begs the question of who will teach these students.

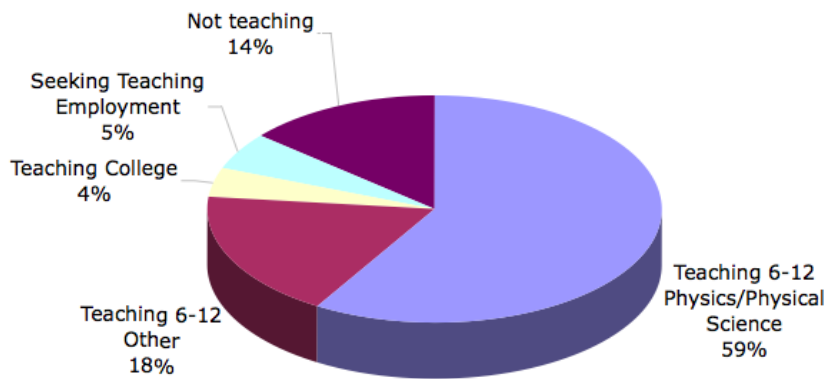
1.1.1 Secondary Teacher Graduation Rates

PhysTEC institutions committed to increasing the number of graduating physics teachers⁸ have been successful in meeting that goal. In several cases, the increase was about a factor of 10. While the absolute numbers may seem small, they indicate the potential impact PhysTEC reforms could have if implemented broadly. Each year U.S. schools hire about

1200 new physics teachers, and only about 400 of these have a physics degree.⁹ If a fraction of the nearly 800 institutions that grant a physics bachelor's degree make similar increases to those made at PhysTEC institutions, this will greatly increase the number of qualified physics teachers in the U.S.



Early Careers for PhysTEC graduates*



*based on known outcomes for 87% of PhysTEC graduates

1.1.2 Early Careers

Most graduates of PhysTEC programs go into K-12 classrooms, where they have an opportunity to make a difference in the lives of many students each year. As a result of effective tracking of graduates, the project can report early career outcomes on nearly 90% of PhysTEC graduates from years one through six of the project. As shown in the graph,

82% of these graduates are currently teaching in K-12 schools or seeking teaching employment,

⁸ Ball State University is already the top producer of physics teachers in Indiana and has focused on improving middle school teacher education and building mentoring programs rather than recruiting more physics teachers. Towson has focused exclusively on elementary teacher education. The other five PhysTEC Institutions not shown on the graph (Cornell University, Florida International University, University of Minnesota, University of North Carolina, and Seattle Pacific University) began projects in 2006 or later, and data on numbers of physics teachers educated are not yet available.

⁹ Neuschatz et al.

and another 4% are teaching at the college level. Most are teaching physics and/or physical science. Other commonly taught subjects include math and chemistry.

1.1.3 Retention

Recent studies suggest that a significant fraction of teachers leave the profession within their first five years.^{10,11,12} Because the craft of teaching takes many years to master, it is critical to not only prepare teachers well, but also to support them so that they remain in the classroom. To address that need, PhysTEC institutions have provided [mentoring](#) to nearly 70% of their teacher graduates, most of it by highly respected and experienced high school master teachers, or Teachers-in-Residence (TIRs). A full 89% of PhysTEC graduates who went into teaching completed three years in the classroom; nationwide, according to a US Department of Education survey, the number was 78% for all teachers.¹³

1.2 Elementary Teacher Preparation

PhysTEC recommends that institutions that prepare elementary teachers adopt research-based science curricula such as *Physics and Everyday Thinking (PET)*¹⁴, *Physics by Inquiry (PbI)*¹⁵, and *Powerful Ideas in Physical Science (PIPS)*¹⁶ in their physical science content courses for these teachers. At the University of Arkansas, Cal Poly San Luis Obispo, the University of Colorado at Boulder, Seattle Pacific University, the University of Minnesota, and Towson University, a course using one or more research-based curricula is required or recommended for all elementary education majors; at Arkansas, PhysTEC funded the initial implementation of PET. In addition, Towson completed a major reform of its elementary field experience course (see [Section 2.2](#)). PhysTEC sites now graduate about 500 elementary teachers per year who have taken at least one reformed science or methods course; in total, PhysTEC has improved the preparation of about 4,000 elementary teachers.

1.3 Key Components

The PhysTEC project recognizes that successful teacher preparation programs share certain interrelated key components. These activities and programs build on one another to provide teachers with a complete educational experience, from recruitment through training in pedagogy and content to induction and mentoring. We will briefly discuss the components here; for greater

¹⁰ NCREL.

¹¹ Neuschatz et al.

¹² R. Ingersoll and J. Kralik, [The Impact of Mentoring on Teacher Retention: What the Research Says](#), Education Commission of the States, 2004.

¹³ J. Marvel et al., [Teacher Attrition and Mobility: Results from the 2004–05 Follow-up Survey](#), US Department of Education, National Center for Education Statistics, Washington, DC (January 2007).

¹⁴ F. Goldberg, *Physics and Everyday Thinking*. It's About Time, Armonk, NY (2006).

¹⁵ L. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry, Vols. I and II*. Wiley, New York (1996).

¹⁶ *Powerful Ideas in Physical Science, Vol. I-IV*. American Association of Physics Teachers, College Park, MD (1995).

detail and links to strategies and resources for implementing each one, see www.PhysTEC.org/components.

1.3.1 Recruitment

PhysTEC institutions have refined the art of recruiting teachers. A strong recruiting effort begins the first day of classes, with faculty members, Teachers-in-Residence, and future teachers visiting introductory courses—both in the physics department and in related areas such as engineering—to promote the teaching profession and inform students whom to contact for more information. The introductory physics course can also be an excellent recruiting tool, when taught by an instructor who can model excellent teaching and engage his or her students. Most PhysTEC sites have added undergraduate peer teachers called [Learning Assistants](#) to make their introductory classes more collaborative, student-centered, and interactive. A strongly supported early teaching experience such as a Learning Assistant program can excite students who hadn't previously considered a teaching career. And personal relationships are always critical—successful teacher preparation programs thrive on excellent advising and mentoring both during and after a teacher's formal education.

Effective teacher recruitment also depends on creating a program that encourages and supports future teachers throughout their education. The University of North Carolina has created a degree program that provides undergraduates a physics major and teaching certification in four years. A number of other PhysTEC sites such as Arkansas and Seattle Pacific University have created alternative degree and certification plans that allow students flexibility in completing their education. Scholarship support can also be critical, as future teachers and their parents know they will not be earning large salaries as classroom teachers. A number of PhysTEC sites have received awards through the NSF's Robert Noyce Teacher Scholarship Program to provide up to \$15,000 per year to future math and science teachers, in exchange for a commitment to teach in a high-need school after graduation.

Last fall, the PhysTEC project received its own award through the Noyce program, to support future physics teachers at six PhysTEC institutions. This is the first Noyce award to focus on a single science discipline, as well as the first given to a professional society (APS and AAPT jointly run the PhysTEC Noyce). Ten students from four of the six PhysTEC Noyce institutions applied and received scholarships for the 2009-2010 academic year. Of these ten, three will be juniors in 2009-2010, five will be seniors, and two will be in post-baccalaureate programs. For more information about the PhysTEC Noyce program, see www.PhysTEC.org/noyce.

The project is also embarking on a new marketing campaign to help sites promote physics and teaching to students who previously have not been engaged in these areas. Project leaders have gathered ideas from the University of Texas at Austin's UTeach math and science teacher preparation program, and are developing a plan with a marketing expert who helped Louisiana State University design a highly successful marketing campaign for its GeauxTeach program, which is based on UTeach. The PhysTEC marketing campaign will roll out in Fall 2009, and project leaders hope it will enable sites to tap new sources of potential majors and teachers.

1.3.2 Teachers-in-Residence

Over the course of the project, 44 Teachers-in-Residence (TIRs) have served at PhysTEC institutions. TIRs are master teachers whom the PhysTEC sites “borrow” from a local school, to help build bridges between the physics department, the education department, and the local school district. TIRs can also strengthen ties between theory and practice by sharing their expertise and classroom experiences with pre-service teachers. A TIR can take on many roles, depending the needs of the institution. TIRs have recruited new teachers, mentored pre-service and beginning teachers, taught methods and content classes, redesigned existing course curricula, developed new courses, and given workshops and presentations at local, regional, and national meetings, including AAPT, National Science Teachers Association (NSTA), and PTEC conferences. Each summer, TIRs from past years contribute to the induction session of the new round of TIRs. Several PhysTEC institutions, including Arkansas, Cal Poly, and Towson, have dedicated institutional funds to sustain a TIR position after project funding ended. Seattle Pacific funds a TIR through a grant from the Boeing Corporation, and this individual participates in PhysTEC activities and interacts frequently with project participants.

Seattle Pacific is also using part of its PhysTEC funds to hire a “Visiting Master Teacher” (VMT). The VMT is a part-time position that fills some of the roles of a traditional TIR. PhysTEC and Seattle Pacific are evaluating the potential benefits of the VMT position for institutions that may not have the resources to support a full-time TIR. This may be an especially important model for smaller institutions.

Exemplary contributions of TIRs to the PhysTEC project include:

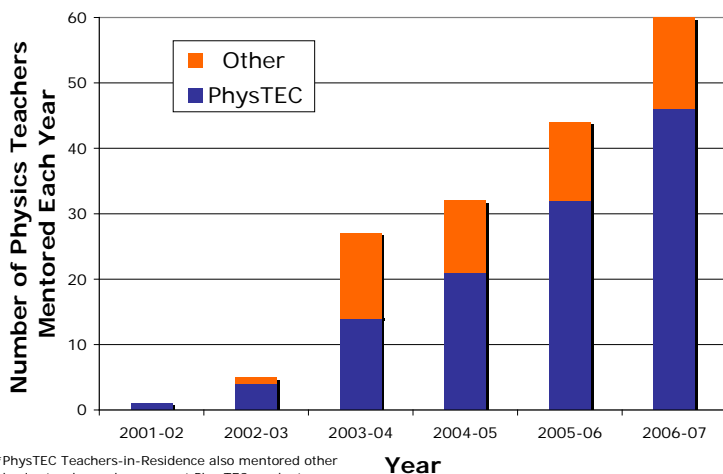
- Leadership in recruitment efforts, including classroom visits, development of recruiting materials, and individual interactions;
- Development of pedagogy courses for Learning Assistants and future teachers;
- A program to promote science education in under-represented communities;
- A winning Toyota Tapestry grant application submitted with local high school teachers, including the TIR's mentee, for an outdoor physics activity area;
- A CD of inquiry-based resources for an elementary teacher field experience course;
- Professional development workshops and courses on inquiry-based teaching;
- The development of a mentoring guide for future TIRs;
- Invited talks at national meetings;
- Numerous publications in venues such as the *APS Forum on Education Newsletter*.

The project hosts an online discussion forum for TIRs, and has collects monthly journal entries as well as beginning- and end-of-year surveys from them. After their year or years of service in the project, 69% of TIRs who were employed as teachers immediately before beginning their TIR year went back to the classroom, providing PhysTEC sites with valuable contacts in their local school systems.

1.3.3 Induction and Mentoring

Teacher education does not end at graduation. PhysTEC institutions provide critical mentoring and induction support during the first years of teaching, which has been shown to improve retention rates of new teachers.¹⁷ In 2007-2008, most PhysTEC teachers in their first and second year of teaching were mentored by TIRs. In addition, PhysTEC TIRs provided mentoring to

PhysTEC Mentoring Activities



*PhysTEC Teachers-in-Residence also mentored other physics teachers who were not PhysTEC graduates.

other new physics teachers located near PhysTEC institutions. In this way, mentoring is an important mechanism through which PhysTEC has been able to reach out to local K-12 communities. The graph below shows the growth of mentoring during the PhysTEC project.

Over the years, we have collected testimonials from individuals whose lives were touched by the project. One TIR's mentee wrote: "You have always been a positive

light in what has otherwise been a bleak time. Through all the stressful times and deadlines, you are a constant reminder of how a teacher should treat their students. I want to be just like you when I grow up. You rock!!!"

Another mentee wrote, "After I got my first teaching job PhysTEC became even more important. I was teaching in a rural school where I was the 'expert' in physics and chemistry. I had a lot of questions that first year and my mentor [assigned by the] school helped me out, but it was the connections I made before that which seemed to help me out even more."

1.3.4 Course Transformation

The PhysTEC project encourages funded institutions to teach introductory physics courses that use interactive engagement methods shown to improve student learning.¹⁸ These courses also serve to model effective teaching practices and often involve more advanced students as [Learning Assistants](#), who have taken the course previously and who guide their peers to a greater understanding of physics concepts. PhysTEC has encouraged its sites to adopt proven curricular reforms because 1) PhysTEC believes that teachers teach as they have been taught; 2) these reforms have been shown to improve learning gains on standardized, research-based content assessments of conceptual understanding; and 3) the high-quality, research-based materials have

¹⁷ [The MetLife Survey of the American Teacher: Expectations and Experiences](#), by Harris Interactive (2006).

¹⁸ Hake, *op cit*.

been carefully designed to avoid many pitfalls that home-cooked curricula may fall into. The hope and expectation is that students whose instructors use effective interactive teaching methods will go on to use these same methods when they become teachers.

PhysTEC impacts far more students than just those who complete a teacher preparation program. In Arkansas project leader Gay Stewart's words, "University of Arkansas' philosophy has been that you never know who is going to be a future teacher, so you should treat all students as if they might be, modeling good pedagogy in introductory physics classes. This has the beautiful side effect that if all students experience an intro class taught the way we would like future teachers to teach, you end up with more MAJORS!" Over 20,000 students have taken reformed courses in algebra- and calculus-based physics at PhysTEC institutions, and around 4,000 students have been influenced by PhysTEC courses in elementary or secondary pedagogical methods. These numbers are especially important as many STEM students become teachers as a second or third career, or help educate future teachers. All of these students will engage in teaching at some point in their lives, whether as a parent, a work colleague, an informal mentor, or in other ways, and improving their attitudes toward science and science education will have a ripple effect in more ways than it is possible to measure.

1.3.5 Assessment

PhysTEC leaders recognize the need to gather data on the project, both to determine whether it is effectively carrying out its goals and to support broader dissemination and advocacy efforts. PhysTEC has therefore undertaken a comprehensive assessment effort, in order to fully evaluate its impact both on classroom teachers and on institutions around the country. The project is evaluating its success through

- the career outcomes and retention rates of teachers who graduate from project institutions;
- the preparation and effectiveness of teachers who graduate from project institutions, using both content assessment and pedagogy assessment instruments; and
- the extent to which the project has catalyzed institutional transformation leading to sustainable teacher preparation programs.

In addition to project-wide summative assessment, PhysTEC recognizes the importance of formative assessment, in particular as it relates to a teacher's education. Both content and pedagogy assessment instruments are used to show areas in which pre-service and new in-service teachers are strong, and areas in which they need to improve. Formative assessment is an especially powerful tool in the context of a mentoring relationship.

1.3.5.1 Content Assessment

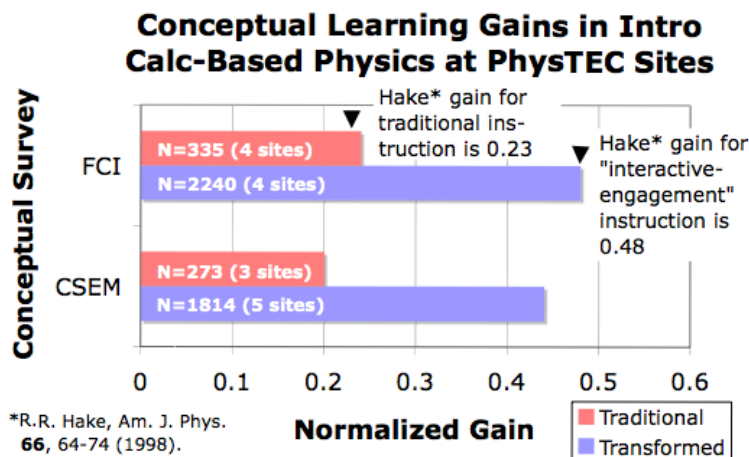
PhysTEC institutions use research-validated instruments including the Force Concept Inventory (FCI)¹⁹ and Conceptual Survey of Electricity and Magnetism (CSEM)²⁰ to assess student

¹⁹ D. Hestenes, M. Wells, G. Swackhamer, "The Force Concept Inventory," *Phys. Teach.* **30**, 141 (1992).

learning at PhysTEC sites and ensure that course reforms are effective. The graph below shows normalized learning gains for courses at PhysTEC sites, both before (“Traditional”) and after (“Transformed”) reforms were implemented. The normalized learning gain g is calculated according to the formula:

$$g \equiv \frac{\text{gain}}{\text{possible gain}} = \frac{\text{post \%} - \text{pre \%}}{100\% - \text{pre \%}}$$

Learning gains approximately doubled at many sites as a result of PhysTEC-supported course reforms. Learning gains on the FCI were nearly identical to published data for “interactive engagement” instruction, indicating a high degree of fidelity in implementing course reforms. The strong performance of PhysTEC students on content assessments provides evidence that PhysTEC teachers are receiving good content preparation in physics.



In the past year, the project has taken content assessment to the next level, by working with PhysTEC teachers in the classroom to give the FCI to their students and provide data to the project for analysis. In 2008-2009, seven PhysTEC teachers and four non-PhysTEC teachers agreed to give the assessment and provide data to the project. Along with FCI pre-test and post-test scores, the project is collecting information from teachers on the school and classroom context in which they are teaching. As of this writing, these data are still being collected and analyzed. Due to the complexity of this type of effort, it is unlikely that the project will be able to draw any conclusions from data collected in 2008-2009, but the project expects to engage a larger number of teachers for 2009-2010, and also to identify a suitable control group with which to compare PhysTEC teachers’ students’ learning gains.

1.3.5.2 Pedagogical Assessment

In order to assess the extent to which PhysTEC institutions are preparing effective teachers, the project has required that each institution have personnel trained in the [Reformed Teaching Observation Protocol \(RTOP\)](#).²¹ The RTOP is a validated research tool developed from the Arizona Collaborative for Excellence in the Preparation of Teachers that identifies the extent to

²⁰ D. Maloney, T. O’Kuma, C. Hieggelke, and A. Van Heuvelen, “Surveying students’ conceptual knowledge of electricity and magnetism,” *Am. J. Phys.* **69**, S12 (2001).

²¹ http://physicsed.buffalostate.edu/AZTEC/RTOP/RTOP_full.

which reformed-based practices have been incorporated into teaching.²² The RTOP yields a score between 0 for a completely traditional or “unreformed” lesson and 100 for a completely interactive or “reformed” lesson. It also encourages observers to consider the context in which the observed lesson takes place, and to take notes on what he or she observes in the classroom.

Because the RTOP is designed for use by trained observers, PhysTEC offered training in using the RTOP to all sites at a [workshop](#) in Fall 2006. The project then asked each institution to conduct observations of a sample of its student teachers and graduated PhysTEC teachers, and to submit scores to the project. Teachers observed in 2006-2007 scored on average slightly above 50, indicating a substantial mastery of interactive engagement teaching methods. In addition, numerous site leaders have reported that the RTOP is a useful tool for formative assessment of new teachers, and can generate beneficial discussion about teaching practices.

1.3.6 Early Teaching Experiences

Most first-year college students do not have well-formed career plans, and those who think they do may change them many times before they graduate. A well-designed early teaching experience can give freshmen or sophomores a low-pressure taste of the rewards and challenges of teaching. They may be surprised at how much fun they have, and how much they learn. PhysTEC views early teaching experiences as an important step along the teacher preparation continuum that begins with recruitment and continues into the first years of a teacher’s career. Project sites have offered a variety of early teaching experiences. Some have created programs that place pre-service teachers into local public school classrooms early on, while others have created in-house early teaching experiences in the form of Learning Assistant programs, which allow students to teach their peers in undergraduate physics courses.

1.3.7 Learning Assistants

The Learning Assistant model was developed independently at several PhysTEC sites, most notably the University of Colorado at Boulder. Learning Assistants are talented undergraduates who work with faculty members to make large-enrollment courses more collaborative, student-centered, and interactive. Learning Assistant programs provide potential future teachers with strongly supported and low-stress early teaching experiences that can encourage them to pursue teaching certification. In many cases, these potential teachers can be unsuspecting students who discover an interest in teaching. Thus, a Learning Assistant program broadens the pool of potential future physics teachers. Learning Assistants also enhance their content knowledge through the process of teaching course material.

The specific roles that Learning Assistants take on can vary between courses, but all programs share certain features that distinguish them from more conventional teaching assistantships:

- Learning Assistants for a particular course are recruited from among the top undergraduates who recently completed that course;

²² M. Piburn, D. Sawada et al., *Reformed Teaching Observation Protocol (RTOP)* ACCEPT IN-003 (2000).

- Concurrent with teaching, Learning Assistants participate in a pedagogy course that introduces them to interactive teaching techniques and education theory;
- Learning Assistants are encouraged to enter a teacher certification program, and generally must do so if they wish to continue working as Learning Assistants for multiple semesters.

All four of the currently funded PhysTEC sites as well as four out of seven of the legacy sites have active Learning Assistant programs, and the idea is spreading beyond the PhysTEC community. In October of 2007, the project sponsored a two-day workshop at the University of Colorado at Boulder for faculty from PTEC institutions. ([See also Section 3.1.2.3](#))

1.3.8 Collaboration

PhysTEC has encouraged physics departments, education schools, and local school districts to work together to create coherent and logical course sequences and teaching experiences leading to teacher certification. Collaborating physics and education faculty at a number of sites have been able to reduce the course burden on their future teachers and allow certain courses to be counted toward both the degree and certification. In some cases, such as North Carolina, this enables teachers to complete their undergraduate majors with certification in four years, thereby reducing the cost of their pre-service education. In addition, a number of sites have submitted joint physics-education grant proposals, including Noyce proposals that support future teachers. Colorado went one step further by becoming a UTeach replication site, which requires a very high degree of interdepartmental collaboration in order to implement a complex math and science teacher preparation program based on the model developed at the University of Texas at Austin.

The linchpin of collaborative efforts at many PhysTEC sites has been the Teacher-in-Residence. Several TIRs have developed and co-taught science methods courses with education faculty members, supplying a wealth of real-life classroom experience and physics content knowledge. The TIR is also in a unique position to use his or her connections in the local school district to improve the preparation, induction, and mentoring of future physics teachers, often through a Teacher Advisory Group.

1.3.9 Teacher Advisory Group

Many PhysTEC sites have recruited local physics teachers to form Teacher Advisory Groups (TAGs), which can advise faculty on how to improve their teacher preparation programs. TAGs typically also become communities where teacher networks form, and where pre-service teachers can meet and learn from experienced working teachers. Several PhysTEC teachers were initially recruited through connections they made with a practicing teacher. Often these relationships lead to TAG teachers facilitating and hosting field placements for student teachers. TAGs have also been good sources of TIRs for PhysTEC institutions.

1.3.10 Sustainability

While PhysTEC institutions have achieved some impressive successes, they will do little to address the long-term issues of teacher shortages and teacher quality if they do not live on beyond the lifetime of external funding. Therefore, the project has sought to catalyze systemic, long-term change at the departmental and institutional level. PhysTEC faculty have succeeded in making permanent many of the initiatives originally supported by project funding, and their programs now serve as models of change for departments and institutions around the country that are seeking to improve their teacher preparation programs. Specific examples of sustained programs at individual sites can be found in the program descriptions below.

2. PhysTEC Institutions

PhysTEC institutions are selected colleges and universities actively engaged in science preparation of future teachers with substantial project support. They are chosen based on their potential to both make substantial increases in the number of teachers they graduate, and to develop programs that will serve as national models. At the time of this writing, there are four currently funded sites and eight “legacy sites” that have completed their main funding period, and are now supporting teacher preparation activities independent of PhysTEC. These institutions remain in close contact with the project, provide advice to currently funded sites, and continue to collect data that allow us to assess the impact of the project. Project leadership communicates with funded sites in a variety of ways, including annual 1.5-day site visits, frequent phone conversations, mid- and end-of-year reports, and required meetings of all site leaders at the PTEC Conference in late winter and the AAPT Summer Meeting, typically in late July.

The following table lists all PhysTEC institutions.

Table 1. PhysTEC Institutions

Institution	Location	Project Term
Currently Funded Institutions		
Cornell University	Ithaca, NY	2007-2010
Florida International University	Miami, FL	2007-2010
University of Minnesota	Minneapolis, MN	2007-2010
University of North Carolina-Chapel Hill	Chapel Hill, NC	2007-2010
Legacy Institutions		
Ball State University	Muncie, IN	2001-2008
California Polytechnic State University	San Luis Obispo, CA	2003-2007
Oregon State University*	Corvallis, OR	2001-2004
Seattle Pacific University	Seattle, WA	2006-2009
Towson University	Baltimore, MD	2004-2008
University of Arizona	Tucson, AZ	2001-2008
University of Arkansas	Fayetteville, AR	2001-2008

University of Colorado at Boulder	Boulder, CO	2004-2008
Western Michigan University	Kalamazoo, MI	2001-2008
Xavier University of Louisiana**	New Orleans, LA	2001-2005

* Due to changes in faculty at Oregon State there did not exist a commitment by the department to engage in the project at the depth required in year three. Consequently, a joint understanding was reached prior to year four to suspend Oregon State as a PhysTEC institution. Ted Hodapp visited the department in the fall of 2004 and held discussions with the department about the possibility of rejoining. Since departmental staffing was still in considerable flux, it did not seem appropriate to pursue rejoining the project. Oregon State remains a Coalition member.

** Owing to the tremendous hardships and difficulties associated with rebuilding Xavier University of Louisiana's program in the wake of Hurricane Katrina, Xavier asked for and was granted permission to suspend activity on the project for the 2005-2006 funding year. As of the drafting of this report, Xavier has not sought to restart project activity. Xavier remains a Coalition member.

2.1 Currently Funded Institutions

In October 2006, PhysTEC solicited applications for new PhysTEC sites that would receive three years' worth of funding. The review process was modeled after that of the NSF, with a two-stage application procedure and a panel of reviewers. Forty-five institutions applied to the first round, demonstrating widespread interest in physics teacher education as well as respect for the efforts of PhysTEC. Twelve applicants were invited to proceed to the second round of the application, and eleven submitted the secondary application materials. At the end of the review process, the panel selected Cornell University, Florida International University, the University of Minnesota, and the University of North Carolina at Chapel Hill to join the project. These sites began their projects in August 2007.

Cornell University's PhysTEC project leaders recognize that relatively few Cornell physics students pursue teaching, and Cornell faculty have not traditionally promoted it as a potential career. As a result, the project aims to raise the awareness and change the attitudes of students and faculty regarding careers in high school science teaching, provide opportunities for students to experience the challenges and rewards of classroom teaching, and provide mentoring and support as they work through the education program and into their first years as teachers. Through targeted one-on-one conversations, the TIR has attracted record numbers of physics majors to School of Education recruiting sessions for future teachers. Cornell's Learning Assistant program launched with eight undergraduates in Spring 2008. Three Cornell future physics teachers are in the first class of PhysTEC Noyce scholars.

Florida International University (FIU) in Miami educates more Hispanic students than any other institution in the country, and that diversity is reflected among FIU's physics majors. Site leader Laird Kramer has built a thriving learning community within the department, and is now seeking to expand these efforts to include educating teachers. The PhysTEC project has been able to build on FIU's Center for High-Energy Physics Research, Education, and Outreach (CHEPREO), which includes a Physics Learning Center targeting underserved students. Project leaders have launched a Learning Assistant program that included eight undergraduates in its

first semester of operation, and has grown since then. In 2008 FIU graduated its first physics teacher in a decade, and has more in the pipeline. The university is poised to provide the lion's share of highly qualified physics teachers to the southern tip of Florida, and especially to Miami-Dade County, which has one of the largest and most diverse school districts in the country.



Florida International students work on an electromagnetism activity.

University of Minnesota project leaders are active participants in Physics Force, a highly successful physics road show developed at the university, and are the driving force behind a unique program for minority students and their parents called Parents and Children Experiencing Science (PACES). Site leaders have used these programs to promote teaching physics as a rewarding career, both to Minnesota undergraduates and to middle and high school students. In addition, they have developed a novel application of the Learning Assistant program in which Learning Assistants work with small teams during lecture classes. There is significant interest in looking at the Learning Assistant program as a means to improve retention of STEM majors. One Learning Assistant said “the experience encouraged me to stick with physics,” and that “If I hadn’t done the program, I don’t know if I would still be a physics major,” because it provided strong connections within the department and gave her confidence in her abilities. With one of the largest undergraduate student bodies in the U.S., Minnesota has tremendous potential to recruit and prepare significant numbers of teachers.

University of North Carolina at Chapel Hill’s (UNC) goal as a PhysTEC institution is to establish a program in which science majors prepare to become high school science teachers as they pursue their undergraduate degrees, and graduate in four years with teaching certification. This program, called UNC-BEST (UNC Baccalaureate Education in Science and Teaching), is a partnership between the College of Arts and Sciences and the School of Education, which began with the Department of Physics and Astronomy and the Department of Biology. It is now expanding to Geological Sciences and Mathematics, and project leaders hope to involve Chemistry in the future. UNC-BEST’s first graduating class, in 2009, included one physics teacher—the first graduating from the school in at least a decade—and seven biology teachers. As part of the program, the UNC TIR worked with a Physics Education Research (PER) specialist to design a physics methods course for students interested in teaching. The project leader is planning to implement further reforms in introductory physics courses, including a classroom based on North Carolina State University’s NSF-funded [SCALE-UP](#) program.

2.2 Legacy Institutions

The initial PhysTEC site solicitation occurred in 2001, and six institutions—Ball State University, Oregon State University, the University of Arizona, the University of Arkansas, Western Michigan University, and Xavier University of Louisiana—were chosen. Of those, four completed their five-year funding term, while two left early for reasons outside the project’s control (See [Table 1](#) for more information). Subsequently, three other sites—Cal Poly San Luis Obispo, Towson University, and the University of Colorado at Boulder—were selected for three-year funding terms. Each legacy site has made significant contributions to the project, and has sustained elements of their teacher preparation program beyond PhysTEC funding.

Ball State University’s PhysTEC project concentrated on improving its middle school science teacher education program, reforming the introductory algebra-based physics courses taken by future middle school physical science teachers, and developing an effective induction and mentoring program for newly certified physics teachers. As a result of Ball State’s mentoring efforts, the site has achieved an enviable 100% retention rate of physics teachers graduated during the PhysTEC funding period. PhysTEC’s influence on the department can be seen in the hiring of a permanent PER faculty member and providing assistance to a doctoral candidate, who is an experienced physics teacher, to assume some of the roles that the TIRs took on during the course of the project. In addition, the PhysTEC TIR model will be used for new teacher induction and mentoring in Ball State’s recently awarded Woodrow Wilson National Fellowship Foundation program. Two Ball State future physics teachers are in the first class of PhysTEC Noyce scholars.

California Polytechnic State University, San Luis Obispo’s PhysTEC project focused on developing and assessing sustainable course reforms, increasing collaboration with the local school districts through a Teacher Advisory Group (TAG), and securing institutional funding for an on-campus TIR. Cal Poly now has one university-funded TIR, who has completed her fifth year in the position. Project leaders developed “day-by-day plans” for introductory calculus-based physics courses and the physical science course for elementary education majors, to allow interactive course reforms to be sustained when transferred between instructors. Faculty and TIRs also worked with local teachers in the TAG to develop and evaluate observation instruments to use in the introductory pedagogy course.

Seattle Pacific University (SPU) began its funding period in 2006 and is finishing its last year as a funded site. SPU, a four-year liberal-arts institution with around 3,000 students, has the potential to serve as a model for teacher preparation programs at liberal arts institutions around the country. One innovation that came out of SPU is the Visiting Master Teacher, who is essentially a part-time TIR taking on a subset of the roles of the traditional PhysTEC TIR. Like many PhysTEC sites, Seattle Pacific has made the Learning Assistant program a cornerstone of its recruitment and early teaching experience strategy. The project leaders also work closely with several progressive school districts, including Seattle and Bellevue, to provide robust, content-rich professional development for teachers. A strong spirit of collaboration exists between Seattle Pacific’s Physics Department and School of Education as well, exemplified by a faculty line split between these two units, and an interdisciplinary Science Education Task Force

consisting of physics and education faculty. PhysTEC also benefits from Seattle Pacific's NSF-funded Teacher Professional Continuum (TPC) grant to develop and improve diagnostic tools and skills, in collaboration with FACET Innovations, a company in the Seattle area that creates professional development and assessment software for teachers. Three SPU future physics teachers are in the first class of PhysTEC Noyce scholars.

Towson University's PhysTEC program is unique within the project in that it supported only elementary science education. Towson graduates about 200 elementary education majors a year (more than any other school in Maryland), and its PhysTEC efforts focused on reforming its field experience course to foster inquiry teaching, maximize contact time with elementary students, and provide mentoring and opportunities for self-reflection. The Towson project has been able to measure considerable progress in the course structural reform efforts, the future teachers' attitudes towards science and science teaching, and, most importantly, the teachers' practice of inquiry science teaching. The deans from the College of Education and the Fisher College of Science and Mathematics have provided funding for a permanent staff position to take on the TIR duties and other PhysTEC efforts that are currently made by the project leaders. Towson is now planning to become a major player in secondary physics teacher preparation as well, and the physics department is hiring a tenure-track faculty member to improve the secondary physics teacher preparation program and recruit more undergraduates to teaching.

University of Arizona's PhysTEC program is built around its College of Science Teacher Preparation Program, and has graduated an average of two physics teachers per project year (up from one in three years pre-PhysTEC), with a 93% retention rate. The project leader has conducted extensive outreach to the local teacher community in developing the program, including establishing an active Teacher Advisory Group and involving teachers in curriculum development for pedagogy courses.

Arizona's program is now a well-established entity on campus that currently supports two adjunct instructor positions. Outside funding is being sought to support TIRs in the future. The project leader has recruited a sizable community of area mentor teachers to provide early field experiences to pre-service teachers, a major component of Arizona's teacher preparation program.

University of Arkansas has been spectacularly successful at recruiting physics teachers, increasing the number of graduates to more than 10 times what it was before the PhysTEC project began. The program develops student interest in physics with inquiry-based introductory courses (which recruit more majors as well as more teachers), guides potential teachers through the licensure process, and mentors them during their



An Arkansas Noyce Scholar works with two undergraduates.

early careers. Course reforms in the calculus-based introductory sequence have proven successful in producing high learning gains, independent of instructor. The project leaders are currently pursuing further course reforms in the algebra-based sequence and the physical science for elementary teachers course, which is now required for all elementary education majors. The university has also funded a TIR position in the College of Education and Health Professions to work with future elementary teachers. Arkansas has achieved substantial success in leveraging administrative support to sustain other PhysTEC initiatives. For instance, the University decided to dedicate its NSF Noyce proposal to the PhysTEC faculty to allow them to fund tuition for pre-service teachers, and a recently-awarded Math and Science Partnership is helping extend some of the gains made in physics to the math program. Arkansas also participates in the PhysTEC Noyce project—two Arkansas students are in the first class of PhysTEC Noyce scholars.

University of Colorado at Boulder site leaders have developed a sophisticated Learning Assistant program that has become the model for many institutions around the country, thanks in part to a [PTEC-sponsored workshop](#) led by Colorado faculty in Fall of 2007. The Learning Assistant program allows students to experience the positive aspects of teaching, and serves as a recruitment tool into the teacher certification process, with around 15% of all Learning Assistants going on to complete a teacher preparation program. The teaching experience is augmented with a weekly course on teaching and learning physics, co-taught by an education faculty member and a former Teacher-in-Residence. It is very popular, with over 50 students applying for approximately 18 spots each semester. Colorado has also gathered data to show that Learning Assistants score on par with first-year graduate students on commonly-used content assessments.²³ They can also demonstrate that their Learning Assistant program has improved undergraduate performance in physics courses, facilitated multi-disciplinary collaboration among faculty, involved more faculty in teacher preparation efforts, and recruited talented science majors to teaching careers.²⁴ The Learning Assistant program has spread beyond Physics and Astronomy to all of the major STEM (science, technology, education, and mathematics) departments. The university's PhysTEC efforts have been further augmented by a number of collaborative grant proposals, including Noyce teaching fellowships and a recent [UTeach replication](#) award through the [National Math and Science Initiative](#).

Western Michigan University has focused its PhysTEC efforts on reforming its introductory physics course sequence, recruiting additional physics majors and minors, and preparing their teaching graduates to use interactive methods. As at many institutions, faculty adoption of course reforms has been uneven, which has allowed the project leaders to gather data to show convincingly that interactive courses yield significantly higher gains on concept assessments than do traditionally taught courses. Western Michigan project leaders also report that they have “built a community of physics teachers composed of pre-service teachers, novice teachers, and experienced local teachers of physics. This community served as a support system for our graduates and other novice teachers as well as out-of-field teachers of physics.” To help support ongoing efforts in teacher education, Western Michigan decided to hire a tenure-track faculty member in physics education research.

²³ N. Finkelstein, V. Otero, and S. Pollock, “[Teaching to Learn: The Colorado Learning Assistant program’s impact on learning content](#),” *APS Forum on Education Newsletter*, Fall 2006/Summer 2007, 11-13.

²⁴ J. Mervis. “A New Twist on Training Teachers.” *Science* 316 (5829), 1270—77 (2007).

3. Dissemination and Advocacy

PhysTEC project leaders view dissemination of project successes and advocacy for physics faculty involvement in teacher education as absolutely essential and central to its mission. The project pursues these goals through a wide variety of efforts in different media and venues.

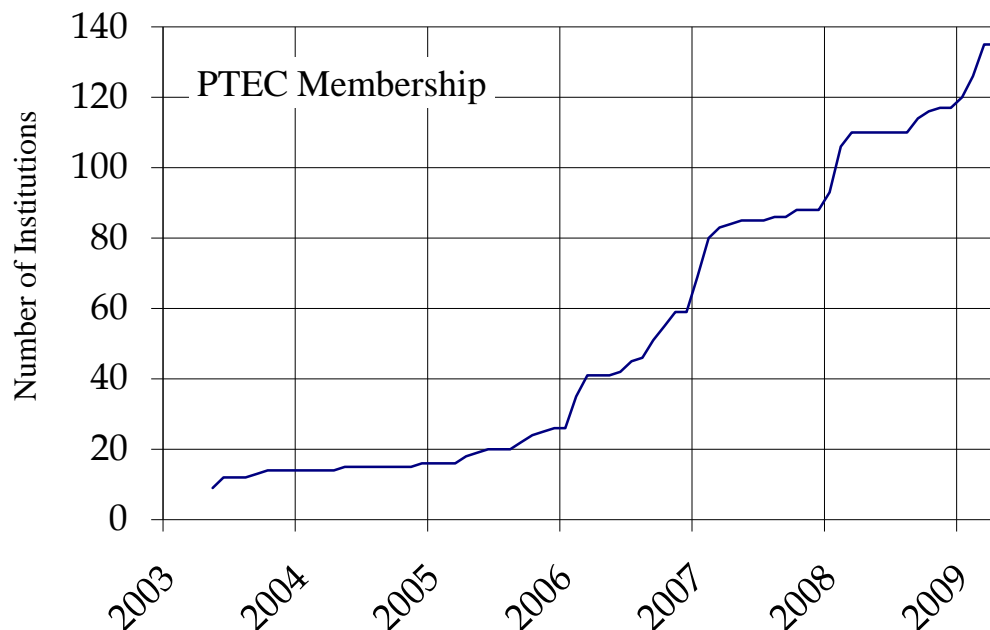
3.1 The Physics Teacher Education Coalition

In addition to the funded PhysTEC Institutions, the project is also building the Physics Teacher Education Coalition, or PTEC, a broad coalition of institutions committed to developing and promoting excellence in physics and physical science teacher preparation. The goals of PTEC are to

- Build a network of institutions engaged in reforming physics teacher education;
- Promote and disseminate successful programs, methods, and ideas; and
- Advocate nationally for improving science teacher education.

3.1.1 Coalition Membership

PTEC institutions do not receive direct funding, but the project sponsors an annual conference and several workshops dedicated to teacher preparation during the course of the year, and PTEC members are invited to participate at a reduced rate. As of this writing the Coalition has 139 member institutions – up from 110 in July 2008. The project is undertaking a major effort to determine how best to use the combined resources of these institutions and future PTEC members to advance physics teacher preparation throughout the country.



The above graph shows growth in PTEC membership over the past six years. A complete list of PTEC members (as of this writing) can be found in [Appendix C](#) of this report.

3.1.2 Conferences and Workshops

PTEC conferences and workshops are the most important way the project disseminates successful programs and builds widespread support for physics teacher education reform. These events are important for both the formal sharing of programs and ideas through invited sessions and the relationships that are built through informal networking.

3.1.2.1 Annual PTEC Conference

Table 2. PTEC Conference Attendance

Since 2005, the PTEC Conference has been held annually in late winter, and has attracted many of the leaders in physics teacher preparation from around the country. The format includes two days of 1.5-hour workshops in three or four parallel tracks, lunchtime plenary speakers, and opening and closing sessions. The project works hard to ensure that all

Year	Location	Attendance
2005	Muncie, IN	82
2006	Fayetteville, AR	85
2007	Boulder, CO	112
2008	Austin, TX	117
2009	Pittsburgh, PA	108

workshops provide opportunities for participant engagement, and that the conference schedule also includes ample time for attendees to interact with each other outside of programmed sessions. The above table shows conference locations and attendance. The site for the PTEC conference is chosen specifically to engage a continually larger audience and reach out to a broad cross-section of the physics community. The [2010 PTEC Conference](#) will be held jointly with the APS/AAPT/National Society of Black Physicists/National Society of Hispanic Physicists meeting in Washington, DC on February 12 and 13, 2010. The theme will be “Diversity in Physics Education: Preparing Teachers for the 21st Century.”

The [2009 PTEC Conference](#) was held in Pittsburgh, PA on March 13 and 14, 2009, with the theme of “Institutional Transformation: How do we change departments and universities to embrace the mission of preparing tomorrow’s teachers?” Among the most popular workshops were “Pedagogical content knowledge needed to teach physics,” led by Eugenia Etkina of Rutgers, who discussed the need for teachers to be familiar not just with physics content but also with physics-specific pedagogy; and “Facilitating change in undergraduate STEM,” led by Noah Finkelstein of the University of Colorado and Charles Henderson of Western Michigan University, who facilitated a conversation on “the need to problematize and improve our approaches to change.” Also well-attended was a panel on “The university role in teacher preparation,” which was led by Howard Gobstein of the Association of Public and Land-Grant Universities (APLU, formerly NASULGC), and included the perspectives of a physics department chair, an arts and sciences dean, and a university provost. All presentations from the conference are available on the [PTEC website](#).

3.1.2.2 Regional Conferences

The project holds regional meetings to catalyze change in states with large university systems, and in regions where the project has connections that it hopes to leverage into significant action on teacher preparation. The first of these was held in August 2007 at the University of North Carolina-Chapel Hill. The [conference](#), inspired by the UNC System President Erskine Bowles' call to action on science teacher preparation, attracted faculty from 14 of the 16 institutions in the UNC system.

In October 2008, the project sponsored [the PTEC-Northwest regional conference](#) at Seattle Pacific University in Seattle, Washington. The program consisted of presentations by national leaders of exemplary teacher preparation programs from around the country, including Monica Plisch (APS), Noah Finkelstein (University of Colorado at Boulder), Michael Marder (University of Texas at Austin), and George "Pinky" Nelson (Western Washington University). The workshop was attended by around 30 teacher preparation professionals, and a similar number of Seattle-area K-12 teachers. Evaluations were very positive, with requests for additional networking/discussion time.

3.1.2.3 Topical Workshops

The project has held two topical workshops focusing on particular elements of teacher preparation. The first of these focused on the [RTOP](#), and took place at the American Center for Physics in College Park, Maryland from October 13-15, 2006. The workshop was run by Kathleen Falconer and Dan MacIsaac from Buffalo State College and PhysTEC Consultant Paul



A Colorado prospective teacher works with an undergraduate in a Tutorial session.

Hickman, and drew 21 faculty members and master teachers from PTEC institutions around the country. Attendees practiced evaluating instruction in videos and discussed their decisions, leading to increased consensus between scorers. The second topical workshop took place on October 24 and 25, 2007, as 22 faculty members from 14 PhysTEC and PTEC institutions participated in a [Learning Assistant Workshop](#) at the University of Colorado at Boulder. Colorado physics and education faculty put together an intensive 1.5-day workshop designed to give visiting professors information and tools to implement a Learning Assistant program on their own campuses. A followup survey indicated that as a result of attending the workshop, several participants either started or modified existing Learning Assistant programs on their campuses, or had plans to do so.

On March 12, 2009, immediately prior to the PTEC Conference, the project hosted a full-day [workshop](#) in partnership with the Association of Public and Land-Grant Universities. The purpose of the workshop was to help faculty and administrators from institutions in the APLU

Leadership Collaborative develop plans to ramp up teacher education activities in their departments. The program included presentations by leaders in teacher preparation and several hours for guided brainstorming and program planning. Participants stated that networking and learning about successful programs were the most valuable aspects of the workshop, and they gave the overall quality of the presentations high marks.

3.1.2.4 Presence at AAPT and APS Meetings

The project has been increasing its presence at AAPT and APS meetings, in order to reach out to a greater fraction of the physics faculty around the country. The PTEC booth was unveiled for the first time in the exhibition hall at the 2007 AAPT Summer Meeting in Greensboro, NC, and has appeared at all AAPT and APS national meetings since then. PhysTEC also co-sponsored a symposium on physics education entitled *The Many-Body Challenge: The Full-Community Solution for Strengthening Teacher Recruitment, Preparation, and Retention in Physics* at the 2008 AAPT Winter Meeting, and an interactive poster session entitled *Physics Teacher Preparation Around the U.S.* (with 15 invited and contributed posters) at the 2008 AAPT Summer Meeting. The project also organizes a TIR session every year at the AAPT Summer Meeting.

3.2 Online dissemination

The PhysTEC project uses a number of online venues to publicize its activities and progress.

3.2.1 PhysTEC website

The PhysTEC website—www.PhysTEC.org—was redesigned in Fall 2007. The goals were to improve both the utility of the site and the reporting of project results. Project leadership identified eleven “key components” that have been essential to the success of PhysTEC sites, and the website contains a page on each of these, with background information, strategies for implementation, and resources. PhysTEC institutions’ cumulative annual reports are also available, for users who want more detail on a particular program. Also on the website are all PhysTEC annual and quarterly reports, presentations and publications from project participants, news and announcements, and information about project outcomes. Data from Google Analytics indicate that the PhysTEC website receives over 1,000 visits a month.

3.2.2 PTEC Website

The PTEC website—www.PTEC.org—is a collaboration with [ComPADRE](http://www.ComPADRE.org), an NSF-funded digital library of resources for physics and astronomy education created by AAPT, AIP, APS, and the American Astronomical Society (AAS), to develop a collection of resources devoted to physics and physical science teacher preparation – the Physics Teacher Education Coalition Digital Library (PTEC-DL). The project is working with the collection editor John Stewart to highlight high-quality materials in the collection. The PTEC website includes

- A digital collection of teacher education resources, including presentations and materials from past conferences and workshops;
- A collection of PTEC member profiles;
- Updates on physics teacher education events, news, and funding opportunities;
- A national map of professional development opportunities for physics teachers.

3.2.3 Discussion forums

The Coalition discussion forum includes representatives from all PTEC institutions, and serves as a place where project leaders can inform PTEC members about events, policy developments, and funding opportunities related to teacher preparation. The AAPT Committee on Teacher Preparation forum, though not managed directly by the project, has many PTEC representatives as members, and frequently hosts lively conversations about physics teacher preparation topics. Other email lists, including ones for PhysTEC site leaders and one for PhysTEC teachers, serve mostly to help disseminate announcements for events.

3.3 National Task Force on Teacher Education in Physics

The joint AAPT/AIP/APS National Task Force on Teacher Education in Physics held its first meeting in May 2008. The Task Force aims to lead the physics community in a response to national and international pressure for improvement in pre-college science education by investigating the following questions:

1. *Increasing the number of qualified teachers* – Are there generalizable, yet flexible, strategies that institutions (and in particular, physics departments and schools or colleges of education) can employ?
2. *Identifying best practice* – Are there effective (a) strategies in recruitment, (b) models of professional preparation, and (c) higher education systems of support during the first three years of teaching?
3. *Research, Policy, Funding Implications* – Are there characteristics of physics departments, special partnerships, and types of institutional support and extramural funding that foster effective programs? Are there important new research agendas in teacher professional education and development in physics, which can be identified and promoted? What new measures of discipline-based teaching effectiveness need to be developed? What new funding avenues and policy changes need to be in place to support these cutting-edge research and development efforts?

The Task Force is in the process of collecting and analyzing data, conducting site visits to nationally recognized institutions with exemplary physics teacher education programs, and preparing to author a report of its findings. The report will be distributed to all physics departments and education schools in the U.S., and disseminated through presentations, workshops, and other mechanisms, under the auspices of the sponsoring professional organizations. The task force plans to release its report at a joint session during the 2010 APS/AAPT meeting.

See [Appendix A.4](#) for a list of Task Force members.

3.4 Publications and Presentations

The PhysTEC project aims to disseminate its successes and findings in a wide variety of venues, targeting diverse audiences. For a full list of publications by project members, see [Appendix B](#). For selected presentations on PhysTEC, please see www.PhysTEC.org/presentations.

3.4.1 PhysTEC Newsletter

In Fall 2008 the project published the second edition of its newsletter [PhysTEC News](#). The goal of this publication is to create a high-quality piece of publicity material to represent the project to sponsoring society board members, university administrators, faculty, donors, and potential project partners. The newsletter has been given to the APS and AAPT Executive Boards, and mailed to all PTEC and PhysTEC institutions as well as targeted physics chairs of institutions that were identified as likely future PTEC members. The newsletter also serves as the top giveaway at the PTEC booth. The next newsletter is planned for Fall 2009.

3.4.2 PTEC Book: Collected Papers on Teacher Preparation

PTEC is sponsoring a book of peer-reviewed papers on teacher preparation, to be published jointly by APS and AAPT. The book will include new reports on cutting-edge research and practice, as well as a few selected reprints of seminal papers. Printed copies will be distributed to chairs of all physics departments in the United States, and the book will also be freely available online. Publication in *Physical Review Special Topics-Physics Education Research* or the *American Journal of Physics* is a prerequisite for inclusion in the book, and article authors are in the process of submitting their papers to one of these two journals. The project expects the book to be completed in 2010.

3.4.3 APS Newsletters

The project publishes articles periodically in *APS News*, APS's monthly newspaper that goes out to its 46,000+ members. In November 2008, *APS News* ran an article on the PhysTEC Noyce Scholarship award. An article on Towson's PhysTEC project appeared in the August/September 2008 edition. A bimonthly feature called the "Education Corner" also features news about the project. In addition, APS's *Capitol Hill Quarterly*, a publication aimed at policy makers, ran an article on PhysTEC in September 2008.

3.4.4 Physics Today Article

PhysTEC co-Principal Investigators Ted Hodapp (APS), Jack Hehn (AIP), and Warren Hein (AAPT) recently co-authored an article for the magazine *Physics Today*, which is published monthly by AIP and reaches over 100,000 physicists. The article states the need for more attention to physics teacher education, describes some of the exemplary programs that PhysTEC is promoting, and gives detailed and practical advice for readers who wish to jump-start teacher

preparation efforts in their own departments. The [article](#) came out in the February 2009 issue and was featured on the PhysTEC website.

3.4.5 APS Forum on Education (FEEd) Newsletter

Since 2005, the APS [Forum on Education Newsletter](#) has contained a section on teacher preparation. Every PhysTEC site has published at least one article in this newsletter, which is distributed electronically to over 4,000 APS members and freely available on the web. Most recently, in the Fall 2008 edition, the TIR from Minnesota wrote about his experience working with the PhysTEC project, and the TIR from Cornell wrote about the problem of out-of-field teachers in physics classrooms.

3.5 Collaborations

In order to maximize its impact, the PhysTEC project continually seeks broad collaborations with a wide range of partnering organizations and efforts. The project has been working closely with APLU on a recent NSF Research, Evaluation, and Technical Assistance (RETA) grant supporting APLU's Science and Mathematics Teacher Imperative, culminating in a [workshop](#) that was held just prior to the 2009 PTEC Conference. Representatives of APLU, UTeach, and Teach for America all led sessions at the Conference, and the project is pursuing additional opportunities to collaborate with each of these organizations. While keeping its focus on physics and physical science teachers, PhysTEC recognizes the benefits of working with others engaged in STEM education in order to have the maximum impact on the future of physics education in the United States.

APPENDIX A: Project Personnel

A.1 PhysTEC Management Team

A.1.1 Present Members

- **Theodore Hodapp**, *PI* (2004-2009), Director of Education and Diversity, American Physical Society. Hodapp is the primary contact for the NSF and is responsible for overall direction and fiscal management of the project. He coordinates the many components of the project and visits each funded institution at least once a year. He maintains on-going communication and timely reporting to NSF. APS pays 100% of his salary, and he works 50-80% time on the PhysTEC project.
- **Warren Hein**, *co-PI* (2005-2007, 2008-2009), Executive Officer, American Association of Physics Teachers. Hein is responsible for coordinating PhysTEC activities that involve AAPT programs and staff. These activities include collaborations with the Physics Teacher Resource Agent (PTRA) program, dissemination of PhysTEC activities through the *American Journal of Physics*, *The Physics Teacher*, and PhysTEC sessions at the AAPT Winter and Summer Meetings, and regional section meetings.

- **Jack Hehn**, *co-PI* (2001-2009), Director of Education Programs, American Institute of Physics. Hehn was a member of the original proposing team and now participates in leadership through the Project Management Team activities, communicates and consults with PhysTEC institutions, and has participated in site visits to funded institutions. He coordinated the initial activities of the External Evaluator (The Momentum Group, Inc.) in formative evaluation efforts.
- **Monica Plisch**, Assistant Director, Education, American Physical Society (2007-2009). Plisch is responsible for project assessment and manages PTEC, including the PTEC national conference. She participates in site visits and works with Hodapp to manage other aspects of the project. Plisch spends 80% of her time on the PhysTEC project.
- **Gabriel Popkin**, Project Manager (2007-2009). Popkin manages many of the day-to-day operations of PhysTEC, including overseeing project communications, managing project and budgetary data, and drafting project documents and promotional materials.
- **Edward Lee**, Project Associate, American Physical Society (2001-2009). Lee's responsibilities include editing documents and participating in Project Management Team meetings.
- **Paul Hickman**, TIR and Mentoring Consultant (2005-2009). Hickman is responsible for coordinating TIR activities, and participates in Project Management Team meetings.
- **David Meltzer**, Assessment Consultant (2007-2009). Meltzer is the editor of the forthcoming teacher preparation book, and leads many aspects of the PhysTEC project assessment effort.
- **Drew Isola**, Consultant (2008-2009). Isola, a former Teacher-in-Residence, is responsible for a variety of activities related to TIRs and PhysTEC teachers.

A.1.2 Past Members

- **John Layman**, *co-PI*, Professor Emeritus at the University of Maryland (2001-2005). Layman participated in site visits. He led the effort and program to establish the TIR group, and helped in organizing two of the first annual project meetings. Layman spearheaded the formal Induction/Mentoring program within PhysTEC and collaborated with AAPT's PTRAs program to create the summer TIR/PTRA Induction and Mentoring workshop.
- **Fredrick Stein**, *PI* (2001-2004), former Director of Education and Outreach, American Physical Society. Stein served as PI through until his retirement from the APS in September 2004. APS was responsible for 100% of his salary, and he worked 50-60% time on the PhysTEC project. The Fund for the Improvement of Postsecondary Education (FIPSE) also contributed to Stein's salary for the first three years.

- **Charlie Holbrow**, *co-PI* (2008), Executive Officer, American Association of Physics Teachers. Holbrow replaced former AAPT Executive Officer and co-PI Toufic Hakim.
- **Toufic Hakim**, *co-PI* (2007-2008), Executive Officer, American Association of Physics Teachers. Hakim replaced Warren Hein as co-PI during Hein's rotation at the NSF.
- **Mary Fehrs**, Associate Project Director for Coalition Development (2005-2007). Fehrs was responsible for organizing and managing the PTEC annual conference, inviting speakers, writing and disseminating the publicity materials, and developing meeting structure. She recruited and communicated with potential Coalition members and was responsible for the ongoing development of the Coalition.
- **Victoria Kwasiborski**, Project Manager (2005-2007), American Physical Society.
- **John Gretz**, Project Coordinator (2004-2005), American Physical Society.
- **Kevin Aylesworth**, Project Coordinator (2002-2004), American Physical Society.

A.2 Past Management Team Consultants

- **Marcia Fethers**, TIR Consultant (2005)
- **Karen Johnston**, Project Evaluator, The Momentum Group (2001-2004)
- **Hal Richtol**, Consultant for Site Visits (2001-2004)
- **Gay Stewart**, Outreach Consultant (2005)

A.3 Advisory Committee

- **George H. Trilling**, *Chair*, Professor Emeritus, University of California, Berkeley, (2001-2007)
- **Robert Beck Clark**, Professor, Department of Physics and Astronomy, Brigham Young University (2001-2007)
- **Sandra Harpole**, Director, Center for Science, Mathematics, and Technology, Mississippi State University (2001-2007)
- **Paul Hickman**, Director of CESAME, Northeastern University (2001- 2005)
- **E. Leonard Jossem**, Professor Emeritus, Department of Physics, The Ohio State University (2001-2007)
- **Lillian McDermott**, Professor, Department of Physics, University of Washington (2001-2007)
- **Jill Marshall**, Associate Professor, Department of Education, University of Texas at Austin (2005-2007)

A.4 Task Force Members

- **Stamatis Vokos**, *Chair* (Seattle Pacific University)

- **Eugenia Etkina** (Rutgers University)
- **J. D. Garcia** (University of Arizona)
- **David Haase** (North Carolina State University)
- **Drew Isola** (Allegan Public Schools)
- **Eugene Levy** (Rice University)
- **Valerie Otero** (University of Colorado at Boulder)
- **Mary Ann Rankin** (University of Texas at Austin)

Society liaisons:

- **Jack Hehn** (American Institute of Physics)
- **Warren Hein** (American Association of Physics Teachers)
- **Ted Hodapp** (American Physical Society)
- **Cathy O'Riordan** (American Institute of Physics)
- **Monica Plisch** (American Physical Society)

Senior Consultant: David Meltzer (Arizona State University)

APPENDIX B: PHYSTEC PUBLICATIONS

B.1 Project Management Team (PMT) Publications

Year	Primary Author	Title	Location/Citation
2009	Hodapp, Hehn, Hein	Preparing High School Physics Teachers	Physics Today, February 2009
2008	Popkin	Noyce Scholarships to Aid Selected Physics Teachers	APS News, November 2008
2008	Popkin	PhysTEC Noyce Scholarship Program Launched	PhysTEC News, Fall 2008
2008	Popkin	Increase in Teachers Graduating from PhysTEC Institutions	PhysTEC News, Fall 2008
2008	Popkin	PhysTEC Teachers Come to Edmonton	PhysTEC News, Fall 2008
2008	Popkin	Projects at PhysTEC Institutions	PhysTEC News, Fall 2008
2008	Popkin	Teacher-in-Residence Profile	PhysTEC News, Fall 2008
2008	Hodapp	Teacher Education: The Big Picture	PhysTEC News, Fall 2008
2008	Popkin	PhysTEC Prepares Future Physics Teachers	Capitol Hill Quarterly, September 2008
2008	Popkin	Towson PhysTEC Project Targets Elementary Science Teaching	APS News, August/September 2008

2008	Popkin	2008 PTEC Conference: "Master Teachers: Change Agents for Teacher Preparation"	APS Forum on Education Newsletter, Summer 2008
2007	Popkin	Conference Connects Physics Teacher Educators	APS News, April 2008
2008	Hodapp	New PhysTEC Sites	PhysTEC News, Spring 2008
2008	Popkin	2008 Conference: "Master Teachers: Change Agents for Teacher Preparation"	PhysTEC News, Spring 2008
2008	Plisch	PTEC Member Profiles	PhysTEC News, Spring 2008
2008	Popkin	Learning Assistant Workshop	PhysTEC News, Spring 2008
2008	Popkin	Perspectives on Teaching	PhysTEC News, Spring 2008
2008	Popkin	Teacher-in-Residence Profile	PhysTEC News, Spring 2008
2008	Plisch	PTEC-North Carolina Regional Workshop	PhysTEC News, Spring 2008
2008	Hodapp	Teacher Education: The Big Picture	PhysTEC News, Spring 2008
2008	Plisch	300 Departments Sign Joint Statement	PhysTEC News, Spring 2008
2008	Popkin	Learning Assistants Impact Undergraduate Teaching	APS News, February 2008
2007	PMT	Four New Sites Added to Teacher Education Program	APS News, April 2007
2006	PMT	Featured PhysTEC University: University of Colorado	APS News, March 2006
2005	PMT	Featured PhysTEC University: Arkansas Ramps Up Teacher Preparation	APS News, December 2005
2005	PMT	Featured PhysTEC School: University of Arizona.	APS News, May 2005
2002	Layman	Guest Editorial: PhysTEC	American Association of Physics Teachers <i>Announcer</i>
2002	Layman	A Coalition to Improve Teaching	APS Forum on Education Newsletter.
2001	Stein	The Blame Game in Teacher Preparation	APS Forum on Education Newsletter, Fall 2001

B.2 PhysTEC Institution Publications

Institution	Year	Authors	Title	Citation
Ball State	2008	Grosnick, D., Watson, J.	Plugging the Leaky Bucket: Retention of Physics Teacher Graduates from Ball State University	<i>APS Forum on Education Newsletter</i> , Spring 2008.
Colorado	2008	Finkelstein, N. and Pollock, S.	Sustaining Educational Reforms in Introductory Physics	<i>Physical Review, Special Topics: PER</i> , 4 (010110) 2008.

Cornell	2008	Alderman, M.	Non-Physics Teachers Are Teaching Physics-We Cannot Replace Them, But We Can Help Them!	<i>APS Forum on Education Newsletter</i> , Fall 2008.
Florida International	2008	Kramer, L., Brewer, E., O'Brien, G.	Improving Physics Education through a Diverse Research and Learning Community at Florida International University	<i>APS Forum on Education Newsletter</i> , Summer 2008.
Florida International	2008	Jones, D.	Join a Physics Teaching Community.	<i>The Physics Teacher</i> , 46 , 2008.
Minnesota	2008	Anderson, J.	The first Year of PhysTEC at the University of Minnesota	<i>APS Forum on Education Newsletter</i> , Fall 2008.
North Carolina	2008	McNeil, L.	Nuts and Bolts of Teacher Preparation	<i>PhysTEC News</i> , Fall 2008.
North Carolina	2008	McNeil, L.	Doing the Right Thing (and in the Right Place): Starting a Teacher Preparation Program at a Research University	<i>APS Forum on Education Newsletter</i> , Summer 2008.
Towson	2008	Lising, L., Sandifer, C.	A Broad Approach to Mentoring in an Inquiry-Focused Early Teaching Experience	<i>APS Forum on Education Newsletter</i> , Spring 2008.
Arizona	2007	Talanquer, V., Tomanek, D., Novodvorsky, I.	Revealing student teachers' thinking through dilemma analysis	<i>Journal of Science Teacher Education</i> , 18 (3) 2007.
Arkansas	2007	Stewart, G.	Teacher Recruitment at the University of Arkansas	<i>APS Forum on Education Newsletter</i> , Spring 2007.
Arkansas	2007	Stewart, J., Griffin, H., Stewart, G.	Context sensitivity of the Force Concept Inventory	<i>Physical Review, Special Topics: PER</i> 3 (010102) 2007.
Arkansas	2007	Stewart, J., McGee, J., Stewart, G.	Using Student Behavior Data to Better Understand Class Performance	<i>Physical Review, Special Topics: PER</i> (Submitted).
Colorado	2007	Price, E., Finkelstein, N.	Preparing Graduate Students to be Educators	<i>American Journal of Physics</i> 76 684, 2008.
Colorado	2007	Kohl, P., Finkelstein, H. Rosengrant, D.	Strongly and Weakly Directed Approaches to Teaching Multiple Representation Use in Physics	<i>Physical Review, Special Topics: PER</i> 3 (010108) 2007.
Colorado	2007	Pollock, S., Finkelstein, N. Kost, L.	Reducing the gender gap in the physics classroom: How sufficient is interactive engagement?	<i>Physical Review, Special Topics: PER</i> , 3 (010107), 2007.
Colorado	2007	Pollock, S., Finkelstein, N.	Sustaining Change: Instructor Effects in Transformed Large Lecture Courses	<i>Proceedings of the 2006 Physics Education Research Conference (PERC)</i> , 2007.
Towson	2007	Sandifer, C., Lising, L., Renwick, E.	Towson's PhysTEC course improvement project, Years 1 and 2: Results and lessons learned	<i>Proceedings of the Association for Science Teacher Education Conference</i> , 2007.
Towson	2007	Lising, L., Tirrochi, L.	A "teacher-in-residence" experience as professional development in elementary science inquiry	<i>Proceedings of the Association for Science Teacher Education Conference</i> , 2007.
Towson	2007	Lising, L., et al.	Instructor guide and resource materials for the Teaching Science in the Elementary School course at Towson University	Self-published.

Western Michigan	2007	Poel, B., Isola, D.	Recruiting a New Generation of Physics Teachers at Western Michigan University	<i>APS Forum on Education Newsletter</i> , Spring 2007.
Western Michigan	2007	Isola, D., Olsen, J.	A Quiet Revolution in Preparing Future Teachers of Physics	<i>APS Forum on Education Newsletter</i> , Spring 2007.
Arizona	2006	Novodvorsky, I.	Shifts in beliefs and thinking of a beginning physics teacher	<i>Journal of Physics Teacher Education Online</i> , 3 (3) 11-17, 2006.
Arkansas	2006	Stewart, G.	Recruiting New Teachers At The University Of Arkansas	<i>APS Forum on Education Newsletter</i> , Fall 2006; <i>PTEC Newsletter</i> .
Arkansas	2006	Stewart, G.	Undergraduate Learning Assistants At The University Of Arkansas	<i>APS Forum on Education Newsletter</i> , Summer 2006; <i>PTEC Newsletter</i> .
Colorado	2006	Otero, V.	The Learning Assistant Model for Teacher Education in Science and Technology	<i>APS Forum on Education Newsletter</i> , Summer 2006.
Colorado	2006	Finkelstein, N.	The Role and Promise of Physics Education Research.	<i>APS News</i> , Back Page, Jan 2006.
Colorado	2006	Otero, V.	Moving Beyond the 'Get It Or Don't' Conception of Formative Assessment	<i>Journal of Teacher Education</i> , 57 , 247 – 255, 2006.
Colorado	2006	Adams, W. K., et al.	A new instrument for measuring student beliefs about physics and learning physics: the Colorado Learning Attitudes about Science Survey	<i>Physical Review, Special Topics: PER</i> , 2 (010101), 2006.
Colorado	2006	Kohl, P.B., Finkelstein, N.	The effect of instructional environment on physics students' representational skills	<i>Physical Review, Special Topics: PER</i> , 2 (010102), 2006.
Colorado	2006	Kohl, P., Finkelstein, N.	The effects of representation on students solving physics problems: a fine-grained characterization	<i>Physical Review, Special Topics: PER</i> , 2 (010106), 2006.
Colorado	2006	Podolefsky, N., Finkelstein, N.	Use of analogy in learning physics: The role of representations	<i>Physical Review, Special Topics: PER</i> , 2 (020101), 2006.
Colorado	2006	Pollock, S.	Transferring transformations: Learning gains, student attitudes, and the impact of multiple instructors in large lecture classes	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Colorado	2006	Otero, V., et al.	Who is Responsible for Preparing Science Teachers?"	<i>Science</i> , 313 (5786), 445-446, 2006.
Seattle Pacific	2006	Seeley, L., Vokos, S.	Creating and Sustaining a Teaching and Learning Professional Community at Seattle Pacific University.	<i>APS Forum on Education Newsletter</i> , Summer 2006.
Towson	2006	Sandifer, C., Lising, L., Tirrochi, L.	Our PhysTEC project: Collaborating with a classroom teacher to improve an elementary science practicum	<i>Proceedings of the Association for Science Teacher Education Conference</i> , 2006.
Arizona	2005	Novodvorsky, I.	Secondary science teacher preparation at the University of Arizona	<i>APS Forum on Education Newsletter</i> , Fall 2005.
Arizona	2005	Novodvorsky, I.	Partners in the Preparation of Secondary Science Teachers	<i>APS Forum on Education Newsletter</i> , Spring 2005.
Ball State	2005	Grosnick, D.	An Advisory Group to Provide Input in the Preparation of Future Teachers	<i>APS Forum on Education Newsletter</i> , Spring 2005.

Cal Poly	2005	Hoellwarth, C.	A direct comparison of conceptual learning and problem solving ability in traditional and studio style classrooms	<i>American Journal of Physics</i> , 73 (5), 459-463, 2005.
Colorado	2005	Finkelstein, N., et al.	CU Physics Education, Recruiting and Preparing Future Physics Teachers and the Teacher Advisory Group	<i>APS Forum on Education Newsletter</i> , Spring 2005.
Colorado	2005	Finkelstein, N.	Replicating and Understanding Successful Innovations: Implementing Tutorials in Introductory Physics	<i>Physical Review, Special Topics: PER</i> , 1 (010101) 2005.
Colorado	2005	Kohl, P.B., Finkelstein, N.	Student representational competence self-assessment and problem solving in physics	<i>Physical Review, Special Topics: PER</i> , 1 (010104), 2005.
Colorado	2005	Finkelstein, N., et al.	When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment	<i>PhysRev Special Topics: PER</i> , 1 (010103), 2005.
Colorado	2005	Finkelstein, N.	Can Computer Simulations Replace Real Equipment in Undergraduate Laboratories?	<i>Proceedings of the 2004 Physics Education Research Conference (PERC)</i> , 818 (3), 2005.
Colorado	2005	Finkelstein, N.	Seeding Change: The Challenges of Transfer and Transformation of Educational Practice and Research in Physics (Part I)	<i>Proceedings of the 2004 Physics Education Research Conference (PERC)</i> , 818 (3), 2005.
Colorado	2005	Finkelstein, N.	Evaluating a model of research-based practices for teacher preparation in a physics department: Colorado PhysTEC	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Colorado	2005	Keller, C.	Assessing The Effectiveness Of A Computer Simulation In Conjunction with Tutorials In Introductory Physics In Undergraduate Physics Recitations	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Colorado	2005	Pollock, S.	No single cause: Learning gains student attitudes and the impacts of multiple effective reforms.	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Colorado	2005	Pollock, S.	Transferring transformations: Learning gains student attitudes and the impact of multiple instructors in large lecture classes.	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Colorado	2005	Price, E.	Seeding Change: The Challenges of Transfer and Transformation of Educational Practice and Research in Physics (Part II)	<i>Proceedings of the 2005 Physics Education Research Conference (PERC)</i> , 818 (3), 2006.
Arizona	2004	Novodvorsky, I.	US Coalition helps new teachers	<i>Physics Education</i> (News brief), 39 (16) 2004.
Arizona	2004	Novodvorsky, I.	The impact of educational research on physics teacher preparation, Quality Development in Teacher Education and Training	<i>Proceedings of 2nd International GIREP Seminar</i> , Udine, Italy, 2004.

Arizona	2004	Novodvorsky, I.	Teaching as they were taught: The importance of reformed university courses, Quality Development in Teacher Education and Training	<i>Proceedings of 2nd International GIREP Seminar</i> , Udine, Italy, 2004.
Arkansas	2004	Stewart, G.	Practicing What I Preach.	<i>APS Forum on Education Newsletter</i> , Summer 2004.
Ball State	2004	Smith, W.	Starting the Semester at Odds: Science Educators' Versus College Students' Reasons for Studying Science	<i>Journal of College Science Teaching</i> , 34 (3), 44-49, 2004.
Ball State	2004	Smith, W.	Data Mining the Internet: Immersing High School Students in Electronic Inquiry	<i>Science Activities</i> , 41 (1), 9-15, 2004.
Ball State	2004	Smith, W.	Using Internet Technology to Address National Science and Teacher Education Standards	<i>The Teacher Educator</i> , 39 (2), 144-156, 2004.
Arizona	2003	Tomanek, D., Talanquer, V., Novodvorsky, I., and Slater, T.F.	Responding to the call for change: The new college of science teacher preparation program at the University of Arizona	<i>Cell Biology Education</i> , 2 (1), 29-34, 2003.
Arizona	2003	Novodvorsky, I.	The Impact of Educational Research on Physics Teacher Preparation	<i>International Commission on Physics Education Newsletter</i> , 46 , 2003.
Arizona	2003	Talanquer, V., Novodvorsky, I., Slater, T., Tomanek, D.	A stronger role for science departments in the preparation of future chemistry teachers	<i>Journal of Chemical Education</i> , 80 (10), 1168-71, 2003.
Arizona	2003	Novodvorsky, I.	Beginning Your First Year	<i>The Physics Teacher</i> , 41 , 371-72, 2003.
Arizona	2002	Novodvorsky, I., Tomanek, D., Talanquer, V., Slater, T.,	A new model of physics teacher preparation	<i>Journal of Physics Teacher Education Online</i> , 1 (2), 2002
Arkansas	2002	Bullock, D. W., et al.	Enhancing the Student-Instructor Interaction Frequency	<i>The Physics Teacher</i> , 40 , 535-541, 2002.

Members of the project have given over 260 presentations to local, regional, and national audiences. Selected presentations by PhysTEC participants are available at: www.PhysTEC.org/presentations.

APPENDIX C: PTEC MEMBERSHIP AS OF JUNE 16, 2009

Anderson University
 Andrews University
 Angelo State University
 Arizona State University
 Ball State University
 Bemidji State University

Boise State University
 Boston University
 Bridgewater State College
 Brigham Young University
 Brigham Young University Idaho
 Buffalo State

California Polytechnic State University, Pomona	Michigan State University
California Polytechnic State University, San Luis Obispo	Middle Tennessee State University
California State University, Chico	Millersville University
California State University, Sacramento	Misericordia University
California University of Pennsylvania	Morningside College
Calvin College	National Superconducting Cyclotron Laboratory
Casper College	North Carolina State Univ
Chatham University	North Georgia College and State University
Chicago State University	Northwestern Oklahoma State University
Colgate University	Oklahoma State University
Cornell University	Oranim Academic College
DePaul University	Oregon State University
Dodge City Community College	Pacific University
East Central University	Pennsylvania State University
Eastern Illinois University	Radford University
Elon University	Randolph College
Emporia State University	Rensselaer Polytechnic Institute
Fairmont State University	Rutgers, the State University of New Jersey
Florida International University	Saint Joseph's University
Fort Hays State University	Saint Mary's College
Francis Marion University	San Jacinto College Central
George Washington University	Seattle Pacific University
Georgia State University	Slippery Rock University
Hamline University	South Dakota State University
Hillsdale College	Southern Oregon University
Hiram College	Spelman College
Hofstra University	SUNY Fredonia
Hope College	Tennessee Technological University
Illinois State University	Texas A&M University-Commerce
Indiana University of Pennsylvania	Texas Southern University
Jackson State University	Texas State University-San Marcos
Jacksonville State University	Towson University
James Madison University	Trinity Christian College
Johns Hopkins University	Tufts University
Johnson C. Smith University	University of Alabama
Kansas State University	University of Alabama Birmingham
Kennesaw State	University of Arizona
King College	University of Arkansas
Lincoln University	University of California, Davis
Lone Star College-North Harris	University of Colorado at Boulder
Loyola College in Maryland	University of Connecticut
McNeese State University	University of Hawaii at Hilo
Medaille College	University of Houston
	University of Illinois

University of Kentucky
University of Louisville
University of Maine
University of Maryland, Baltimore County
University of Maryland, College Park
University of Michigan- Dearborn
University of Minnesota
University of Missouri-Columbia
University of Missouri-Rolla
University of Montana
University of Nevada Las Vegas
University of Nevada Reno
University of North Carolina-Asheville
University of North Carolina-Chapel Hill
University of Northern Colorado
University of Northern Iowa
University of Notre Dame
University of Pittsburgh
University of Pittsburgh at Greensburg
University of San Diego

University of South Dakota
University of Southern Indiana
University of Southern Mississippi
University of Tennessee
University of Texas at Austin
University of Texas at El Paso
University of Washington
University of Wisconsin-Madison
University of Wisconsin-Stevens Point
University of Wisconsin-Whitewater
Weizmann Institute of Science
West Virginia State University
Western Kentucky University
Western Michigan University
Wheeling Jesuit University
Winona State University
Winston-Salem State University
Women's Christian College
Wright State University
Xavier University of Louisiana