

Executive Summary

This report documents the activities of the PhysTEC project during its seventh year (August 1, 2007 to July 31, 2008). 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 involving 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 high school physics teachers graduating from their programs, in some cases by a factor of 10;
- Using master teachers to develop bridges between their physics departments, education schools, and local K-12 school districts, and provide critical mentoring support to new graduates;
- Transforming content and pedagogy courses for future physics and physical science teachers to promote learning through interactive engagement;
- Securing continuing allocation of substantial departmental and institutional resources for teacher preparation programs;
- Measuring project outcomes and disseminating results through publications, presentations, and workshops.

The project also includes the Physics Teacher Education Coalition (PTEC), which currently includes 110 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, and activities at prominent national meetings. The project recently launched two additional major research and dissemination efforts: the National Task Force on the Professional Preparation of Teachers of Physics, and a book of collected papers on teacher preparation.

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](#)) currently graduate approximately 8% of all new high school teachers of physics¹ from about 1.5% of the institutions that offer physics majors. 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. Of those teachers whom the project has succeeded in tracking, over three-quarters are teaching in a K-12 school. PhysTEC has also influenced 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. The Teacher-in-Residence program and Teacher Advisory Groups have created authentic collaboration 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 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 recruit⁵ and among the most difficult to retain.⁶ 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.⁷ In addition,

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 North Central Regional Education Laboratory (NCREL). “*Teacher Turnover in the Midwest: Who Stays, Leaves, and Moves?*” Policy Issues No. 10 (2001).

⁷ Neuschatz et al.

many states such as Texas⁸ have adopted laws requiring students to take four years of science.

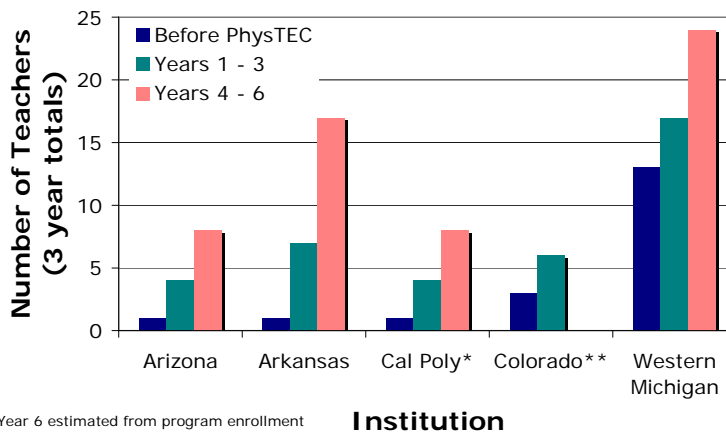
Legislation of this type, while addressing the need for a technologically literate workforce and citizenry, begs the question of who will teach these students.

1.1.1 Secondary Teacher Graduation Rates

PhysTEC institutions committed to increasing the number of graduating physics teachers⁹ have been successful in meeting that

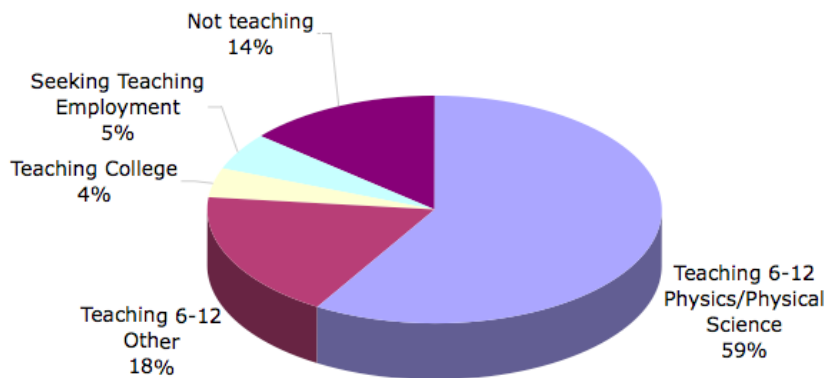
goal. In several cases, the increase was about a factor of 10. While the absolute numbers may seem small, they indicate the potential impact PhysTEC reforms could have if implemented broadly. Each year U.S. schools hire about 1200 new physics teachers, and only about 400 of these have a physics degree.¹⁰ If a fraction of the nearly 800 institutions that grant a physics bachelor's degree make similar increases, this will greatly increase the number of qualified physics teachers in the U.S.

Increase in Physics Teachers Educated at PhysTEC Institutions



*Year 6 estimated from program enrollment
 **Became a PhysTEC site in 2004

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,

⁸ Texas House Bill 1, 79th Legislature, 3rd Called Session, (2006).

⁹ 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 is not yet available.

¹⁰ Neuschatz et al.

82% of these graduates are currently teaching in K-12 schools or seeking teaching employment, 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.^{11,12,13} Because the craft of teaching takes many years to master, it is critical to not only prepare teachers well, but to support them and keep them in the classroom. As most PhysTEC teachers have only been in the classroom for one to three years, the project cannot yet present conclusive results on the retention of its teachers, but we are tracking project graduates in order to assess the effects of PhysTEC on teacher retention.

1.2 Elementary Teacher Preparation

Several PhysTEC institutions have adopted research-based 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 future elementary teachers. At Arkansas, Cal Poly, Colorado, and Towson, one of these courses is required for all elementary education majors, and 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](#)). The goal of these efforts is to better prepare elementary teachers to teach science lessons, to encourage them to teach as many as are allowed by local curricula guidelines, and to make these lessons inquiry-based and interactive. 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 3,000 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 detail and links to strategies and resources for implementing each one, see www.PhysTEC.org/components.

¹¹ NCREL op. cit.

¹² M. Neuschatz, M. McFarling, and S. White. *Reaching the Critical Mass*. American Institute of Physics (AIP), 2008. Highlights available at <http://www.aip.org/statistics/trends/highlite/hs2/hshigh.htm>.

¹³ R. Ingersoll and J. Kralik, [The Impact of Mentoring on Teacher Retention: What the Research Says](#), Education Commission of the States, 2004.

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).

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 and Teachers-in-Residence visiting introductory courses to promote the teaching profession and inform students whom to contact for more information. The introductory course can also be an excellent recruiting tool, when taught by an instructor who can model excellent teaching and engage his or her students. A strongly supported early teaching experience can excite students who hadn't 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.

1.3.2 Teachers-in-Residence

Over the course of the project, 41 Teachers-in-Residence (TIRs) have served at PhysTEC institutions. TIRs are master teachers whom the PhysTEC sites “borrow” for one or more years from their local school districts, to help build a bridge between the university and the classroom. 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 the University of Arkansas, Cal Poly San Luis Obispo, and Towson University, have dedicated institutional funds to sustain a TIR position after project funding ended. In addition, Seattle Pacific University funds a TIR through a grant from the Boeing Corporation, and this individual participates in PhysTEC activities and interacts frequently with project participants.

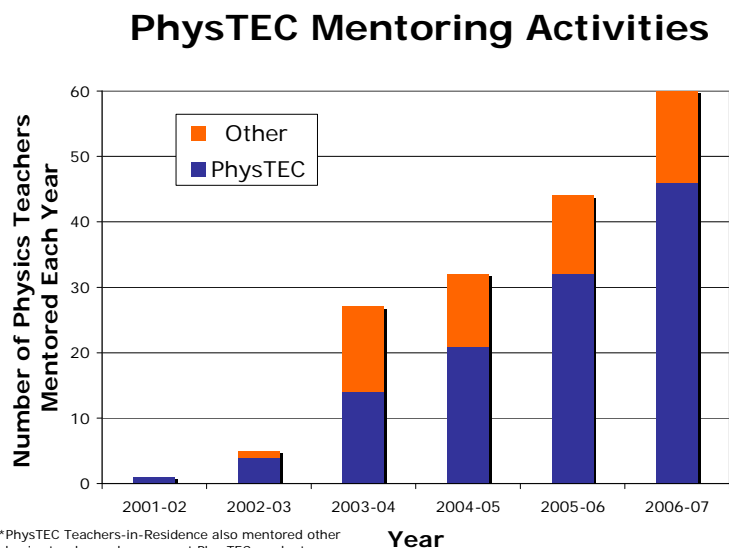
Seattle Pacific is also using part of its PhysTEC funds to hire a “Visiting Master Teacher” (VMT). The VMT is a part-time position that fills some of the roles of a traditional TIR. PhysTEC and Seattle Pacific are evaluating the potential benefits of the VMT position for smaller institutions that may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

Exemplary contributions of TIRs to the PhysTEC project include:

- Development of pedagogy courses for 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 talk sessions at national meetings
- Numerous publications

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 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

At PhysTEC institutions, introductory physics courses 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 (See [Section 1.6](#) for more information). 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 R. R. Hake.

been carefully designed to avoid many pitfalls that home-cooked curricula may fall into. Our 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 17,000 students have taken reformed courses in algebra- and calculus-based physics at PhysTEC institutions, and over 3,000 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 significant impact for many years.

1.3.5 Assessment

PhysTEC leaders recognize the need to gather data on the project, both in order 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. Current project assessment initiatives include studies of

- the quality of teachers who graduate from project institutions, using both content assessment and pedagogy assessment instruments;
- the career outcomes and retention rates of teachers who graduate from project institutions; 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 inservice 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.

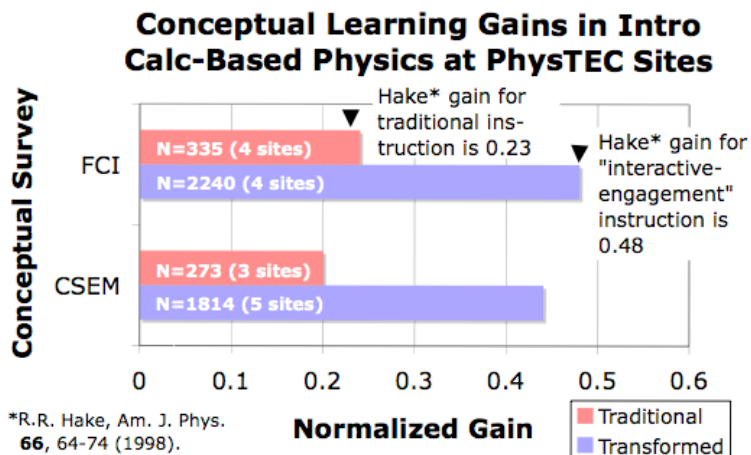
1.3.5.1 Content Assessment

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

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

and ensure that course reforms are effective. The graph 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.

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 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 in fall of 2006 (see [Section 3.1.2.3](#)). 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.

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/index.htm.

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

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. 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.
- 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.

All five 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 as well. 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, 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.

The linchpin of collaborative efforts at many 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 be able 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 TAGs, which can advise faculty on how to improve their teacher preparation programs. TAGs can 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.

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 PhysTEC, and they 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 [Section 2.3](#).

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 five currently funded sites and seven “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 March and the AAPT Summer Meeting in 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
Seattle Pacific University	Seattle, WA	2006-2009
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
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

The currently funded PhysTEC institutions were brought into the project in two stages. Seattle Pacific University came on board in August 2006 for a three-year term, at a lower level of funding than other sites receive. In October 2006, PhysTEC solicited applications for new PhysTEC sites that would also 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. 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.

Seattle Pacific University is a fairly small (around 3000 students), four-year, liberal-arts institution. As a result, it has the potential to serve as a model for teacher preparation programs at liberal arts institutions around the country. It also differs from most project sites in that its TIR is funded by external sources (Boeing Corporation) rather than by PhysTEC, and has a somewhat different role from the traditional PhysTEC TIR. Like many PhysTEC sites, Seattle Pacific has made a 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 develops professional development software for teachers.

Florida International University (FIU) in Miami, Florida 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. There appears to be strong potential for collaboration between PhysTEC and FIU's Center for High-Energy Physics Research, Education, and Outreach (CHEPREO) project, 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. Florida International 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, one of the largest school districts in the country.



Florida International professor Laird Kramer and students study the results of a momentum experiment.

The 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, and as of this writing involves primarily the Department of Physics and Astronomy and the Department of Biology. Project leaders hope to expand the program to include Geological Sciences, Chemistry, and Mathematics, and to graduate their first physics teacher in 2009. In addition, 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 hoping to implement further reforms in introductory physics courses, including a classroom based on North Carolina State University's NSF-funded SCALE-UP program.

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 firsthand 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. Site leader Rob Thorne and Teacher-in-Residence Marty Alderman are collaborating with students at Cornell's Johnson Graduate School of Management to develop a webpage with recruitment resources to share with institutions around the country and beyond. Alderman has also used old-fashioned one-on-one conversation to attract record numbers of physics majors to School of Education recruiting sessions for future teachers. Their Learning Assistant program launched with eight undergraduates in spring 2008.

University of Minnesota project leaders are driving forces behind a number of unique outreach programs, including a physics road show, *The Physics Force*, and a program for minority students and their parents called Parents and Children Experiencing Science (PACES). Site leader Cindy Cattell and 2007-2008 Teacher-in-Residence Nancy Bresnahan used these programs to promote teaching physics as a rewarding career, both to University of Minnesota undergraduates and to middle and high school students. In addition, they have developed a program that incorporates Learning Assistants into lecture classes in a novel way. With one of the largest undergraduate student bodies in the U.S., Minnesota has tremendous potential to recruit and prepare significant numbers of teachers.

2.2 Legacy Institutions

The initial PhysTEC site solicitation occurred in 2001, from which six initial 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 State University 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 has concentrated on the improvement of middle school science teacher education, the reform of the introductory algebra-based physics courses taken by these students, and the development of an effective induction and mentoring program for newly certified physics teachers. As a result of Ball State's mentoring efforts, they have 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 doctoral candidate who is an experienced physics teacher, and who assumes many of the roles the TIRs took on during the course of the project, as well as the addition of a permanent PER faculty line. 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.

California Polytechnic State University, San Luis Obispo completed its PhysTEC funding period in 2006-2007. The goals of Cal Poly's project were to develop and assess sustainable course reforms, increase collaboration with the local school districts through a Teacher Advisory Group (TAG), and secure institutional funding for on-campus TIRs. Cal Poly now has one university-funded TIR, who is starting her fifth year in the position. Project leaders have also developed "day-by-day plans" for introductory calculus-based courses and the physical science for elementary education majors, to allow interactive course reforms to be sustained regardless of the particular instructor teaching a given course. Faculty and TIRs also worked with local teachers in the TAG to develop and evaluate observation instruments to use in the introductory pedagogy course

Towson University's PhysTEC program is unique within the project in that it supports only elementary science education. Towson graduates about 200 elementary education majors a year (more than any other school in Maryland), and its PhysTEC efforts have focused on reforming the field experience course these students take to foster inquiry teaching, maximize contact time with elementary students, and provide mentoring and opportunities for self-reflection. In order to support the course reforms, the Towson project has also developed training and networking workshops and flexible curricular resources for both classroom mentor teachers and part-time course instructors. Using surveys and a classroom observational instrument based on the National Science Education Standards, 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



Towson University professor Cody Sandifer works with a future elementary teacher.

become a major player in secondary physics teacher preparation as well, and project co-leader Cody Sandifer has already started a Learning Assistant program after attending the PTEC workshop ([see Section 3.1.2.3](#)) in Colorado last fall. The physics department is hiring a tenure-track faculty member to improve the secondary physics teacher preparation program and recruit more undergraduates to teaching.

The 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 nearly perfect retention rate. The project leader has conducted extensive outreach to the local teacher community in developing the program, including establishing an active TAG and involving teachers in curriculum development for pedagogy courses. Arizona's program is now a well-established entity on campus, and its future is secure. The funding that supports two adjunct instructor positions is guaranteed through 2011, and may be renewed for an additional ten years after that. 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.

The 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 the early years of their professional lives. Arkansas also has a counterpart program to the Learning Assistants model at the University of Colorado that has played a significant role in recruitment and retention of new teachers. Course reforms in the calculus-based introductory sequence have proven quite 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 enjoyed 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 the graduate dean and the Physics Department have agreed to cost-share two positions for Master of Arts in Teaching students.

The University of Colorado at Boulder has 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 ([see Section 3.1.2.3](#)). This program allows students to experience the positive aspects of teaching, and serves as a recruitment tool into the teacher certification process. 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 post scores on commonly used content assessments that are similar to those posted by

typical first-year graduate students.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 far 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. Western Michigan has focused its PhysTEC efforts on reforming its introductory 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 higher gains on concept assessments than do traditionally taught courses. Western Michigan project leaders also report that although they did not set out with this goal, 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 on-going efforts in teacher education, Western Michigan made a decision during the project to hire a tenure-track faculty line in physics education research. Charles Henderson now holds this position.

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

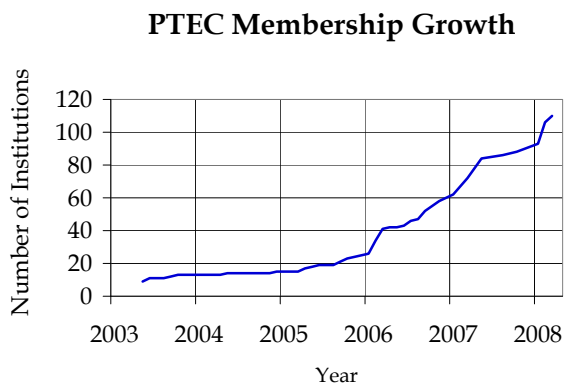
- Build a network of institutions engaged in reforming physics teacher education;
- Promote and disseminate successful programs, methods, and ideas; and
- Advocate nationally for improving science teacher education.

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).

3.1.1 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 110 member institutions – up from 86 in July, 2007. The project is pleased to have attracted such widespread interest, and 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 graph at left shows growth in PTEC membership over the past five 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

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, plenary speakers during lunch breaks, and opening and closing sessions. The project works hard to ensure that all workshops provide opportunities for participant engagement, and that the conference schedule also provides ample time for attendees to interact with each other outside of programmed sessions. The above table shows conference locations and attendance.

Table 2. PTEC Conference Attendance

Year	Location	Attendance
2005	Muncie, Indiana	82
2006	Fayetteville, Arkansas	85
2007	Boulder, Colorado	112
2008	Austin, Texas	117

The 2008 Conference took place on February 29th and March 1st at the Omni Southpark Hotel in Austin, Texas. For the second straight year, the conference attracted a capacity crowd of around 120 physics and education faculty, administrators, teachers, and students, who soaked up two packed days of one-and-a-half-hour workshops led by national experts on master teachers, assessment and evaluation, curriculum and teaching methods, and institutional partnerships. We received very positive feedback on the conference from participants, with nearly everyone who responded to our evaluation survey telling us that the event met or exceeded their expectations.



Helen Quinn (Stanford Linear Accelerator Center), Stamatis Vokos (Seattle Pacific University), and Valerie Otero (University of Colorado at Boulder) have an animated discussion at the 2008 PTEC Conference.

Responses to the question about the most valuable aspect of the conference were split between the workshops themselves, and the opportunities to network with colleagues. The ideas that participants reported being most excited to try at their home institutions included Learning Assistant programs, assessment ideas, specific teacher preparation strategies such as Teachers-in-Residence or induction and mentoring support, and specific curricula or interactive teaching methods they learned about at the conference. Online proceedings from this conference are available at www.ptec.org/conferences/2008/workshops.cfm.

The 2009 Conference will take place in Pittsburgh on March 13th and 14th, 2009. The theme will be Institutional Transformation.

3.1.2.2 Regional Conferences

On August 3, 2007, the project held the first regional PTEC conference in Chapel Hill, North Carolina, for institutions in University of North Carolina system. The conference was inspired by the UNC system President Erskine Bowles' call to action on science teacher preparation. Faculty from 14 out of 16 institutions in the UNC system attended presentations by Ted Hodapp of APS, Eugenia Etkina of Rutgers University, Valerie Otero of Colorado, Paul Hickman of the PhysTEC project, and Jill Marshall of the University of Texas at Austin. Participants then spent the last two hours of the meeting developing action plans to implement at their schools. The agenda and materials are available at www.ptec.org/conferences/NC07 for all participants.

The project intends to hold future regional meetings to catalyze change in other states with large university systems, and in regions where the project has connections that it hopes to leverage into significant action on teacher preparation. Currently planned are a Fall 2008 conference in Seattle for institutions in the Pacific Northwest, and a Spring 2009 conference in the Minnesota/Wisconsin area for institutions in the upper Midwest.

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 (see [Section 1.3.5.2](#)), 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 Hickman, and drew 21 faculty members and master teachers from PTEC institutions around the country. During this workshop attendees worked in pairs to evaluate videos of physics instruction. The 14 videos that were evaluated had been produced by PhysTEC institutions by recording classes taught by their pre-service teachers, graduates, and

faculty. The settings included labs, tutorials, and lectures. The workshop participants rated it a success, and nearly unanimously reported confidence in their abilities to effectively observe and score their teachers. In addition, the spread of scores assigned to identical videos decreased significantly after a single analysis session, giving the project confidence in its ability to improve inter-rater reliability for different RTOP scorers.



Colorado education professor Valerie Otero works with two Learning Assistants during the PTEC Learning Assistant Workshop.

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 they will need to implement a Learning Assistant program on their own campuses. The workshop program consisted of sessions focusing on various aspects of the Colorado program. Workshop participants also had several opportunities to interact directly with Learning Assistants, including a question-and-answer session, a chance to attend the weekly pedagogy course

that all first-year Learning Assistants take, and a visit to one of the recitation sections in which Learning Assistants work with undergraduates. Participants provided positive feedback on the workshop, and indicated they found it very useful to be able to see the Learning Assistants in action and interact with them. Many expressed the desire for follow-up workshops and online resources for institutions with Learning Assistant programs, and a survey we recently conducted indicates that as a result of attending the workshop, several have either started or modified existing Learning Assistant programs on their campuses, or have plans to do so.

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. We presented the PTEC booth for the first time in the exhibition hall at the 2007 AAPT Summer Meeting in Greensboro, North Carolina. Since then we have taken it to the 2008 AAPT Winter and Summer Meetings in Baltimore and Edmonton, as well as the 2008 APS March and April Meetings in New Orleans and Saint Louis, and the Coalition for National Science Funding exhibition and reception in June, 2008.²⁵ 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 Baltimore meeting, and an interactive poster session entitled “Physics Teacher Preparation Around the U.S.” (with 15 invited and contributed

²⁵ No federal funds were used for this event.

posters) at the Edmonton Meeting. Future plans include an interdisciplinary symposium on teacher preparation at the 2009 joint AAPT/AAAS Winter Meeting in Chicago. Project Management Team members Ted Hodapp and Paul Hickman gave talks in Edmonton (see <http://PhysTEC.org/presentations/index.php>), and a number of PhysTEC Teachers-in-Residence presented their experiences at the session “How do Master Teachers Help Prepare Teachers of Physics?”

3.2 Online dissemination

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

3.2.1 PhysTEC website

The PhysTEC website (www.PhysTEC.org) was redesigned in Fall of 2007. The goals were to improve both the utility of the site and the reporting of project results. Project leadership identified ten “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 received nearly 2,000 visits in May 2008 alone.

3.2.2 PTEC Website

The PTEC website – www.ptec.org – is a collaboration with ComPADRE to develop a collection devoted to physics and physical science teacher preparation – the Physics Teacher Education Coalition Digital Library (PTEC-DL). ComPADRE, an NSF-funded AAPT/AIP/APS/American Astronomical Society (AAS) partnership, is a digital library of resources for physics and astronomy education. Currently the project is working with the collection editor John Stewart to highlight the 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 institution profiles](#);
- Teacher education news and announcements;
- A [national map](#) of professional development opportunities for physics teachers.

3.2.3 Listservs

The project manages several listservs that provide opportunities for discussions and announcements about teacher preparation. The AAPT Committee on Teacher Preparation listserv has 328 members and frequently serves as a forum for lively conversations about topical issues in the teacher preparation community. Other listservs, including ones for PhysTEC site leaders and PTEC members, serve mostly to help disseminate announcements for events such as the

PTEC Conference. Teachers-in-Residence post monthly journal responses to a TIR listserv that helps build the TIR community.

3.3 National Task Force on the Professional Preparation of Teachers of Physics

The joint AAPT/AIP/APS National Task Force on the Professional Preparation of Teachers of 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 a drastic improvement in pre-college science education, and to the national debate on accountability in pre-college 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 agenda 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 will collect and analyze data, conduct site visits to nationally recognized institutions with exemplary physics teacher education programs, and 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.

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 Spring of 2008 the project published the first edition of its newsletter [PhysTEC News](#). The goal of this publication was to create a high-quality piece of publicity material to represent the project to sponsoring society board members, university administrators, donors, and future project partners. We have given the newsletter to the APS and AAPT Executive Boards, and

mailed it to all PTEC and PhysTEC institutions as well as targeted physics chairs of institutions that we 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 of 2008, and annually thereafter.

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 be the first of its kind, and will include new reports reflecting cutting-edge research and practice, as well as a few selected reprints of seminal papers. The book editors have received approximately 35 prospectuses for articles to be included in the book, and are in the process of reviewing the submissions and working with the authors to prepare them for publication. Printed copies will be distributed to chairs of all physics departments in the United States, and the book will also be freely available online. For more information, please see www.ptec.org/features/newsDetail.cfm?id=139.

3.4.3 APS Forum on Education (FEEd) Newsletter

John Stewart (University of Arkansas) is the editor of the Section on Teacher Preparation of the APS [Forum on Education Newsletter](#). This newsletter is distributed electronically to over 4000 APS members and freely available on the web. The *Newsletter* has published articles by PhysTEC participants from a number of project institutions, including Arizona, Arkansas, Ball State, Cal Poly, Colorado, Seattle Pacific, Towson, and Western Michigan. The Summer 2007 edition includes an article by Seattle Pacific's joint physics-education faculty member Eleanor Close. The Spring 2008 edition includes articles by Ball State project leaders David Grosnick and James Watson, and by Towson project leaders Laura Lising and Cody Sandifer entitled. The Summer 2008 edition includes the first articles on new PhysTEC sites, by North Carolina project leader Laurie McNeil and Florida International project leaders Laird Kramer, Eric Brewes, and George O'brien.

3.4.4 APS News

The project publishes articles periodically in *APS News*, APS's monthly newsletter that goes out to its 46,000+ members. *APS News* ran an article in April 2008 on the previous month's [PTEC Conference](#), and one in February 2008 on the [Colorado Learning Assistant Workshop](#). An article on Towson's PhysTEC project will appear in the August/September 2008 edition.

3.5 Collaborations

Recognizing that educating the next generation of physics teachers is a large and interdisciplinary task, the PhysTEC project seeks broad collaborations with a wide range of partnering organizations and efforts. This was well represented at the 2008 PTEC Conference, which featured a full-day workshop on the University of Texas' UTeach program as well as special sessions led by representatives of the National Association of State Universities and Land-Grant Colleges (NASULGC). Also present was the director of education for the American

Chemical Society, with which the project is continuing to work to broaden efforts to prepare science teachers. The project has also held discussions with Teach for America and the math teacher recruitment project Math for America about possible joint efforts. While keeping its focus on physics and physical science teachers, PhysTEC recognizes the necessity 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* (2004-2008), 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.
- **Charlie Holbrow**, *co-PI* (2008), Executive Officer, American Association of Physics Teachers. Holbrow replaced former AAPT Executive Officer and co-PI Toufic Hakim.
- **Jack Hehn**, *co-PI* (2001-2008), 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 activities of the External Evaluator (The Momentum Group, Inc.) in formative evaluation efforts. Hehn has been involved in the effort to develop the joint task force on the preparation of teachers of physics.
- **Monica Plisch** (2007-2008), Assistant Director, Education, American Physical Society. 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.
- **Warren Hein**, *co-PI* (2005-2007), Associate Executive Officer, American Association of Physics Teachers. Hein was 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.

- **Gabriel Popkin**, *Project Manager* (2007). Popkin manages many of the day-to-day operations of PhysTEC, including communicating with project partners, managing project and budgetary data, and drafting major project documents.
- **Edward Lee**, *Project Associate* (2001-2007), American Physical Society. Lee's responsibilities include editing documents and participating in Project Management Team meetings.
- **Paul Hickman**, *TIR and Mentoring Consultant* (2005-2007). Hickman is responsible for coordinating TIR activities, and participates in Project Management Team meetings.
- **David Meltzer**, *Assessment Consultant* (2007-2008). Meltzer is the editor of the forthcoming teacher preparation book, and leads many aspects of the PhysTEC project assessment effort.

A.1.2 Past Members

- **John Layman**, *co-PI* (2001-2005) retired, Professor Emeritus at the University of Maryland. Layman participated in site visits. He led the effort and program to establish the TIR group, and helped in organizing two previous annual 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.
- **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 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**, Faculty Emeritus, Lawrence Berkeley National Laboratory, *Chair* (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**, Emeritus Professor, Department of Physics, The Ohio State University (2001-2007)
- **Lillian McDermott**, Professor, Department of Physics, University of Washington (2001-2007)
- **Jill Marshall**, Assistant 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)
- **George "Pinky" Nelson** (Western Washington University)
- **Valerie Otero** (University of Colorado at Boulder)
- **Mary Ann Rankin** (University of Texas at Austin)

APPENDIX B: PHYSTEC PUBLICATIONS

B.1 Project Management Team (PMT) Publications

Year	Author	Title	Citation
2008	Popkin, G.	Towson PhysTEC project targets elementary science teaching	<i>APS News</i> , August/September 2008.
2008	Popkin, G.	2008 Conference: "Master Teachers: Change Agents for Teacher Preparation"	<i>APS Forum on Education Newsletter</i> , Summer 2008.
2008	Plisch, M.	Contributing to Teacher Preparation through "Broader Impacts" Activities	<i>APS Forum on Education Newsletter</i> , Summer 2008.
2008	Hickman, P., Isola, D.,	Using Formative Assessment and Feedback to Improve Science	<i>Assessing Science Learning: Perspectives from Research and</i>

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

B.2 PhysTEC Institution Publications

Institution	Year	Authors	Title	Citation
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.

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.
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.
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.
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	2008	Stewart, G., Stewart, J.	Pressures Lowering the Educational Value of Introductory Science Courses	<i>Cell Biology Education</i> , Winter 2008 (Accepted).
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> (Accepted).
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).
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> .
Arkansas	2004	Stewart, G.	Practicing What I Preach.	<i>APS Forum on Education Newsletter</i> , Summer 2004.
Arkansas	2002	Bullock, D. W., et al.	Enhancing the Student-Instructor Interaction Frequency	<i>The Physics Teacher</i> , 40 , 535-541, 2002.
BSU	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.
BSU	2005	Grosnick, D.	An Advisory Group to Provide Input in the Preparation of Future Teachers	<i>APS Forum on Education Newsletter</i> , Spring 2005.
BSU	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.
BSU	2004	Smith, W.	Data Mining the Internet: Immersing High School Students in Electronic Inquiry	<i>Science Activities</i> , 41 (1), 9-15, 2004.
BSU	2004	Smith, W.	Using Internet Technology to Address National Science and Teacher Education Standards	<i>The Teacher Educator</i> , 39 (2), 144-156, 2004.
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	2008	Finkelstein, N. and Pollock, S.	Sustaining Educational Reforms in Introductory Physics	<i>Physical Review, Special Topics: PER</i> , in press.
Colorado	2007	Price, E., Finkelstein, N.	Preparing Graduate Students to be Educators	<i>American Journal of Physics</i> (in press).
Colorado	2007	Kohl, P., Finkelstein, H. Rosengrant, D.	Strongly and Weakly Directed Approaches to Teaching Multiple Representation Use in Physics	<i>Physical Review</i> (in press).
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.
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.
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.
FIU	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.
FIU	2008	Jones, D.	Join a Physics Teaching Community.	<i>The Physics Teacher</i> . 46 , 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.
SPU	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	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.
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.
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.
WMU	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.
WMU	2007	Isola, D., Olsen, J.	A Quiet Revolution in Preparing Future Teachers of Physics	<i>APS Forum on Education Newsletter</i> , Spring 2007.

Members of the project have given over 260 presentations to local, regional and national

audiences. Selected presentations by PhysTEC participants are available at:
<http://www.PhysTEC.org/presentations>.

APPENDIX C: PTEC MEMBERSHIP AS OF JULY 1, 2008

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
California Polytechnic State University, San Luis Obispo
California State University, Chico
California State University, Sacramento
California University of Pennsylvania
Casper College
Colgate University
Cornell University
DePaul University
East Central University
Eastern Illinois University
Elon University
Emporia State University
Fairmont State University
Florida International University
Fort Hays State University
Francis Marion University
George Washington University
Hillsdale College
Hiram College
Hofstra University
Hope College
Illinois State University
Indiana University of Pennsylvania
Jacksonville State University
James Madison University
Kansas State University
Kennesaw State

King College
Lone Star College-North Harris
Loyola College in Maryland
McNeese State University
Middle Tennessee State University
Millersville University
Misericordia University
Morningside College
National Superconducting Cyclotron Laboratory
North Carolina State Univ
Northwestern Oklahoma State University
Oklahoma State University
Oranim Academic College
Oregon State University
Pacific University
Radford University
Rensselaer Polytechnic Institute
Rutgers, the State University of New Jersey
Saint Joseph's University
Saint Mary's College
San Jacinto College Central
Seattle Pacific University
Slippery Rock University
Southern Oregon University
Spelman College
Tennessee Technological University
Texas A&M University-Commerce
Texas Southern University
Texas State University-San Marcos
Towson University
Tufts University
University of Alabama
University of Alabama Birmingham
University of Arizona
University of Arkansas
University of California, Davis
University of Colorado at Boulder
University of Connecticut
University of Houston
University of Kentucky
University of Louisville
University of Maine
University of Maryland Baltimore County
University of Michigan-Dearborn
University of Minnesota

University of Missouri-Columbia
University of Missouri-Rolla
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 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
Western Kentucky University
Western Michigan University
Winona State University
Winston-Salem State University
Wright State University
Xavier University of Louisiana