

Executive Summary

This report documents the activities of the Physics Teacher Education Coalition (PhysTEC) project in the second year of its second round of funding (August 1, 2010 to July 31, 2011). The mission of PhysTEC is to improve and promote the education of future physics and physical science teachers. Specifically, the project aims to

- Demonstrate successful models for
 - Increasing the number of highly qualified high school physics teachers;
 - Improving the quality of K-8 physical science teacher education;
- Spread best-practice ideas throughout the physics teacher preparation community;
- Transform physics departments to engage in preparing physics teachers.

PhysTEC is a partnership between the American Physical Society (APS) and the American Association of Physics Teachers (AAPT). The project is funded primarily by the National Science Foundation, and has also received significant funds from the APS's 21st Century Campaign, as well as direct and in-kind support from each of its partner institutions.

PhysTEC funds selected universities to develop their physics teacher preparation programs into national models with substantial project support. Five newly selected sites will begin funding in Fall 2011, bringing the total number of supported sites to 22; in addition, one newly funded project that is not a traditional PhysTEC site will begin in Fall 2011. Supported sites have achieved a number of significant successes, including:

- Increasing the number of physics and physical science teachers graduating from their programs;
- 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 institutional resources to sustain program components;
- Disseminating results through publications and presentations at conferences and workshops;
- Raising the profile of teacher preparation efforts in the physics community.

The project also includes the PhysTEC Member Institutions, which as of this writing number 234. The project organizes an annual national conference, as well as smaller regional and topical workshops, for these members.

The project disseminates its results and reaches out to the physics community in a variety of ways, including newsletters, brochures, websites, videos, articles in a number of venues, activities at prominent national meetings, and regular status reports. The project is near completion on two additional major research and dissemination efforts: the report of 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.

1. Results

The PhysTEC project can report significant findings and results. The number of teachers graduating each year from PhysTEC institutions has greatly increased since the project began in 2001. Of those graduates for whom the project has current employment information, over three-quarters are teaching in a K-12 school. Sites have developed and refined models of recruiting, course transformation, early teaching experiences, induction, and mentoring. Teachers-in-Residence and Teacher Advisory Groups have helped to create authentic collaborations among physics departments, education schools, and local school districts.

Because of the great need for highly qualified secondary physics and physical science teachers in the US, 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: less than half of the 27,000 high school physics teachers in the U.S. have completed a major or minor in physics or physics education.¹ The severe shortage of qualified high school physics teachers is confirmed by superintendents and principals, who rate physics teachers among the hardest to recruit.² 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.³ In addition, many states such as Texas have adopted laws requiring students to take four years of science.⁴ Legislation of this type, while addressing the need for a technologically literate workforce and citizenry, begs the question of who will teach these students. The consequences of the shortage of secondary physics teachers showed up strongly in the results of the third Trends in International Mathematics and Science Study (TIMSS), where US high school graduates underperformed in physics relative to nearly all other countries surveyed.⁵

1.1 Secondary Teacher Graduation Rates

PhysTEC sites committed to increasing the number of graduating physics teachers⁶ have been successful in meeting that goal. 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.⁷ By contrast, every PhysTEC teacher is required to have a physics major, minor, or equivalent content preparation, and must have completed a teacher preparation program. If a significant

¹ S. White and C. Tesfaye, "Who Teaches High School Physics?", American Institute of Physics, 2010. Available online at <http://www.aip.org/statistics/trends/hstrends.html>

² *Educator Supply and Demand in the United States*, American Association of Employment in Education, Columbus, OH, 2008.

³ S. White and C. Tesfaye, *op cit*.

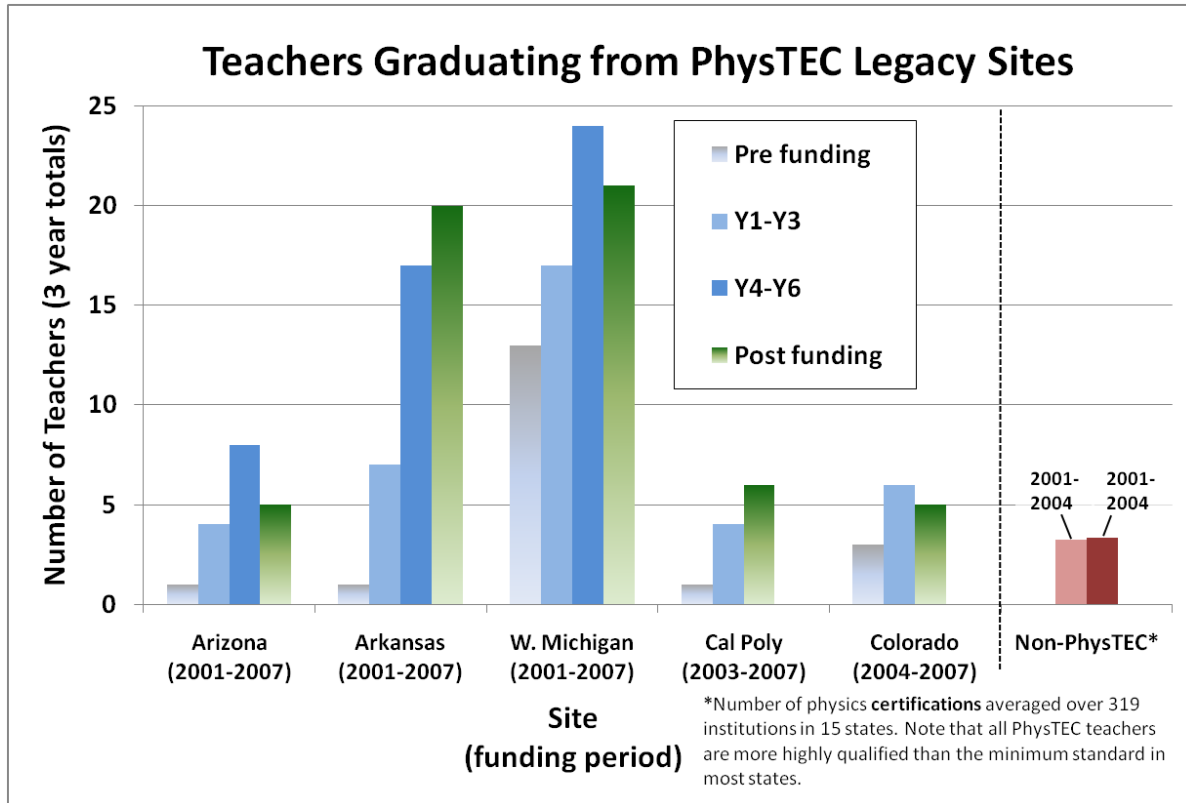
⁴ Texas House Bill 1, 79th Legislature, 3rd Called Session, 2006.

⁵ National Center for Education Statistics, "Highlights from the Third International Mathematics and Science Study," 1999.

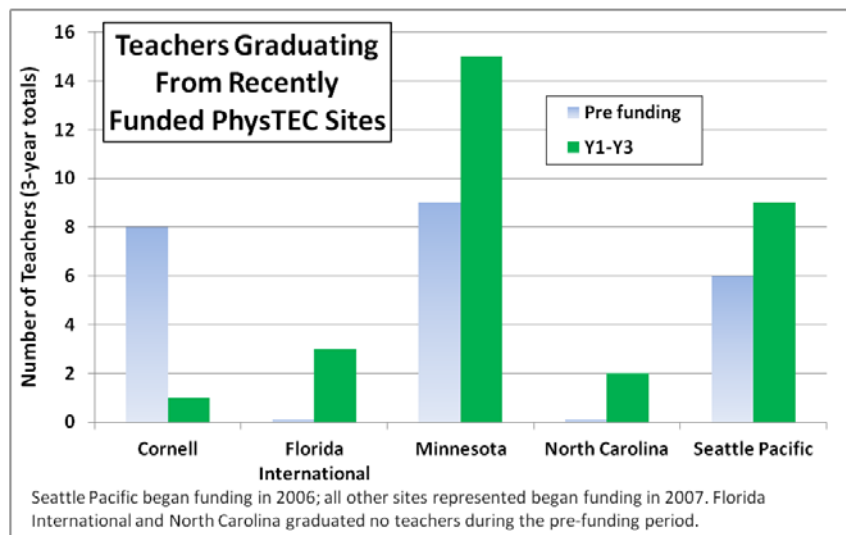
⁶ Ball State University focused its project on improving middle school teacher education and building mentoring programs. Towson University focused its first project exclusively on elementary teacher education. Data from sites beginning in 2010 are not yet available.

⁷ M. Neuschatz, M. McFarling, and S. White. *Reaching the Critical Mass*. American Institute of Physics, 2008. Available online at <http://www.aip.org/statistics/trends/hstrends.html>

fraction of the nearly 800 institutions that grant a physics bachelor's degree make similar increases to those made at PhysTEC institutions, this will answer the need for the number of qualified physics teachers in the nation's classrooms.



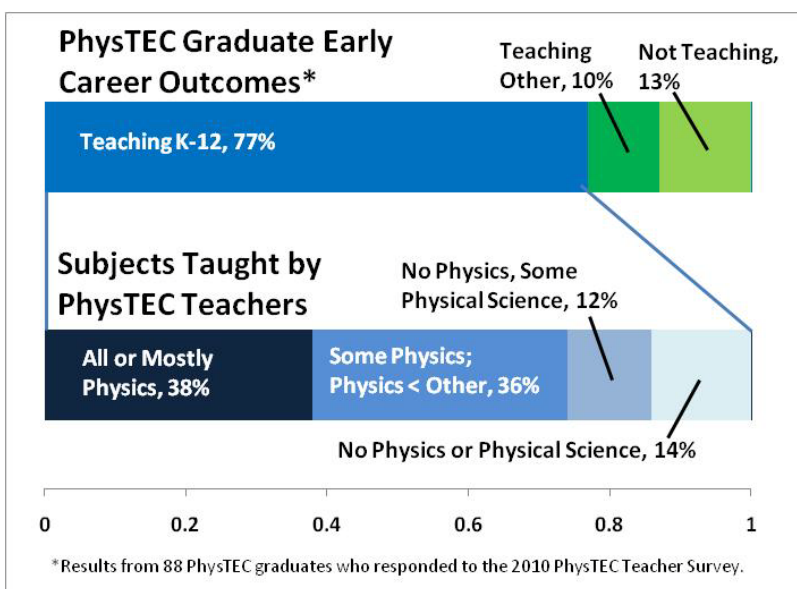
In the accompanying graphs, we divide PhysTEC institutions into “legacy sites” and “recently funded sites.” Legacy sites are those institutions for which we believe the numbers of graduates reflect the full effect of project reforms. Because many project components impact students in their freshman and sophomore years, their effects cannot be seen in the graduation data until as many as four years later, when these students graduate from bachelor’s or MAT programs. Thus, among legacy sites, we see graduate numbers in years 4-6 and the post-funding years that exceed those in years 1-3. Depending on the success sites have had in sustaining program components, graduate numbers may continue to grow in post-funding years.



Among recently funded sites, we see growth in the numbers of graduates at all but one institution, and we expect to see continued growth as programs mature and reach their full impact. Florida and North Carolina have both graduated their first teachers in recent memory under the PhysTEC project. The drop in teachers graduating from Cornell reflects a set of circumstances largely outside the control of project leaders, as most of the teachers who graduated in the pre-funding years were MAT candidates who did their bachelor's degrees elsewhere. Cornell also reports an increase in undergraduates in the physics teacher pipeline.

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. In 2010, PhysTEC sent a survey to all program graduates for whom it had up-to-date contact information. As shown in the graph, 77% of these graduates are currently teaching in K-12 schools, and another 10% are teaching at other levels. Most of those in K-12 schools are teaching physics and/or physical science. Other commonly taught subjects include math and chemistry.



1.2 Key Components

Successful physics teacher preparation programs share certain key components, and exist within a supportive institutional context. These contextual and programmatic components build on one another to provide teachers with a complete educational experience, from recruitment through early teaching experiences, training in pedagogy and content, to induction and mentoring.

This report will briefly discuss the components here; for greater detail and links to strategies and resources for implementing each one, see www.PhysTEC.org/components.

1.2.1 Recruitment

A strong recruiting effort at most PhysTEC sites begins on the first day of classes, with faculty members, Teachers-in-Residence, and future teachers visiting introductory courses to introduce themselves and encourage students to consider teaching. This has the effect of legitimizing teaching as a career option in the eyes of students. Some sites distribute and collect information cards to target students who may be interested in considering a teaching career. A number of sites have also created posters, brochures, and other recruitment materials and put them up around science buildings and other areas that students frequent. Several sites have held open houses for high school students and teachers, at which they promoted their teacher preparation program.

Introductory physics courses themselves also serve as important recruiting tools, provided the instructors model interactive, engaging teaching methods. Most PhysTEC sites have added undergraduate peer teachers called [Learning Assistants](#). These programs can engage students who had expressed no previous interest in teaching, and encourage them to consider a teaching career. (Follow link or see below for more detail.)

Effective teacher recruitment also depends on creating a program that encourages and supports future teachers throughout their education. Some sites have created a degree program that provides undergraduates a physics major and teaching certification in four years; others have created alternative degree and certification plans that allow students flexibility in completing their education. Good advising and mentoring throughout the program is crucial to retaining interested students. Scholarship support can also be critical. A number of PhysTEC sites have received awards through the NSF's [Robert Noyce Teacher Scholarship Program](#) to provide scholarships to future math and science teachers, in exchange for a commitment to teach in a high-need school after graduation.

In the last two years, site leaders at several sites have hired a marketing professional to help them develop targeted campaigns to recruit more physics majors and teachers. These sites are in the early stages of implementing the campaigns, and the project is eager to learn lessons on how to reach students who previously have not been engaged. North Carolina has developed a recruiting web page with the theme “Do Physics. Be Anything.” at www.physics.unc.edu/academics/UGrecruit.

The project has also developed several [videos](#) intended to help universities recruit physics teachers. These videos are freely available on the web to all universities, and are promoted at meetings.

1.2.2 Early Teaching Experiences

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. A well-designed early teaching experience can give freshmen or sophomores a low-pressure taste of the rewards and challenges of teaching. Project sites have offered a variety of early teaching experiences. Some have created programs that place preservice teachers into local public school classrooms early on; some of these are modeled after Step 1, the course that kicks off the UTeach Program's teacher preparation curriculum. Other sites have created in-house early teaching experiences in the form of Learning Assistant programs, which allow students to help educate their peers in undergraduate physics courses.

1.2.3 Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is subject-specific knowledge about teaching that includes student difficulties and prior conceptions, as well as content-specific instructional and assessment strategies. PCK has come to be recognized as a crucial element of what teachers need to be effective in the classroom. As the project moves forward, it will be placing greater emphasis on making sure funded sites include PCK training in courses that their future teachers

take. Sites with enough students in the program can offer a specialized course in PCK for physics teachers.

One program that is exemplary in emphasizing PCK is Rutgers University's teacher preparation program. On the strength of this program, Rutgers has become PhysTEC's first [endorsed site](#) (follow link or see below for more detail). In Spring 2010, PhysTEC organized a [topical workshop](#) on PCK at Rutgers for Coalition members.

1.2.4 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. By engaging students who had expressed no previous interest in teaching, 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, and data from Colorado show that Learning Assistants can improve learning gains of students in classes that use them.⁸

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 at many institutions are required to do so if they wish to continue as Learning Assistants.

All currently funded sites and most legacy sites have active Learning Assistant programs, and the idea is spreading beyond the PhysTEC community. In October of 2010, the project sponsored a two-day [topical workshop](#) at the University of Colorado at Boulder for faculty from Coalition institutions. A large fraction of the applicants to last fall's [request for proposals](#) included Learning Assistant programs in their applications, including all five of the selected sites.

1.2.5 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.⁹ 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

⁸ University of Colorado, "Learning Assistant Model for Teacher Preparation in Science and Technology (LA-TEST) Project Annual Report to the National Science Foundation, Year 4 Academic Year 2008-2009." <http://laprogram.colorado.edu/sites/default/files/reports/la-program-09-10.pdf> (Accessed 11 May 2011).

⁹ The MetLife Survey of the American Teacher: Expectations and Experiences, by Harris Interactive, 2006.

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 project has 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."

1.2.6 Champion

The champion is a change agent at the university who ensures program success. Typically, though not always, this is a tenured physics faculty member; the project has found that non-tenure track faculty members, lecturers, and emeritus faculty rarely have the clout necessary to effect change within a physics department. In addition, most physics departments do not have tenure and promotion structures that reward teacher preparation activities, so an untenured professor puts him- or herself at risk by devoting too much time to activities that do not count toward promotion.

In some cases, the champion may actively run the program; in other cases, the champion may take a less active role, but he or she advocates for the program and steps up when support is needed. A successful champion is usually part of a leadership team. The project has found that the most successful leadership teams include someone with physics education research expertise, and someone who is knowledgeable about the local school context. Education faculty members or Teachers-in-Residence may be best equipped to provide this expertise.

1.2.7 Teachers-in-Residence

Over the course of the project, 50 Teachers-in-Residence (TIRs) have served at PhysTEC institutions. TIRs are master teachers whom PhysTEC sites "borrow" from a local school for a year, 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 preservice teachers. After their service in the project, more than half of the PhysTEC 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. Several PhysTEC institutions, including Arkansas, Cal Poly, Florida International, and Towson, have dedicated institutional funds to sustain a TIR position after project funding ended.

Seattle Pacific, which received a lower level of funding than other Supported Sites, used 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. Based on the SPU model, the project is providing

funding for VMTs at PhysTEC Noyce sites to provide mentoring and support for Noyce scholars. The VMT may be an especially important model for smaller institutions.

A TIR can take on many roles, depending on the needs of the institution. Examples of roles played by TIRs in the PhysTEC project include:

- Leadership in recruitment efforts, including classroom visits, development of recruiting materials, and individual interactions;
- Development and teaching of pedagogy courses for Learning Assistants and future teachers;
- Coordinating and overseeing Learning Assistant programs;
- Advising and mentoring students within the program as well as teachers who have graduated from the program;
- Developing collaborative relationships between the physics department, education school, and local school districts;
- Creating and leading Teacher Advisory Groups with local teachers;
- Providing professional development workshops and courses on inquiry-based teaching;
- Giving talks at national meetings such as AAPT and NSTA;
- Writing articles for publication in venues such as the *APS Forum on Education Newsletter*;
- Assisting with student teaching placements.

Each summer, TIRs from past years contribute to the induction session of the new round of TIRs and pass along valuable knowledge and experience. Because it is the largest investment of the project, PhysTEC leaders have recognized the importance of “making the case” for TIRs, and communicating the unique value they provide to a teacher preparation program. For this purpose, the project assessment team has surveyed all TIRs and developed a TIR interview protocol that will inform a large-scale study of the TIR component of the project.

1.2.8 Collaboration

Collaboration between physics departments, education schools, and local school districts is essential to create a coherent and effective teacher preparation program. 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 physics degree and teaching certification. In some cases, this enables teachers to complete their undergraduate majors with certification in four years, thereby reducing the cost of their preservice education. A strong alliance with members of the College of Education has also helped Florida International site leaders bring science teacher preparation into the disciplinary departments. 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. Middle Tennessee State is also a UTeach replication site, and University of California, Davis has a similar program involving all science and math disciplines.

1.2.9 Institutional Commitment

Institutional commitment means internal financial support to sustain program elements, and intellectual and cultural support for those who choose to go into teaching. Physics teacher

education programs need support from physics and education faculty, chairs, and deans, as well as upper-level university administration.

PhysTEC has found that, for physics teacher education reform, the critical unit within a university or college is the physics department. Successful departments must recognize teacher preparation as part of their mission, and back this up by rewarding faculty for teacher preparation activities, encouraging and supporting students to pursue teaching careers, supporting course reform efforts, and, if possible, hiring faculty with education experience and interest. Education schools also have a key role to play, in collaborating with physics departments to make sure their programs meet the needs of future physics teachers. And support from the upper administration is critical. Many universities are recognizing that they have a critical role to play in addressing the need for more highly qualified science and math teachers, and have implemented institution-wide or even system-wide initiatives to prepare more of these teachers. PhysTEC has been working closely with the Association of Public and Land-grant Universities (APLU) to engage university administrators in this effort.

1.2.10 Assessment

PhysTEC leaders recognize the need to gather data, both to determine whether the project 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 by gathering and analyzing data on

- the degrees, career outcomes, and retention rates of teachers who graduate from funded institutions;
- the preparation and effectiveness of teachers who graduate from funded institutions, using content knowledge assessment of both the undergraduate courses these teachers take and the secondary courses they later teach; 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, both as it relates to a teacher's education and to the project as a whole. Both content and pedagogy assessment instruments are used to show areas in which preservice 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. In 2011-2012, the project will be contracting with a consultant to do project-wide formative assessment as well as receiving feedback from our Advisory Committee.

1.2.10.1 Degrees, Career Outcomes, and Retention

The project collects data annually from all sites on current and past graduates, including contact information, degrees and certifications, and employment information. In 2010, recognizing the vital importance of tracking teachers and their careers beyond graduation, the project also contracted with the AIP's Statistical Research Center to design a survey for PhysTEC graduates, based on the quadrennial survey given to high school physics teachers around the country. The major results of this survey appear in the Results section above. This was the most thorough

attempt to gather data directly from graduates to date, and the project plans to implement a second round of the survey this fall, which will capture detailed information on PhysTEC teachers' retention rates in the classroom.

1.2.10.2 Content Assessment

The PhysTEC project encourages funded institutions to teach introductory physics courses that use interactive, research-based methods shown to improve student learning. These courses also serve to model effective teaching practices, and often involve more advanced students as [Learning Assistants](#). PhysTEC has encouraged its sites to adopt proven curricular reforms because 1) PhysTEC understands 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 understanding¹⁰.

PhysTEC sites use research-validated instruments including the Force Concept Inventory (FCI)¹¹ and Conceptual Survey of Electricity and Magnetism (CSEM)¹² to assess student learning at PhysTEC sites and ensure that course reforms are effective. Typically, the normalized learning gain is used to assess the effectiveness of these courses; this is calculated by dividing the difference between post- and pre-test score by the difference between 100% and the pre-test score. Learning gains at most PhysTEC sites are in the range that is consistent with typical gains for courses using “interactive engagement” instruction, according to the literature¹³. Some sites' gains are somewhat lower, reflecting inconsistent understanding and implementation of course reforms among faculty. These sites are working to improve undergraduate instruction.

The project also works 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 gave the assessment to a total of 539 students; in 2009-2010, eleven teachers gave the assessment to a total of 688 students. As of this writing, ten teachers have given the pre-test to a total of 895 students in 2010-2011, but post-test data are still being collected and analyzed. Along with FCI pre-test and post-test scores, the project collects information from teachers on the school and classroom context in which they are teaching, both through surveys and telephone interviews. Due to the limited data collected and the large number of variables that can affect student learning gains, drawing conclusions from this effort has thus far been challenging. However, preliminary analysis of data from the past two years shows that for most teachers, average gains remain relatively consistent from year to year, and students in more advanced courses tend to have higher gains.

1.2.10.3 Sustainability

While PhysTEC sites have achieved impressive successes, project reforms 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,

¹⁰ R.R. Hake, "Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* 66, 64- 74, 1998.

¹¹ D. Hestenes, M. Wells, G. Swackhamer, "The Force Concept Inventory," *Phys. Teach.* **30**, 141, 1992.

¹² 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.

¹³ R. R. Hake, *op cit*.

long-term change at the departmental and institutional level. PhysTEC sites have succeeded in making permanent many of the initiatives originally supported by project funding, including TIRs, Learning Assistant programs, and new and reformed courses. 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](#).

PhysTEC has developed plans for a study on sustainability that will include four “legacy” sites that have ended their funding period. Project leaders and an assessment consultant will visit each site and determine to what extent project reforms are being carried on post-funding, and what conclusions can be drawn more generally about sustainability of teacher preparation efforts.

1.2.10.4 Advisory Committee

The project has engaged an external advisory committee to provide a broader perspective on the project’s context and activities. The committee is composed of a diverse group of senior members of the science and education disciplines, who will meet once annually for two days to learn about the project and provide guidance to project management on ongoing activities and future directions. The new advisory committee met for the first time in Fall 2010 and provided its report to project management. For a list of advisory committee members, see [Appendix 3](#).

1.2.11 Elementary Teacher Education

Although the PhysTEC project focuses primarily on high school teacher education, it also recognizes the great need for elementary teachers who can teach physical science confidently and effectively. A growing body of evidence suggests that students’ early educational experience can profoundly influence their attitudes toward science and their decisions whether or not to pursue a science career. Elementary teachers cannot be expected to master physics concepts at the same level as a high school teacher who specializes in the field, but research has shown that carefully constructed semester-long curricula can significantly improve both elementary teachers’ attitudes toward science and their ability to teach using inquiry. For this reason, the project has encouraged its sites to create and, if possible, require physical science courses for future elementary teachers using research-based curricula such as [Physics and Everyday Thinking \(PET\)](#), [Physics by Inquiry \(PbI\)](#), and [Powerful Ideas in Physical Science \(PIPS\)](#) in their physical science content courses for future elementary teachers. Most PhysTEC sites now offer one of these courses or something similar for elementary teachers, and many of the new sites are also planning to make this available.

2. PhysTEC Supported Sites

PhysTEC Supported Sites are selected colleges and universities that are developing their physics teacher preparation programs into national models 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 sites joining the project, five sites continuing their funding period, three sites transitioning off funding, and eleven “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 provide data necessary to assess the impact of the project.

Project leadership communicates with funded sites in a variety of ways, including annual 1.5-day visits to currently funded sites, video conferences, phone conversations, mid- and end-of-year reports, and meetings of all site leaders at the annual PhysTEC Conference, typically in later winter, and the AAPT Summer Meeting, typically in late July. Project meetings provide an important opportunity for site leaders to share successes and challenges and to learn from each other. In addition, project management often invites leaders from one site on a visit to another site, when an opportunity for collaboration and synergy presents itself. In this way, the project is more than the sum of its parts, as innovations at one site are frequently adopted at other sites.

The following table lists all PhysTEC Supported Sites.

Table 1. PhysTEC Supported Sites			
Institution	Type	Location	Project Term
Institutions Beginning Funding Period			
Boston University	Comprehensive	Boston, MA	2011-2014
California State University, San Marcos	Targeted	San Marcos, CA	2011-2014
State University of New York at Geneseo	Targeted	Geneseo, NY	2011-2014
Virginia Polytechnic Institute and State University	Comprehensive	Blacksburg, VA	2011-2014
Wright State University	Comprehensive	Dayton, OH	2011-2014
Institutions Continuing Funding Period			
California State University, Long Beach	Comprehensive	Long Beach, CA	2010-2013
Chicago State University	Targeted	Chicago, IL	2010-2013
Middle Tennessee State University	Comprehensive	Murfreesboro, TN	2010-2013
Towson University*	Comprehensive	Towson, MD	2010-2013
University of California, Davis	Comprehensive	Davis, CA	2010-2013
Institutions Transitioning Off Funding			
Cornell University	Comprehensive	Ithaca, NY	2007-2011
University of Minnesota	Comprehensive	Minneapolis, MN	2007-2011
University of North Carolina-Chapel Hill	Comprehensive	Chapel Hill, NC	2007-2011
Legacy Institutions			
Ball State University	Comprehensive	Muncie, IN	2001-2008
California Polytechnic State University, San Luis Obispo	Comprehensive	San Luis Obispo, CA	2003-2007
Florida International University	Comprehensive	Miami, FL	2007-2010
Oregon State University**	Comprehensive	Corvallis, OR	2001-2004

Seattle Pacific University	Targeted	Seattle, WA	2006-2009
Towson University*	Comprehensive	Baltimore, MD	2004-2008
University of Arizona	Comprehensive	Tucson, AZ	2001-2008
University of Arkansas	Comprehensive	Fayetteville, AR	2001-2008
University of Colorado at Boulder	Comprehensive	Boulder, CO	2004-2008
Western Michigan University	Comprehensive	Kalamazoo, MI	2001-2008
Xavier University of Louisiana***	Comprehensive	New Orleans, LA	2001-2005

*Towson University's first PhysTEC project focused on elementary teacher education. Its second project will focus on secondary teacher education.

** Due to changes and attrition among physics faculty, Oregon State left the project prior to year four.

*** Xavier University of Louisiana suspended project activity in 2005, due to the hardship resulting from Hurricane Katrina.

2.1 Institutions Beginning Funding Period

In October 2010, PhysTEC solicited applications for new PhysTEC sites that would receive up to three years' worth of funding. Similarly to 2009 and 2006, the review process was modeled after that of the NSF, with a two-stage application procedure and a review panel. As in 2009, the project invited proposals in two categories—Comprehensive Sites that would be funded at up to \$100k/year to engage in a full range of PhysTEC activities, and Targeted Sites that would be funded at up to \$25k/year to focus on subset of these activities. The Request for Proposals was announced on the web, in *APS News*, on project email lists, and in a mailing that went to all physics department heads in the country. In addition, project director Theodore Hodapp led a workshop on the solicitation at the 2010 PhysTEC Conference.

Ultimately, 70 institutions applied to the first round—34 as Comprehensive Sites and 36 as Pilot Sites. Fourteen applicants—eight Comprehensive and six Targeted—were invited to proceed to the second round of the application, and 13 submitted the secondary application materials. At the end of the review process, the project invited Boston University; California State University, San Marcos; SUNY Geneseo; Virginia Tech; and Wright State University to join the project. These sites will begin their projects in August 2011, and will be supported by funds from the National Science Foundation. In addition, the project has made a one-time \$25k award to a team proposing to create a set of videos illustrating interactions among Learning Assistants. This project will be led jointly by researchers and faculty members from Florida International University and Seattle Pacific University, both PhysTEC legacy sites.

Boston University (BU) is a large private institution in the Greater Boston area. In collaboration with the School of Education, the BU Physics Department has a history of educational outreach and professional development efforts in the Boston area and a strong working relationship with local school districts. PhysTEC project leaders hope to improve the perception, among both the students and the faculty, of teaching as a career, and to recruit physics teachers from both physics and engineering majors, as well as Learning Assistants. With the help of TIR recruited from a high-need district, project leaders hope to provide a model for other urban institutions in New England and the US.

The **California State University San Marcos (CSUSM)** PhysTEC project will address the national and regional shortage of highly qualified physics teachers through recruitment, early teaching experiences, program development, and mentoring. Project leaders plan to create a Physics Education Option in the Applied Physics degree, expand their existing Learning Assistants program to a local community college partner, and facilitate early teaching experiences at local high schools. Located in north San Diego County, CSUSM is a growing regional-comprehensive university that enrolls almost 9,000 undergraduates. Recently designated as an Hispanic-Serving Institution, CSUSM is culturally and ethnically diverse and representative of its surrounding region.

SUNY Geneseo is among the top five non-Ph.D. granting institutions in the US in terms of the number of physics majors it graduates. In order to make it easier for future teachers to meet New York State requirements, project leaders have proposed a five-year program leading to a BA, MEd, and certification in science teaching. The project plans to develop and test a model of collaborative Activity Teams, bringing together upper-level teacher candidates, first and second-year physics majors, and area high school students, with the goal of encouraging physics majors to consider careers in high school teaching. In addition, the site will develop two new courses that integrate physics content knowledge with physics pedagogy. The site will employ a part-time TIR whose efforts will focus on recruiting, and the project plans to engage teacher candidates in local school districts through a “Build-it, Teach-it, Leave-it” demonstration equipment program and in-school tutoring

Virginia Tech is a large public land-grant university in rural Southwestern Virginia, with around 31,000 students. This site’s PhysTEC project takes place in the context of a university-wide initiative to promote science and math education and teacher professional development, and the physics department recently introduced a BA program tailored specifically toward the School of Education’s teacher certification program, which leads to a Master’s in Education degree. The project leaders’ vision is to integrate an intense educational experience for prospective teachers with a mentoring and professional development network for program alumni and other physics teachers in the state. The educational experience will include a Physics BA/MAED program with learner-centered teaching of physics introductory courses, early-field experiences, and courses in science methods and physics teaching pedagogy. The alumni network will offer regular “homecomings” on the Virginia Tech campus, continued interactions with the Virginia Tech PhysTEC program through personal contacts and online discussion forums, as well as mentoring relationships between new and experienced teachers.

Wright State University is an open-enrollment public university in Dayton, Ohio with a student population of approximately 19,000. The physics department is in a strong position to begin its PhysTEC project, with four faculty members holding joint appointments in the College of Education & Human Services, an active peer instruction program, and six inquiry-based physics courses that support the physics content knowledge and PCK of future K-12 teachers. Project leaders plan to launch a multi-faceted recruitment and retention plan that includes developing more flexible program options to better meet the needs of potential candidates and increase their access into teaching, focusing on academic advising, assigning a PhysTEC mentor/advisor to students pursuing a teaching career, and better marketing of programs. They also plan to develop multiple PCK courses offered exclusively for future secondary physics or physical science

teachers. Ultimately, project leaders hope to create a culture that values teaching to support students seeking licensure as well as faculty interested in improving their own teaching.

The **Video Resource for Learning Assistant Development** is a project led by a team of physics education researchers at Florida International University and Seattle Pacific University, both PhysTEC [legacy sites](#). The outcome will be a package of thematic case-based “video workshops” created to complement and enhance the Learning Assistant pedagogy course developed at the University of Colorado, Boulder, also a legacy site. The video episodes for this project will showcase a variety of exemplary interactive instructional strategies. The resource will provide Learning Assistants with opportunities to observe, discuss, and reflect on a variety of teaching situations, developing their pedagogical content knowledge and supporting their emerging identity as teaching professionals. In addition, the Video Resource will offer users a view of other institutions’ LAs at work in transformed courses.

2.2 Currently Funded Institutions

In 2009, 52 institutions sent letters of interest for PhysTEC funding—26 as Comprehensive Sites and 26 as Pilot Sites. Thirteen applicants—seven Comprehensive and six Pilot—were invited to proceed to the second round of the application, and all submitted the secondary application materials. At the end of the review process, the project leaders invited California State University, Long Beach; Chicago State University; Middle Tennessee State University; Towson University; and the University of California, Davis to join the project. These sites began their projects in August 2010, and are supported by funds from NSF.

California State University, Long Beach (CSULB) is a large comprehensive university and Hispanic Serving Institution located in the Los Angeles metropolitan area, with a population of nearly 38,000 students. The CSULB PhysTEC project employs a part-time TIR—a model that has been used by other sites in the past—and has focused its efforts thus far on recruiting and developing new courses for future teachers. A physics department open house held in the fall attracted around 35 area high school teachers and students; another held in the spring was equally successful. Project leaders also gave out information cards to students in introductory courses, and followed up with communication and advising for those who indicated an interest in teaching. The site plans to implement a Learning Assistant program.



Cal State Long Beach recruiting poster

Chicago State University (CSU) is a public, urban, minority-serving institution serving around 7,000 students on the South Side of Chicago. Because of CSU’s location and environment, support from PhysTEC has the potential to increase the number of students of color going on to teach science in high-need area schools. Project leaders have focused on recruiting, both at CSU

and at nearby two-year colleges. Although it does not include a full-time TIR, the project is also developing an internship model called the “teacher immersion institute” to enable future teachers to work with inservice teachers. The project is leveraging a number of ongoing education and outreach programs at the university, including a Noyce Scholarship, as well as internships with various local museums and organizations.

Middle Tennessee State University

(MTSU) is home to over 25,000 students in the geographic center of Tennessee, a state that has recently increased the number of science and math courses needed to graduate from high school. The project is well poised within the university, as the university president has declared the goal of becoming a leader in science and math teacher preparation, and the university has been named a replication site for UTeach, the science and math teacher preparation program started at the University of Texas at Austin. Like



The first class of PhysTEC future teachers at Middle Tennessee State

at CSULB, MTSU project leaders have held an open house and made a major recruiting push in introductory courses. In addition, the project hired a marketing consultant to design a recruitment campaign, which it plans to implement in Fall 2011. As part of UTeach, the TIR is co-teaching the STEP 1 course, an introduction to the classroom for prospective teachers.

Towson University is a public university in Maryland with a student population of just over 21,000. As at MTSU, upper level support for the project is strong at Towson, as administrators hope to make the university a leader in science and math teacher preparation. Towson’s current PhysTEC project builds on a number of successful existing initiatives to increase student retention, including a freshman seminar, inquiry-based introductory courses, mentoring opportunities, a Learning Assistant program, and scholarship opportunities, including a Noyce Scholarship. Project leaders are restructuring the course sequence for future teachers, and have created flexible programs that reduce the course load and time required to earn certification.

University of California, Davis (UC Davis) is a large, comprehensive public university located in the state’s Central Valley, a region where highly qualified teachers of physical science are in especially short supply. The PhysTEC project is building off of the established Mathematics and Science Teaching (MAST) program, which uses master teachers to provide students with early teaching experiences. Project leaders have established a Learning Assistant program, and are working on restructuring the introductory course sequence that prospective teachers will take. The department is also planning to add a teaching track to either its Physics or Applied Physics major, to capitalize on interest among its students in teaching.

2.3 Institutions Transitioning off Funding

In October 2006, 45 institutions sent letters of interest for PhysTEC funding, and twelve were invited to proceed to the second round of the application, of which eleven submitted the secondary application materials. At the end of the review process, Cornell University, Florida International University, the University of Minnesota, and the University of North Carolina at Chapel Hill were chosen to join the project. These sites began their projects in August 2007, and were supported by funds from APS's 21st Century Campaign. Florida International transitioned off funding in July 2010; the other three continued their projects into 2010-2011, using unspent project funds.

Cornell University's PhysTEC project leaders report that the project has greatly improved attitudes toward teaching careers in the physics department, among both students and faculty. Through extensive advertising and targeted one-on-one conversations, Cornell TIRs have substantially increased the number of students considering physics teaching. Cornell's Undergraduate Teaching Assistant (UTA) program (similar to a Learning Assistant program) launched with eight undergraduates in Spring 2008, and has expanded to include 19 UTAs in Spring 2011. Experienced UTAs can become Master UTAs, who mentor newcomers to the program. Three Cornell future physics teachers are in the first two classes of PhysTEC Noyce Scholars, and one of the TIRs hired during the project continues on as VMT.

University of Minnesota project leaders have developed a novel implementation of the Learning Assistant program, in which Learning Assistants work with small teams of students during lecture classes. In the first two years of the program, 60 Learning Assistants were hired to help with these classes, and the program has shown potential as a means to increase major retention as well as recruit teachers. 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. Minnesota extended its PhysTEC MOU for a fourth year to hire a new TIR using internal funds that match project funds 3:1, and will continue employing a TIR in 2011-2012 to teach the Physics and Everyday Thinking (PET) course for elementary teachers. Project leaders are also looking for ways to sustain their Learning Assistant program.

The **University of North Carolina at Chapel Hill** (UNC) has established a program called UNC-BEST (UNC Baccalaureate Education in Science and Teaching), which allows students to graduate with a science degree and teaching certification in four years. It began with the Departments of Physics and Astronomy and of Biology, and has since expanded to Chemistry, Geological Sciences, and Mathematics. UNC-BEST's first graduating class, in 2009, included one physics teacher—the first graduating from the school in at least a decade. UNC employs a Physics Education Research (PER) specialist, who has done much of the development for the physics methods course that students interested in teaching take. UNC is a PhysTEC Noyce site, and is hiring a VMT to take on some of the roles the TIR has filled.

2.4 Legacy Sites

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 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 achieved a 100% retention rate for the sixteen high school physics teachers who graduated during its PhysTEC funding period of 2001-2008, thanks to effective induction and mentoring. Two Ball State future physics teachers were in the first class of PhysTEC Noyce scholars, and one received a second year of support. The site's 2006-2007 TIR is now serving as Visiting Master Teacher

California Polytechnic State University, San Luis Obispo has increased the number of teachers graduating from its program by over 500%, and has been successful in sustaining gains in the number of teachers graduating from its program. The university has funded one TIR since the site went off PhysTEC funding in 2007, who has now completed her sixth year in the position, and began funding a second TIR in 2010. Both TIRs work directly with middle and high school teaching candidates, supervising student teachers and teaching methods courses. They also teach a physical science courses to future elementary teachers.

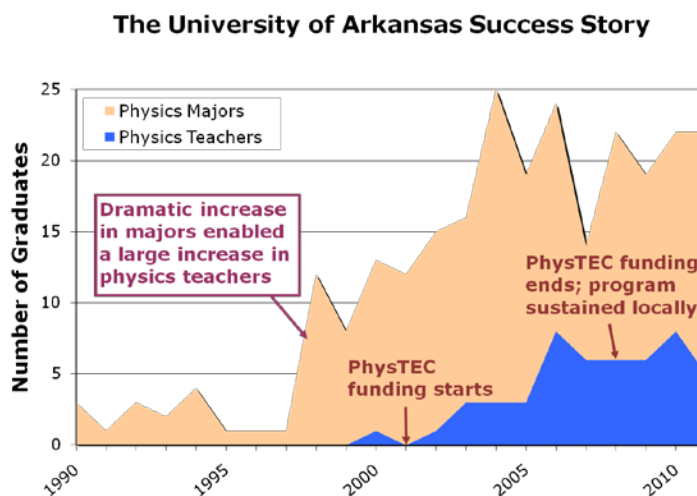
Florida International University (FIU) project leaders launched a Learning Assistant program in 2007 that has spread to the Math, Chemistry, and Earth Sciences departments, and now attracts over 100 applicants per semester. Physics Learning Assistants learn the highly regarded Modeling approach to teaching, developed at Arizona State University. Science and math teacher certification is done in the disciplinary departments, as of Fall 2009. In 2008 FIU graduated its first physics teacher in a decade, and has graduated one per year since then, with more in the pipeline. The university is among the institutions graduating the most Hispanic physics majors in the country, and is poised to provide the lion's share of highly qualified physics teachers to the southern tip of Florida, and especially to the Miami-Dade County Public Schools, one of the largest and most diverse districts in the country.

Seattle Pacific University (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 (VMT), a part-time hire who takes 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. Thanks to effective recruiting and advising, as well as a departmental culture that strongly values teaching, SPU has recruited a large number of PhysTEC Noyce scholars, with a total of ten over the three years of the program.

Towson University's original PhysTEC project focused on reforming its field experience course for elementary teachers, and was unique within the project in that it supported only elementary science education. Project leaders were able to measure progress in future teachers' attitudes toward and practice of science and science teaching. University administration provided funding for a permanent staff position to take on TIR duties and other PhysTEC efforts that were made by project leaders.

University of Arizona's PhysTEC program was built around its College of Science Teacher Preparation Program, and graduated an average of two physics teachers per project year, up from one in three years pre-PhysTEC. The project leader establishing an active Teacher Advisory Group that was involved in program design and curriculum development for pedagogy courses, and that now provides a network of mentors to provide early field experiences to preservice teachers.

University of Arkansas has been spectacularly successful at recruiting, advising, and mentoring physics teachers, increasing the number of graduates to more than 10 times what it was before the PhysTEC project began. As the graph shows, the increase in teachers was preceded by a dramatic increase in the number of majors; the reforms that enabled these increases are largely complementary. The program develops student interest in physics with inquiry-based introductory courses, closely advises potential teachers as they progress through the licensure process, and mentors them during their early careers. The university has also funded a TIR position in the College of Education and Health Professions to work with future elementary teachers. Arkansas leveraged their PhysTEC success into a Math and Science Partnership grant that is helping extend some of the gains made in physics to the math program. Four Arkansas future teachers have received PhysTEC Noyce Scholarships, and the department has brought a former TIR on board as VMT.



University of Colorado at Boulder (CU-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 two [PhysTEC-sponsored workshops](#) led by Colorado faculty in Fall 2007 and Fall 2010. Project leaders have gathered data showing that the 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.¹⁴ 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 NSF Noyce Teaching Fellowships and a recent [UTeach replication](#) award through the [National Math and Science Initiative](#).

Western Michigan University project leaders and TIRs built a community of preservice, novice, and experienced physics teachers. This community serves as a support system for

¹⁴ J. Mervis. "A New Twist on Training Teachers." *Science* 316 (5829), 1270—77 (2007).

graduates and other novice, as well as out-of-field, teachers of physics. To help support ongoing efforts in teacher education, the Western Michigan physics department hired a tenure-track faculty member in physics education research. Two Western Michigan future teachers are PhysTEC Noyce Scholars, and the department has hired a VMT to mentor these teachers.

2.4 Future Funding Opportunities

The project anticipates funding approximately six additional sites (three comprehensive, three pilot) to start in 2012.

2.5 PhysTEC Noyce Program

In Fall 2008, the PhysTEC project received an award through the NSF's Robert Noyce Teacher Scholarship Program to support future physics teachers at six PhysTEC sites. This was 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). For the 2011-2012 academic year, ten students from four PhysTEC sites received Noyce scholarships. Of these, seven are returning scholars, and three are new applicants. Seven will be post-baccalaureate students, two will be seniors, and one will be a junior in 2011-2012. They will join fourteen additional scholars who received awards in one of the two previous years. More information about the PhysTEC Noyce Program is available at www.PhysTEC.org/noyce.

2.6 PhysTEC Endorsement

The project now offers "PhysTEC endorsement" to institutions that have not received PhysTEC funding, but whose physics teacher preparation programs meet the standards of the project. Institutions seeking endorsement submit an application, and partially fund a site visit by project leaders. Endorsed institutions enjoy many of the same benefits as funded (present and past) sites, including the potential to be included in future PhysTEC Noyce projects, being featured in conferences and workshops, and connection to a national network of PhysTEC sites.

In 2010, Rutgers University became the first PhysTEC Endorsed Site. The Rutgers physics and physical science teacher education program, led by Eugenia Etkina, graduated an average of 6 students per year over the past 5 years and anticipates graduating 8 students this spring. The program focuses on preparing teachers of physics or physical science who are knowledgeable in the content and processes of physics, who can engage students in active learning of physics using scientific inquiry, and who can assess student progress in ways that improve learning.

3. Dissemination and Advocacy

The PhysTEC project views dissemination of project successes and advocacy for physics faculty involvement in teacher education as a central part of its mission, and as essential for progress on increasing the number of highly qualified physics teachers. The project pursues these goals through a wide variety of efforts in different media and venues.

3.1 The Physics Teacher Education Coalition

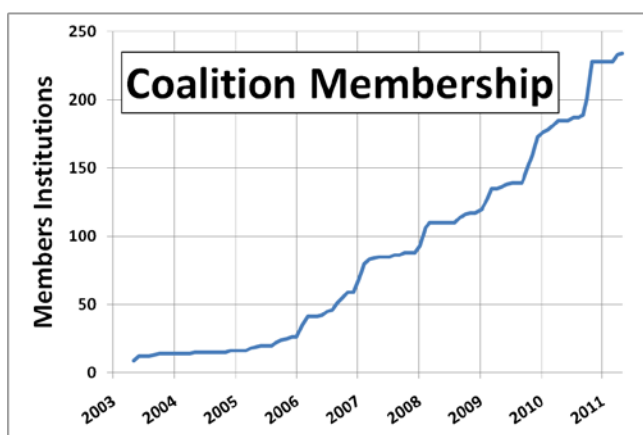
In addition to the PhysTEC Supported Sites, the project is also building a broad Coalition of institutions committed to improving physics and physical science teacher education. The goals of the Coalition are to

- 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.

Previously this Coalition was known as PTEC, but the project has decided to phase out this acronym. The project expects to finish combining the [PhysTEC](#) and [PTEC](#) websites in 2011.

3.1.1 Coalition Membership

Coalition members are institutions that are involved in preparing preservice physics teachers. Some of these institutions have well-developed programs that graduate multiple teachers per year; others engage at a lower level but participate in conferences and workshops to get ideas from leaders in the field. Coalition membership is free, but the project requires that members identify one or more contact people, at least one of whom



must be a physics faculty member; maintain a page on the project website; and provide the past three years' worth of physics teacher graduate data upon joining, which they then update annually. Institutions that do not graduate physics teachers, such as national labs and two-year colleges, can join as "affiliate members." As of this writing the Coalition has 234 member institutions.

Coalition 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 Coalition members are invited to participate at a reduced rate. The project strives to provide these institutions with appropriate expertise and information to advance their programs, and to mobilize them to act as a powerful force to convince the broader physics community of the importance of engaging in teacher education.

The graph above shows growth in Coalition membership over the past eight years, and the map below shows their geographical distribution. The Coalition members include around 30% of all physics departments granting bachelor's degrees, and there is at least one member institution in all but 3 states, with coverage roughly corresponding to major population centers. Data collected from Coalition members suggest that they graduate between 200 and 300 physics teachers per year. A complete list of Coalition members can be found in [Appendix C](#) of this report.

Physics Teacher Education Coalition Member Institutions



3.1.2 Conferences and Workshops

PhysTEC conferences and workshops are the most significant ways 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 PhysTEC Conference

Since 2005, the PhysTEC 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 typically includes two days of 1.5-hour workshops and panel discussions in three or four parallel tracks, lunchtime plenary speakers, opening and closing sessions, and a poster session with a reception. The project works hard to ensure that all 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 table below shows past and future conference locations and attendance. The sites for the PhysTEC Conference are chosen to engage a larger audience and reach out to a broad cross-section of the physics community.

The [2011 PhysTEC Conference](#) will focus on the theme “Sustainability for Teacher Education Programs,” and will be held jointly with the UTeach Institute Annual Conference in Austin, Texas, in May. PhysTEC and UTeach registrants are encouraged to attend each other’s conferences, and receive discounted registration fees. In addition, the sessions on the afternoon of the second day of the PhysTEC Conference will be part of both conferences. Carl Wieman,

Associate Director for Science at White House Office of Science and Technology Policy and Physics Nobel laureate, will deliver a joint plenary talk.

The 2012 PhysTEC Conference will be held in Ontario, California, in conjunction with the AAPT Winter Meeting. Project leaders are also reaching out to the California-based CalTeach program for potential collaboration.

Year	Location	Attendance
2012	Ontario, CA	TBD
2011	Austin, TX	127*
2010	Washington, DC	100
2009	Pittsburgh, PA	108
2008	Austin, TX	117
2007	Boulder, CO	112
2006	Fayetteville, AR	85
2005	Muncie, IN	82
*Final conference pre-registration		

3.1.2.2 Topical Workshops

The project has held five topical workshops focusing on particular elements of teacher preparation. Most recently, in October 2010, the project sponsored its second workshop focusing on the University of Colorado's Learning Assistant program (the first took place in October 2007). The two-day workshop was designed by faculty and staff at CU-Boulder, and provided participating faculty from other institutions with information they need to set up a successful Learning Assistant program. Participants observed learning assistant tutorials, participated in the pedagogy class that first-year Learning Assistants take, and received copies of the materials developed by CU-Boulder faculty and staff. Thirty-eight faculty and staff representing 21 PhysTEC Member Institutions attended the workshop, which took place on the CU-Boulder campus. Approximately half of the attendees were from physics departments, with the others representing math, biology, geology, chemistry, and education. The workshop schedule and selected presentations are available at www.PTEC.org/conferences/cula10

Past topical workshops include

- A two-day [workshop](#) in April 2010 at Rutgers University in New Brunswick, New Jersey, to assist faculty in developing their future teachers' pedagogical content knowledge (PCK).
- A one-day [workshop](#) in partnership with the Association of Public and Land-grant Universities in March 2009, just before the 2009 PhysTEC Conference.
- A two-day [workshop](#) in October 2007 on the University of Colorado at Boulder's Learning Assistant program.
- A three-day workshop focusing on the Reformed Teaching Observation Protocol¹⁵, which took place at the American Center for Physics in College Park, Maryland in October 2006.

3.1.2.3 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. Regional conferences have been held at the University of North Carolina-Chapel Hill in 2007, and at Seattle Pacific University in 2008. For more information on these conferences, see www.PTEC.org/conferences

¹⁵ 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. See also http://physicsed.buffalostate.edu/AZTEC/RTOP/RTOP_full

3.1.2.4 PhysTEC Programmatic Review Board

The PhysTEC Programmatic Review Board is a group of recognized experts in physics teacher education who provide intellectual guidance to the project on its initiatives and programs. The board meets two to three times per year, primarily by teleconference. Recently, the board has provided input into the new site application process, and the PhysTEC website update. See [Appendix A.5](#) for Programmatic Review Board members.

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) is organized around 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 sites’ cumulative annual reports are also available for readers 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), which was redesigned in Fall 2009, hosts information about the Coalition, including a database of member profiles and web pages for PhysTEC conferences and workshops. In addition, the site contains a collection of resources devoted to physics and physical science teacher preparation that is part of [ComPADRE](#), an NSF-funded digital library of resources for physics and astronomy education created by AAPT, AIP, APS, and the American Astronomical Society (AAS). The project is working with the collection editor to assemble and highlight high-quality materials in the collection. The PTEC website gets over 3,000 visits per month and is updated continuously.

The combined PhysTEC-PTEC website (see Section 3.1) will use the current PTEC design and structure, but will combine content from both sites and will be hosted on APS servers. The project will retain both URLs, and point all traffic to the merged site.

3.2.3 Discussion List

The Coalition email discussion list includes representatives from all Coalition member institutions, and serves as a place where project leaders can inform members about events, policy developments, and funding opportunities related to teacher preparation. Other email lists, including ones for PhysTEC site leaders, TIRs, and PhysTEC teachers, serve mostly to help disseminate announcements for events and opportunities.

3.3 National Task Force on Teacher Education in Physics

The joint AAPT/AIP/APS National Task Force on Teacher Education in Physics grew out of the PhysTEC project. Project leaders realized that an authoritative national report would greatly raise the profile of physics teacher education, and help disseminate the best practices in the field, as well as advocate for more resources. The Task Force released a document that includes a set of

findings and recommendations on February 13, 2010 at the PhysTEC Conference. The release, which summarizes more than two years of research on physics teacher preparation programs at US universities, is the synopsis of a report the task force plans to unveil later in 2011 and distribute to every physics department and education school in the country. The report will also be disseminated through presentations, workshops, and other mechanisms, under the auspices of the sponsoring professional organizations. Task Force members and project leaders have a number of talks on the outcomes of the project.

More information and a summary of the task force's findings and recommendations are available at www.PTEC.org/TaskForce. See [Appendix A.4](#) for a list of Task Force members.

3.4 Book: Collected Papers on Teacher Preparation

The project is sponsoring a book of peer-reviewed papers on physics teacher preparation, to be published jointly by APS and AAPT. The book will include five new reports on cutting-edge research and practice, as well as 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 either of the peer-reviewed journals *Physical Review Special Topics-Physics Education Research* or the *American Journal of Physics* is a prerequisite for inclusion in the book. In addition to reprinting each of the articles, the book will include one-to-two-page executive summaries of each article. The project expects the book to be completed in 2011.

3.5 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.

3.5.1 Annual PhysTEC Newsletter

In Fall 2010 the project published the fourth edition of its newsletter [PhysTEC News](#). The goal of this publication is to create a high-quality publication to represent the project to potential project partners, sponsoring society board members, university administrators, faculty, and donors. The newsletter is given to the APS and AAPT Executive Boards, and copies are mailed to all Coalition and PhysTEC institutions as well as the chairs of every US physics department that grants a bachelor's degree. The newsletter also serves as the top giveaway at the project's exhibition booth. The next newsletter is planned for Fall 2011.

3.5.2 Videos

Recognizing the importance of digital media, especially for the generation of students who are in college now, the project has created three videos designed to encourage students to consider physics teaching careers. The first was a five-minute video profile of a graduate of the Cal Poly teacher education program. The second, a 3.5-minute video entitled "Teach Physics," features four young physics teachers who talk about what excites them about their jobs, as well as extensive footage from these teachers' classrooms. The third, a two-minute video promoting the [Robert Noyce Teacher Scholarship Program](#), is intended for potential scholarship applicants. The organizers of the 2010 Noyce PI meeting contracted with the project to produce this video, and

give a copy to all participants. All three videos can be seen, downloaded, or embedded at www.PhysTEC.org/video, and DVD copies were created and distributed for the latter two.

3.4.4 APS News

Articles about the project are periodically published in *APS News*, APS's monthly newspaper that goes out to its 48,000+ members. The October 2010 edition included an article about the early careers of PhysTEC teachers. A bimonthly feature called the "Education Corner" also frequently features news about the project.

3.4.5 APS Forum on Education (FEd) Newsletter

Since 2005, the APS [Forum on Education Newsletter](#) has contained a section on teacher preparation. Almost 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. The Spring 2011 edition included articles by project leaders at Chicago State and UC Davis, and the Fall 2010 edition included articles by leaders at Middle Tennessee State and Cal State, Long Beach.

3.4.6 AAPT eNNOUNCER

PhysTEC-related announcements regularly appear in AAPT's monthly email newsletter to members.

3.4.7 Status Reports

The project publishes status reports approximately every three to four months. These are sent to PhysTEC Member Institutions, partner society heads, and NSF Program Officers, and are placed on the PhysTEC website.

3.5 Presence at AAPT and APS Meetings

In order to reach out to a greater fraction of the physics faculty around the country, the project has been increasing its presence at AAPT and APS meetings. The project staffs an exhibit booth at these meetings, and sponsors or co-sponsors sessions, particularly at AAPT meetings.

The project also organizes a one-day professional development workshop every year for PhysTEC teachers and TIRs, prior to the AAPT Summer Meeting. Funding is provided for TIRs just finishing or just beginning their terms, as well as a limited number of PhysTEC graduates from the past three years, and all PhysTEC Noyce Scholars in their first two years of teaching. Workshops include panel discussions of teachers and TIRs, discussion of assessment instruments and techniques, and sessions on interactive teaching methods and pedagogical content knowledge.

4. Collaborations

In order to maximize its impact, the PhysTEC project seeks collaborations with a wide range of partnering organizations and efforts. [UTeach](#), a highly successful science and math teacher preparation program that began at the University of Texas in Austin, was strongly represented at the 2010 Conference, with two workshops devoted to the UTeach replication effort. As described above, the 2011 PhysTEC Conference will be held jointly with the UTeach Institute's annual

conference.

The project has also helped inspire the American Chemical Society (ACS) to launch a parallel effort for chemistry teachers, and like last year, this year's PhysTEC Conference will feature a workshop on the chemistry teacher preparation. ACS has received NSF funding to hold a planning meeting to investigate forming the "Chemistry Teacher Education Coalition", and has invited institutions to sign onto a statement in support of chemistry departments engaging in teacher education, both initiatives modeled after PhysTEC. In addition, the project continues to work with the Association of Public and Land-grant Universities (APLU), whose [Science and Mathematics Teacher Imperative](#) (SMTI) is engaging university administrations to take pledges to increase the number of science and math teachers educated at their institutions. The APLU collaboration includes presenting at their annual SMTI meeting, pursuing joint dissemination projects, and consulting with their project management to promote collective actions on campuses.

APPENDIX A: Project Personnel

A.1 PhysTEC Management Team

A.1.1 Present Members

- **Theodore Hodapp**, *PI* (2004-2011), Director of Education and Diversity, APS. Hodapp is the primary contact for 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. He spends roughly 50% of his time on the PhysTEC project.
- **Monica Plisch**, (2007-2011; *co-PI* 2009-2011) Assistant Director of Education, APS. Plisch manages Coalition activities, including the annual PhysTEC Conference. She also directs the PhysTEC Noyce project. Plisch participates in site visits and works with Hodapp to manage other aspects of the project, spending around 80% of her time on the PhysTEC project.
- **Beth Cunningham**, (*co-PI* 2010-2011) Executive Officer, AAPT. Cunningham coordinates AAPT's involvement in the project.
- **Warren Hein**, (2001-2011; *co-PI* 2005-2007, 2008-2009, 2010), Executive Officer Emeritus, AAPT. Hein now leads the PhysTEC Noyce project's VMT efforts. Prior to his retirement, he coordinated AAPT's involvement in the project.
- **Jack Hehn**, *co-PI* (2001-2009), Director of Education Programs, American Institute of Physics. Hehn was a member of the original proposing team and continues to participate in the Project Management Team meetings.
- **Gabriel Popkin**, Project Manager (2007-2011), APS. Popkin writes and edits major project documents, writes articles about the project for publication, and participates in major project meetings. Previously he managed many of the day-to-day project operations.
- **Sara Webb**, Project Coordinator (2010-2011), APS. Webb manages many of the day-to-day operations of PhysTEC, including coordinating project meetings, updating project websites, managing project and budgetary data, and handling a variety of other tasks.
- **Jon Anderson**, TIR and Mentoring Consultant (2009-2011). Anderson is responsible for coordinating TIR activities and outreach to PhysTEC teachers. He participates in Project Management Team meetings.
- **David Meltzer**, Assessment Consultant (2007-2011). Meltzer is the editor of the forthcoming teacher preparation book, and advises the PhysTEC project assessment effort.

A.1.2 Past Members

- **Philip Hammer**, *co-PI* (2009-2010), Associate Executive Officer, AAPT. Hammer led the project's efforts to engage teachers and TIRs and coordinated efforts of AAPT for the project.
- **John Layman**, *co-PI* (2001-2005), Professor Emeritus at the University of Maryland.
- **Fredrick Stein**, *PI* (2001-2004), former Director of Education and Outreach, APS. Stein served as PI until his retirement from the APS in September 2004. He worked 50-60% time on the PhysTEC project.
- **Charlie Holbrow**, *co-PI* (2008), Executive Officer, AAPT. Holbrow replaced former AAPT Executive Officer and co-PI Toufic Hakim.
- **Toufic Hakim**, *co-PI* (2007-2008), Executive Officer, AAPT. Hakim replaced Warren Hein as co-PI during Hein's rotation at the NSF.
- **Mary Fehrs**, Associate Project Director for Coalition Development, APS (2005-2007). Fehrs was responsible for developing the Coalition, and organizing and managing the annual PhysTEC conference.
- **Edward Lee**, Project Associate, APS (2001-2010).
- **Victoria Kwasiowski**, Project Manager (2005-2007), APS.
- **John Gretz**, Project Coordinator (2004-2005), APS.
- **Kevin Aylesworth**, Project Coordinator (2002-2004), APS.
- **Shirley Wilson**, Project Assistant, APS (2009-2010).

A.2 Past Management Team Consultants

- **Paul Hickman**, TIR and Mentoring Consultant (2005-2009). Hickman was responsible for coordinating TIR activities, and participated in Project Management Team meetings.
- **Drew Isola**, Consultant (2008-2009). Isola, a former Teacher-in-Residence, has been responsible for a variety of activities related to TIRs and PhysTEC teachers.
- **Marcia Fethers**, TIR Consultant (2005)
- **Gay Stewart**, Outreach Consultant (2005)
- **Karen Johnston**, Project Evaluator, The Momentum Group (2001-2004)
- **Hal Richtol**, Consultant for Site Visits (2001-2004)

A.3 Advisory Committee

A.3.1 Advisory Committee

The current Advisory Committee met for the first time in Fall 2010. Members are:

- **Helen Quinn**, *Chair*, Professor Emeritus, Stanford Linear Accelerator Center
- **Keith Clay**, Professor, Physics Department, Green River Community College
- **Mary Kirchhoff**, Director, Education Division, American Chemical Society
- **Jill Marshall**, Associate Professor, Department of Education, University of Texas at Austin
- **Jose Mestre**, Professor, Department of Physics, University of Illinois at Urbana-Champaign
- **JoAnne Vasquez**, Vice President, Helios Foundation

Kimberly Mitchell, Senior Program Officer at the Bill and Melinda Gates Foundation, is a past member of the current Advisory Committee.

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)
- **Theodore Hodapp** (American Physical Society)
- **Cathy O'Riordan** (American Institute of Physics)
- **Monica Plisch** (American Physical Society)

Senior Consultant: David Meltzer (Arizona State University)

A.5 Programmatic Review Board Members

- **Eugenia Etkina** (Rutgers University)
- **Noah Finkelstein** (University of Colorado at Boulder)
- **Michael Marder** (University of Texas at Austin)
- **Mary Lee McJimsey** (North Central High School, Spokane, WA)
- **Gay Stewart** (University of Arkansas)
- **Stamatis Vokos** (Seattle Pacific University)

Former member:

- **Paula Heron** (University of Washington)

APPENDIX B: PhysTEC Publications

B.1 Project Management Team (PMT) Publications

Year	Primary Author	Title	Location/Citation
2011	Popkin	Minority Serving Institutions Take on Teacher Preparation	CSWP & COM Gazette (Pg. 7), Spring 2011
2010	Popkin	PhysTEC Project Synopsis	December 2010
2010	Popkin	PhysTEC Scholarship Program for Future Physics Teachers	APS Forum on Education Newsletter, Summer 2010
2010	Popkin	Teacher Education Program Adds Five New Sites	APS News, April 2010
2010	Popkin	Teacher Preparation Conference Focuses on Diversity	APS News, April 2010
2010	Popkin	Task Force Calls Physics Teacher Preparation Massively Inadequate	APS News, April 2010
2009	Popkin (editor)	PhysTEC News	PhysTEC News, Fall 2009
2009	Popkin	APS-Led Project Receives \$6.5M NSF Grant	APS News, October 2009
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 (editor)	PhysTEC News	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
2008	Popkin	Conference Connects Physics Teacher Educators	APS News, April 2008
2008	Popkin (editor)	PhysTEC News	PhysTEC News, Spring 2008
2008	Popkin	Learning Assistants Impact Undergraduate Teaching	APS News, February 2008
2007	APS Staff	Four New Sites Added to Teacher Education Program	APS News, April 2007
2006	APS Staff	Featured PhysTEC University: University of Colorado	APS News, March 2006

2005	APS Staff	Featured PhysTEC University: Arkansas Ramps Up Teacher Preparation	APS News, December 2005
2005	APS Staff	Featured PhysTEC School: University of Arizona.	APS News, May 2005
2002	Layman	Guest Editorial: PhysTEC	American Association of Physics Teachers Announcer
2002	Hein, Layman	A Coalition to Improve Teaching	APS Forum on Education Newsletter.
2001	Stein	The Blame Game in Teacher Preparation	APS Forum on Education Newsletter.

B.2 PhysTEC Institution Publications

Institution	Year	Authors	Title	Citation
Cal Poly	2011	Hoellwart, C., Moelter, M.	Exposing Students to the Idea that Theories Can Change	The Physics Teacher, Vol 49, March 2011, pp 180-183.
Chicago State	2011	Sabella, M., Van Duzor, A.	Preparing urban students to teach in the urban classroom: Chicago State University's PhysTEC Program	APS Forum on Education Newsletter, Spring 2011.
UC Davis	2011	Webb, D.	PhysTEC Program at the University of California, Davis	APS Forum on Education Newsletter, Spring 2011.
Cal State Long Beach	2010	Kwon, C.	The CSULB PhysTEC Project	APS Forum on Education Newsletter, Fall 2010.
Colorado	2010	Otereo, V., Ross, M., Sherman, S.	A Synergistic Model of Educational Change	APS Forum on Education Newsletter, Fall 2010.
Colorado	2010	Otero, V., Pollock, S., Finkelstein, N.	A physics department's role in preparing physics teachers: The Colorado learning assistant model	American Journal of Physics, Volume 78, Issue 11, pp. 1218, November 2010.
Middle Tennessee State	2010	Henderson, R.	Physics Teaching Embraced at MTSU with the help of PhysTEC	APS Forum on Education Newsletter, Fall 2010.
Arkansas	2010	Stewart, G., Stewart, J.	University of Arkansas Noyce Scholarship Program	APS Forum on Education Newsletter, Summer 2010.
Cornell	2010	Thorne, R.	PhysTEC at Cornell: A Progress Report	APS Forum on Education Newsletter, Spring 2010.
Florida International	2010	Brewe, E., Kramer, L., O'Brien, G., Rodriguez, I., Pamela, P., Sawtelle, V.	A longitudinal study of the role of Modeling Instruction in establishing supportive environments for conceptual learning of underrepresented students	Proceedings of the 2009 NARST Annual International Conference, 2010.

Florida International	2010	Brewe, E., Sawtelle, V., Kramer, L., O'Brien, G., Rodriguez, I., Pamela, P.	Toward equity through participations in modeling instruction in introductory university physics	Physical Review Special Topics - Physics Education Research 6 , 010106.
Florida International	2010	Kramer, L., O'Brien, G., Brewe, E.	Integrating science students into learning communities through Modeling Instruction	NEA Higher Education Advocate (in press) June 2010.
Florida International	2010	Sawtelle, V., Brewe, E., Kramer, L.	Exploring the Relationship Between Self-efficacy and Retention of Students, both Men and Women, in Introductory Physics	Proceedings of NARST 2010 National Conference (Stand-Alone Paper) 2010
Colorado	2009	Spike, B., Finkelstein, N.	A Study of Undergraduate and Graduate Student Conceptions of Teaching	<i>Proceedings of the 2009 Physics Education Research Conf.</i> , AIP Press, 1179 , 281-284, (2009)
Florida International	2009	Brewe, E., Kramer, L., O'Brien, G.	Investigating Student Communities with Network Analysis of Interactions in a Physics Learning	AIP Conference Proceedings CP1179:105 (2009).
Florida International	2009	Brewe, E., Kramer, L., O'Brien, G.	Modeling Instruction: Positive attitudinal shifts in introductory physics measured with CLASS	Phys. Rev. ST Phys. Educ. Res. 5, 013102.
Florida International	2009	Sawtelle, V., Brewe, E., Kramer, L.	An Exploratory Qualitative Study of the Proximal Goal Setting of Two Introductory Modeling Instruction Physics Students	AIP Conference Proceedings CP1179:261, (2009).
Ball State	2008	Grosnick, D., Watson, J.	Plugging the Leaky Bucket: Retention of Physics Teacher Graduates from Ball State University	APS Forum on Education Newsletter, Spring 2008.
Colorado	2008	Finkelstein, N. and Pollock, S.	Sustaining Educational Reforms in Introductory Physics	Physical Review, Special Topics: PER, 4 (010110) 2008.
Cornell	2008	Alderman, M.	Non-Physics Teachers Are Teaching Physics-We Cannot Replace Them, But We Can Help Them!	APS Forum on Education Newsletter, Fall 2008.
Florida International	2008	Jones, D.	Join a Physics Teaching Community.	The Physics Teacher, 46, 2008.
Florida International	2008	Kramer, L., Brewe, E., O'Brien, G.	Improving Physics Education through a Diverse Research and Learning Community at Florida International University	APS Forum on Education Newsletter, Summer 2008.
Florida International	2008	Kramer, L., Brewe, E., O'Brien, G.	CLASS Shifts in Modeling Instruction	AIP Conf. Proc. 1064, 79 (2008)
Florida International	2008	Sawtelle, V., Brewe, E., Kramer, L., Saul, J.	Validation study of the Colorado Learning Attitudes about Science Survey at a Hispanic-serving institution	Phys. Rev. ST Phys. Educ. Res. 5, 023101
Florida International	2008	Wells, L., et al	Impact of the FIU PhysTEC Reform of Introductory Physics Labs	AIP Conf. Proc. 1064, 79 (2008)
Minnesota	2008	Anderson, J.	The first Year of PhysTEC at the University of Minnesota	APS Forum on Education Newsletter, Fall 2008.

North Carolina	2008	McNeil, L.	Nuts and Bolts of Teacher Preparation	PhysTEC News, 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	APS Forum on Education Newsletter, Summer 2008.
Towson	2008	Lising, L., Sandifer, C.	A Broad Approach to Mentoring in an Inquiry-Focused Early Teaching Experience	APS Forum on Education Newsletter, Spring 2008.
Arizona	2007	Talanquer, V., Tomanek, D., Novodvorsky, I.	Revealing student teachers' thinking through dilemma analysis	Journal of Science Teacher Education, 18 (3) 2007.
Arkansas	2007	Stewart, G.	Teacher Recruitment at the University of Arkansas	APS Forum on Education Newsletter, Spring 2007.
Arkansas	2007	Stewart, J., Griffin, H., Stewart, G.	Context sensitivity of the Force Concept Inventory	Physical Review, Special Topics: PER 3 (010102) 2007.
Colorado	2007	Kohl, P., Finkelstein, H. Rosengrant, D.	Strongly and Weakly Directed Approaches to Teaching Multiple Representation Use in Physics	Physical Review, Special Topics: PER 3 (010108) 2007.
Colorado	2007	Pollock, S., Finkelstein, N.	Sustaining Change: Instructor Effects in Transformed Large Lecture Courses	Proceedings of the 2006 Physics Education Research Conference (PERC), 2007.
Colorado	2007	Pollock, S., Finkelstein, N. Kost, L.	Reducing the gender gap in the physics classroom: How sufficient is interactive engagement?	Physical Review, Special Topics: PER, 3 (010107), 2007.
Colorado	2007	Price, E., Finkelstein, N.	Preparing Graduate Students to be Educators	American Journal of Physics 76 684, 2008.
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	2007	Lising, L., Tirrochi, L.	A "teacher-in-residence" experience as professional development in elementary science inquiry	Proceedings of the Association for Science Teacher Education Conference, 2007.
Towson	2007	Sandifer, C., Lising, L., Renwick, E.	Towson's PhysTEC course improvement project, Years 1 and 2: Results and lessons learned	Proceedings of the Association for Science Teacher Education Conference, 2007.
Western Michigan	2007	Isola, D., Olsen, J.	A Quiet Revolution in Preparing Future Teachers of Physics	APS Forum on Education Newsletter, Spring 2007.
Western Michigan	2007	Poel, B., Isola, D.	Recruiting a New Generation of Physics Teachers at Western Michigan University	APS Forum on Education Newsletter, Spring 2007.
Arizona	2006	Novodvorsky, I.	Shifts in beliefs and thinking of a beginning physics teacher	Journal of Physics Teacher Education Online, 3 (3) 11-17, 2006.
Arkansas	2006	Stewart, G.	Recruiting New Teachers At The University Of Arkansas	APS Forum on Education Newsletter, Fall 2006; PTEC Newsletter.

Arkansas	2006	Stewart, G.	Undergraduate Learning Assistants At The University Of Arkansas	APS Forum on Education Newsletter, Summer 2006; PTEC Newsletter.
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	Physical Review, Special Topics: PER, 2 (010101), 2006.
Colorado	2006	Finkelstein, N.	The Role and Promise of Physics Education Research.	APS News, Back Page, Jan 2006.
Colorado	2006	Kohl, P., Finkelstein, N.	The effects of representation on students solving physics problems: a fine-grained characterization	Physical Review, Special Topics: PER, 2 (010106), 2006.
Colorado	2006	Kohl, P.B., Finkelstein, N.	The effect of instructional environment on physics students' representational skills	Physical Review, Special Topics: PER, 2 (010102), 2006.
Colorado	2006	Otero, V.	The Learning Assistant Model for Teacher Education in Science and Technology	APS Forum on Education Newsletter, Summer 2006.
Colorado	2006	Otero, V.	Moving Beyond the 'Get It Or Don't' Conception of Formative Assessment	Journal of Teacher Education, 57, 247 – 255, 2006.
Colorado	2006	Otero, V., et al.	Who is Responsible for Preparing Science Teachers?"	Science, 313 (5786), 445-446, 2006.
Colorado	2006	Podolefsky, N., Finkelstein, N.	Use of analogy in learning physics: The role of representations	Physical Review, Special Topics: PER, 2 (020101), 2006.
Colorado	2006	Pollock, S.	Transferring transformations: Learning gains, student attitudes, and the impact of multiple instructors in large lecture classes	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Seattle Pacific	2006	Seeley, L., Vokos, S.	Creating and Sustaining a Teaching and Learning Professional Community at Seattle Pacific University.	APS Forum on Education Newsletter, Summer 2006.
Towson	2006	Sandifer, C., Lising, L., Tirrochi, L.	Our PhysTEC project: Collaborating with a classroom teacher to improve an elementary science practicum	Proceedings of the Association for Science Teacher Education Conference, 2006.
Arizona	2005	Novodvorsky, I.	Secondary science teacher preparation at the University of Arizona	APS Forum on Education Newsletter, Fall 2005.
Arizona	2005	Novodvorsky, I.	Partners in the Preparation of Secondary Science Teachers	APS Forum on Education Newsletter, Spring 2005.
Ball State	2005	Grosnick, D.	An Advisory Group to Provide Input in the Preparation of Future Teachers	APS Forum on Education Newsletter, Spring 2005.
Cal Poly	2005	Hoellwarth, C.	A direct comparison of conceptual learning and problem solving ability in traditional and studio style classrooms	American Journal of Physics, 73 (5), 459-463, 2005.
Colorado	2005	Finkelstein, N.	Replicating and Understanding Successful Innovations: Implementing Tutorials in Introductory Physics	Physical Review, Special Topics: PER, 1 (010101) 2005.

Colorado	2005	Finkelstein, N.	Can Computer Simulations Replace Real Equipment in Undergraduate Laboratories?	Proceedings of the 2004 Physics Education Research Conference (PERC), 818 (3), 2005.
Colorado	2005	Finkelstein, N.	Seeding Change: The Challenges of Transfer and Transformation of Educational Practice and Research in Physics (Part I)	Proceedings of the 2004 Physics Education Research Conference (PERC), 818 (3), 2005.
Colorado	2005	Finkelstein, N.	Evaluating a model of research-based practices for teacher preparation in a physics department: Colorado PhysTEC	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Colorado	2005	Finkelstein, N., et al.	CU Physics Education, Recruiting and Preparing Future Physics Teachers and the Teacher Advisory Group	APS Forum on Education Newsletter, Spring 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	PhysRev Special Topics: PER, 1 (010103), 2005.
Colorado	2005	Keller, C.	Assessing The Effectiveness Of A Computer Simulation In Conjunction with Tutorials In Introductory Physics In Undergraduate Physics Recitations	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Colorado	2005	Kohl, P.B., Finkelstein, N.	Student representational competence self-assessment and problem solving in physics	Physical Review, Special Topics: PER, 1 (010104), 2005.
Colorado	2005	Pollock, S.	No single cause: Learning gains student attitudes and the impacts of multiple effective reforms.	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Colorado	2005	Pollock, S.	Transferring transformations: Learning gains student attitudes and the impact of multiple instructors in large lecture classes.	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Colorado	2005	Price, E.	Seeding Change: The Challenges of Transfer and Transformation of Educational Practice and Research in Physics (Part II)	Proceedings of the 2005 Physics Education Research Conference (PERC), 818 (3), 2006.
Arizona	2004	Novodvorsky, I.	US Coalition helps new teachers	Physics Education (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	Proceedings of 2nd International GIREP Seminar, 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	Proceedings of 2nd International GIREP Seminar, Udine, Italy, 2004.
Arkansas	2004	Stewart, G.	Practicing What I Preach.	APS Forum on Education Newsletter, Summer 2004.
Ball State	2004	Smith, W.	Starting the Semester at Odds: Science Educators' Versus College Students' Reasons for Studying Science	Journal of College Science Teaching, 34 (3), 44-49, 2004.

Ball State	2004	Smith, W.	Data Mining the Internet: Immersing High School Students in Electronic Inquiry	Science Activities, 41 (1), 9-15, 2004.
Ball State	2004	Smith, W.	Using Internet Technology to Address National Science and Teacher Education Standards	The Teacher Educator, 39 (2), 144-156, 2004.
Arizona	2003	Novodvorsky, I, et al	Responding to the call for change: The new college of science teacher preparation program at the University of Arizona	Cell Biology Education, 2 (1), 29-34, 2003.
Arizona	2003	Novodvorsky, I, et al	A stronger role for science departments in the preparation of future chemistry teachers	Journal of Chemical Education, 80 (10), 1168-71, 2003.
Arizona	2003	Novodvorsky, I.	The Impact of Educational Research on Physics Teacher Preparation	International Commission on Physics Education Newsletter, 46, 2003.
Arizona	2003	Novodvorsky, I.	Beginning Your First Year	The Physics Teacher, 41, 371-72, 2003.
Arizona	2002	Novodvorsky, I, et al	A new model of physics teacher preparation	Journal of Physics Teacher Education Online, 1 (2), 2002
Arkansas	2002	Bullock, D. W., et al.	Enhancing the Student-Instructor Interaction Frequency	The Physics Teacher, 40, 535-541, 2002.

Members of the project have given numerous presentations to local, regional, and national audiences. Selected presentations by PhysTEC project leaders are available at:

www.PhysTEC.org/presentations.

B.3 PhysTEC Press

Title	Publication	Date
National initiatives recruit and retrain science teachers	Physics Today	January 2011
CSU Selected to be a National Model for the Preparation of High School Physics Teachers	CSU News	October 2010
Cornell producing future high school physics teachers	Cornell University Chronicle	11/30/2009
FIU's New Approach to Teaching Sends Scientists into the Classroom	News@FIU	11/30/2009
A genuine teaching experience	Physics Today	October 2009
PhysTEC Integrates Physics, Education	NSTA Reports	January 2009
U takes part in effort to improve physics teaching	Minnesota Daily	11/9/2008
Teaching Physics Matters	Connect	Fall 2008

APPENDIX C: PTEC Membership as of May 20, 2010

Abilene Christian University
Adrian College
Anderson University
Andrews University
Angelo State University
Arizona State University
Armstrong Atlantic State University
Auburn University
Augustana College
Ball State University
Bemidji State University
Berry College
Boise State University
Boston University
Bowdoin College
Bridgewater State University
Brigham Young University
Brigham Young University-Idaho
Buffalo State University
Butler University
California Polytechnic State University,
Pomona
California Polytechnic State University, San
Luis Obispo
California State University San Marcos
California State University, Chico
California State University, East Bay
California State University, Fresno
California State University, Long Beach
California State University, Sacramento
California University of Pennsylvania
Calvin College
Canisius College
Casper College
Central Washington University
Chatham University
Chicago State University
Chuvash State Teacher Training University
Claflin University
Cleveland State University
Colgate University
Cornell University
DePaul University
Dodge City Community College
East Carolina University
East Central University
Eastern Illinois University
Eastern Kentucky University
Elon University
Emporia State University
Fairmont State University
Florida A & M University
Florida International University
Florida State University
Fort Hays State University
Francis Marion University
George Washington University
Georgia Southern University
Georgia State University
Hamline University
Hillsdale College
Hiram College
Hofstra University
Hope College
Howard University
Illinois State University
Indiana University of Pennsylvania
Iowa State University
Ithaca College
Jackson State University
Jacksonville State University
James Madison University
Johns Hopkins University
Johnson C. Smith University
Juniata College
Kansas State University
Kennesaw State University
Kent State University
King College
Lawrence Technological University
Lehman College, City University of New
York
Lincoln University
Lone Star College-North Harris
Longwood University
Louisiana State University
Loyola University Maryland
McKendree University

McNeese State University	Southern Methodist University
Medaille College	Southern Oregon University
Michigan State University	Southern University and A&M College
Middle Tennessee State University	Southwestern Oklahoma State University
Millersville University	Spelman College
Minnesota State University Moorhead	St. Ambrose University
Misericordia University	St. John's University
Missouri University of Science and Technology	Stony Brook University
Monmouth College	SUNY Cortland
Morningside College	SUNY Fredonia
National Superconducting Cyclotron Laboratory	SUNY Geneseo
New Mexico State University	Tarleton State University
North Carolina A&T State University	Tennessee Technological University
North Carolina State University	Texas A&M University
North Georgia College and State University	Texas A&M University-Commerce
Northwestern Oklahoma State University	Texas Southern University
Oklahoma State University	Texas State University-San Marcos
Oranim Academic College	The Citadel
Oregon State University	Towson University
Pacific University	Trinity Christian College
Passaic County Community College	Truman State University
Pennsylvania State University	Tufts University
Pittsburg State University	University of Alabama
Portland State University	University of Alabama at Birmingham
Purdue University	University of Arizona
Radford University	University of Arkansas
Randolph College	University of California at Riverside
Rensselaer Polytechnic Institute	University of California, Berkeley
Rochester Institute of Technology	University of California, Davis
Rowan University	University of California, Santa Cruz
Rutgers, the State University of New Jersey	University of Cincinnati
Saint Anselm College	University of Colorado at Boulder
Saint Joseph's University	University of Connecticut
Saint Mary's College	University of Education
Salisbury University	University of Hawaii at Hilo
San Antonio College	University of Hawaii at Manoa
San Jacinto College Central	University of Houston
Seattle Pacific University	University of Houston Clear Lake
Slippery Rock University	University of Idaho
Sonoma State University	University of Illinois
South Dakota State University	University of Illinois-Chicago
Southeastern Louisiana University	University of Kentucky
Southern Illinois University Edwardsville	University of Louisville
	University of Maine
	University of Maryland, Baltimore County

University of Maryland, College Park
University of Massachusetts Dartmouth
University of Massachusetts-Boston
University of Memphis
University of Michigan, Ann Arbor
University of Michigan, Dearborn
University of Minnesota
University of Missouri
University of Missouri-Kansas City
University of Montana
University of Nebraska-Lincoln
University of Nevada, Las Vegas
University of Nevada, Reno
University of New Hampshire
University of North Carolina at Asheville
University of North Carolina at Chapel Hill
University of Northern Colorado
University of Northern Iowa
University of Notre Dame
University of Oregon
University of Pittsburgh
University of Pittsburgh at Greensburg
University of Rhode Island
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 Brownsville
University of Texas at El Paso
University of Texas at San Antonio
University of Texas at Tyler
University of Texas-Pan American
University of Toledo
University of Washington
University of Wisconsin-Madison
University of Wisconsin-Milwaukee
University of Wisconsin-River Falls
University of Wisconsin-Stevens Point
University of Wisconsin-Whitewater
University of Wyoming
Vassar College
Vincennes University
Virginia Tech

Wayne State University
Weizmann Institute of Science
West Virginia State University
West Virginia University
Western Illinois University
Western Kentucky University
Western Michigan University
Western Washington University
Wheeling Jesuit University
Wichita State University
Winona State University
Winston-Salem State University
Women's Christian College
Worcester Polytechnic Institute
Wright State University
Xavier University of Louisiana