PhysTEC: Successful U.S. teacher recruitment and preparation model from AAPT and APS

David R. Sokoloff
Department of Physics, 1274 University of Oregon, Eugene, Oregon 97403-1274, USA, and American Association of Physics Teachers, One Physics Ellipse, College Park, MD 20740-3845.

E-mail: sokoloff@uoregon.edu

(Received 7 November 2011; accepted 12 March 2012)

Abstract

The U.S. faces a critical shortage of qualified physics and physical science teachers. Two-thirds of new physics teachers lack a physics degree, and over 90% of middle school physical science students are taught by teachers without a physical science major or certification. In order to address this crisis, the American Physical Society (APS) and the American Association of Physics Teachers (AAPT) developed the PhysTEC project, with support from the American Institute of Physics (AIP). The mission of PhysTEC is to improve and promote the education of future physics and physical science teachers. Specifically, the project aims to (1) demonstrate successful models for increasing the number of highly qualified high school physics teachers and improving the quality of K-8 physical science teacher education, (2) spread best-practice ideas throughout the physics teacher preparation community, and (3) transform physics departments to engage in preparing physics teachers. To date the PhysTEC project has helped funded institutions to (1) double, or more, their production of high school physics teachers, (2) use master teachers to develop bridges between their physics departments, education schools, and local K-12 school districts, (3) transform content and pedagogy courses for future physics and physical science teachers to promote learning through interactive engagement, (4) secure continuing allocation of substantial departmental and institutional resources for teacher preparation programs, and (5) measure project outcomes and disseminate results through publications, presentations, and workshops.

Keywords: Physics teacher preparation, teacher training, pre-service teachers.

Resumen

Los EE.UU. se enfrentan a una escasez crítica de la Física y profesores calificados en Ciencias Físicas. Dos tercios de los nuevos profesores de Física carecen de un título en Física, y más del 90% de los estudiantes de la Ciencia Física de secundaria son enseñados por maestros sin la principal certificación para ciencias Físicas. Para hacer frente a esta crisis, la Sociedad Americana de Física (APS) y la Asociación Americana de Profesores de Física (AAPT) desarrolló el proyecto PhysTEC, con el apoyo del Instituto Americano de Física (AIP). La misión de PhysTEC es mejorar y promover la futura educación de la Física y los maestros de Física. Específicamente, el proyecto tiene como objetivo (1) demostrar modelos exitosos para aumentar el número de maestros altamente calificados de escuelas secundarias y mejorar la calidad de K-8 educación de profesores de ciencias físicas, (2) difundir las ideas mejores-prácticas a lo largo de la preparación de maestros de Física, y (3) la transformación de los departamentos de Física para participar en la preparación de los profesores de Física. Hasta la fecha en que el proyecto PhysTEC ha ayudado a financiar instituciones de (1) doble, o más, su producción de profesores de Física de secundaria, (2) utilizar a los profesores de maestría para desarrollar puentes entre sus departamentos de Física, escuelas de educación, y distritos escolares locales K-12, (3) transformación del contenido y cursos pedagógicos para el futuro de la Física y los maestros de ciencias físicas para promover el aprendizaje a través de la participación interactiva, (4) asegurar la asignación de permanente de importantes recursos departamentales e institucionales para programas de formación docente, y (5) medir los resultados del proyecto y difundirlos a través de publicaciones, presentaciones y talleres.

Palabras clave: Preparación de los maestros de Física, formación docente, pre-servicio de docentes.

PACS: 01.30.la, 01.40.ek, 01.40.jc **ISSN 1870-9095**

I. INTRODUCTION

The shortage of qualified high school physics teachers in the U.S. is well documented. In their 2009 study, the American Association of Employment in Education listed physics as the second from the top in its list of the top 13 high demand fields for secondary teachers [1]. Only about one third of the new secondary physics teachers each year have a major or minor in physics, compared to three quarters for all of science and sixty percent for mathematics [2]. And, while the number of students taking physics in

high school has been growing by eight percent per decade since the mid-1980's, the number of bachelor's degrees awarded in physics has been just about constant during this period [3]. In its 2007 report, *Rising Above the Gathering Storm*, the U.S. National Academies recommended dramatic increases in the number of physical science degrees awarded each year [4], yet the teachers qualified to educate these students will not be available without a dramatic increase in the number of physics teachers recruited and trained each year.

PhysTEC [5] is a teacher recruitment and training program that was begun by the American Physical Society (APS), the American Association of Physics Teachers (AAPT) and American Institute of Physics (AIP) in 2001. It is currently run by APS (Theodore Hodapp, PI and Director, and Monica Plisch, Co-PI) and by AAPT (Beth Cunningham, Co-PI) with major funding from the National Science Foundation and the APS 21st Century Fund. The goals of PhysTEC are (1) Demonstrate successful models for increasing the number of highly-qualified high school physics teachers and improving the quality of K-8 physical science teacher education, (2) Spread best-practice ideas throughout the physics teacher preparation community, and (3) Transform physics departments to engage them in preparing physics teachers.

There are two components to the PhysTEC program, (1) Funded Demonstration Sites and (2) a National Coalition.

II. PHYSTEC FUNDED DEMONSTRATION SITES

Since its inception, there have been 21 colleges and universities selected as PhysTEC Funded Demonstration Sites. Nine are currently funded from PhysTEC funds, while twelve that were previously funded, are now sustained with internal and other funding. Fig. 1 shows the current and previously funded PhysTEC sites.

There are two types of Funded Demonstration Sites: Comprehensive Sites that are funded up to $300,000 and Targeted Sites that are funded up to $75,000. In the most recent round of competition (projects beginning fall, 2011) PhysTEC funded only 4 of the 71 proposals that were submitted.

While the Targeted Sites implement some innovative idea(s), the Comprehensive Sites implement all of the components deemed critical to success by PhysTEC. These include: (1) developing special strategies to recruit future teachers from among majors and elsewhere, (2) providing an early teaching experience for interested students (Learning Assistants), (3) introduction of interactive engagement strategies in introductory course(s), (4) mentoring of teachers (at all stages), (5) establishing bridges between key groups (physics department, education school, school districts), (6) hiring of Physics Education Research (PER) faculty, (7) hiring a Master Teacher (Teacher in Residence), and (8) making financial support available for prospective teachers (Noyce Scholarships).

From experiences with current and previous PhysTEC Funded Demonstration Sites, it is clear that there are a number of key elements to making a successful site. There must be a "champion" at the institution who will serve in a number of key roles. This is the person who writes the proposal and leads and promotes the program at the institution. This person will make necessary contacts with the administration to build long-term support, obtain additional and sustainable funding, and work with the Teacher in Residence (see below) to develop physics-specific curricula for pedagogy courses, and to bridge the gap between the physics department, the education school and the K-12 schools. The "champion" will also lead recruitment of students and be the student advocate at all levels within the institution. Without such a "champion," the program will never get off the ground.

Sites Currently Funded by PhysTEC
Boston University
California State University, San Marcos
State University of New York, Genesco
Virginia Tech
California State University, Long Beach
Chicago State University
Middle Tennessee State University
Towson University
University of California, Davis.
Sites Previously Funded by PhysTEC, Now Sustained by Internal and Other Funds
Cornell University
University of Minnesota
University of North Carolina at Chapel Hill
Ball State University
California State Polytechnic University, San Luis Obispo
Florida International University
Seattle Pacific University
Towson University (elementary education project)
University of Arizona
University of Arkansas
University of Colorado at Boulder
Western Michigan University

FIGURE 1. Sites that have been funded by PhysTEC.

A second key element for every Comprehensive Site is the addition of a Teacher in Residence to the physics department. The TIR is a high school physics teacher who is hired by the institution using PhysTEC grant funds. (Various employment arrangements are possible, depending on the particular needs of the institution, TIR and high school. In some cases, the TIR continues teaching part time at his/her high school while also working at the institution. Because of the shortage of qualified teachers, there is sometimes a conflict about removing a teacher from his or her school to become a full-time TIR!) The TIR must be selected carefully and must have special skills, since s/he will serve as the crucial link between the departmental faculty, the schools and the education faculty.

The usual roles of the TIR are: (1) helping establish and foster relationships with the education school, (2) helping

provide linkage to practicing teachers, (3) doing the "leg work" of establishing and maintaining relationships, programs, recruitment efforts, etc., (4) involvement in secondary methods courses (providing the physics perspective), (5) involvement in reforming introductory courses and establishing the Learning Assistant program, (6) providing "reality" check on the teacher education program, (7) acting as mentor during the year and following years to existing local (sometimes distant) physics teachers, (8) interacting one-on-one with prospective teachers, (9) teaching or co-teaching methods and other courses, and (10) coordinating classroom placement and observation of teachers.

A third key element at successful PhysTEC sites is engagement of the physics faculty in this effort by emphasizing its discipline and societal importance. The cooperation and, hopefully, participation of physics faculty is essential for success at (1) setting departmental priorities and initiatives, (2) recruiting future teachers from among physics majors, (3) reforming introductory courses, (4) establishing physics education major tracks in the departmental curriculum, (5) establishing faculty connections with education, and (6) connecting with in-service high school teachers through teacher enhancement activities. The roles of the "champion" and TIR in engagement of faculty cannot be overemphasized.

III. LEARNING ASSISTANTS AND NOYCE SCHOLARSHIPS

One of the hallmarks of all Comprehensive Sites is the creation of Learning Assistant opportunities and the recruitment of undergraduate students to assist in active learning components of the introductory physics courses. These students might serve as assistant introductory lab instructors, instructional assistants in hands-on, interactive, tutorials or facilitators in collaborative problem solving tutorials. These are essential, early teaching experiences for the students that in many cases help them to realize how much they enjoy teaching. In fact it has been found that the Learning Assistant experience is often the strongest recruiter of students into teaching. The availability of peer instructors in the introductory courses also facilitates the introduction of active learning strategies. Furthermore, these active learning experiences model effective ways of teaching that the students will implement in their future high school classrooms.

One of the rewards for students who decide to pursue teaching as a career is the availability of scholarship money for their undergraduate and teacher certification studies. The Robert Noyce Teacher Scholarship Program of the National Science Foundation [6] provides scholarship support of up to $15,000 per year for up to two years for students enrolled in science, technology, engineering, and mathematics majors that will lead to teacher certification as K-12 mathematics and/or science teachers. In return, scholarship recipients are required to complete two years of teaching in a high-need school district for each year of support. The program seeks to increase the number of K-12 teachers with strong STEM content knowledge who teach in high-need school districts. Noyce support is available for junior and senior undergraduates, and post-baccalaureate students pursuing teaching certification. Every Comprehensive Site is required to have Noyce Scholarships available.

IV. UNIVERSITY OF ARKANSAS—A CASE STUDY

The University of Arkansas was one of the first Comprehensive Sites funded by PhysTEC in 2001, and has been one of the most successful. There was an early recognition in the Physics Department of the importance of increasing the number of physics teachers. The fact that the PhysTEC program is a joint program of both AAPT *and* APS was influential in raising the level of interest among the research faculty who might not ordinarily have interest in a purely AAPT program.

As one of the first accomplishments, the Physics Department, in cooperation with the College of Education, designed two physics curricula for pre-education students (middle and high school) that fulfill the requirements for the BA physics degree while also fulfilling the pre-education requirements for entry into the Master of Arts in Teaching program.

Next, the introductory physics sequence was revised—with strong input of the TIR—to present a model of learning through inquiry based activities. Over the years, the PhysTEC initiative has impacted most courses in the introductory curriculum. Learning Assistants were recruited to assist with University of Washington style tutorials [7] in the university physics course, and also to assist in the college physics laboratory.

As part of the PhysTEC collaboration, with large input from the TIR, courses were created in the College of Education to further explore the methodologies used to create the PhysTEC introductory courses. The TIRs continued teaching part-time and maintained relationships with the schools, worked on revision of the college physics lab, helped implement modeling-based group problem solving in university physics, introduced active learning ideas into science methods courses for secondary, middle and elementary school teachers, and developed a mentoring relationship with teachers that carried over from pre-service to in-service through regional AAPT meetings, workshops, and electronically. The site also implemented a successful Noyce Scholarship program.

The dramatic accomplishment of the Arkansas PhysTEC site in increasing physics teacher production is shown in Fig. 2[8], while Fig. 3 shows a summary of the successes of several PhysTEC sites [9].

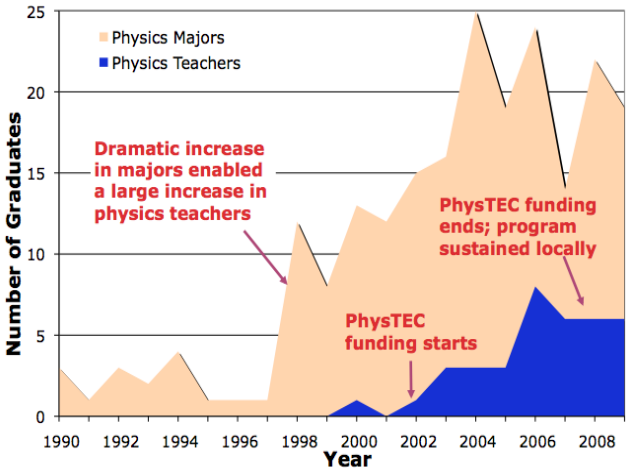

FIGURE 2. Physics teacher production at University of Arkansas 1990-2009.

V. PTEC—THE NATIONAL COALITION

The broader PTEC [10] national coalition currently has over 220 members. Fig. 4 shows the distribution of PhysTEC Funded Sites and PTEC coalition members in the U.S. [11] the broad set of activities sponsored by and for this coalition includes: Annual national conference, identification of community leaders, regional and national topical workshops, sharing of innovative ideas, broad dissemination of what works to improve physics teacher recruitment and preparation. Among the recent national activities have been (1) gatherings at national AAPT meetings in Washington, DC (February, 2010), Omaha, NE (July, 2011) and Ontario, CA (February, 2012), (2) sponsorship of a National Taskforce on Teacher Education that has issued a position paper [12] on best practices, (3) creation of a Physics Teacher Education Digital Library [13], and (4) development of a best-practice book, Physics Teacher Education, *Teacher Education in Physics: Collected Papers* [14].

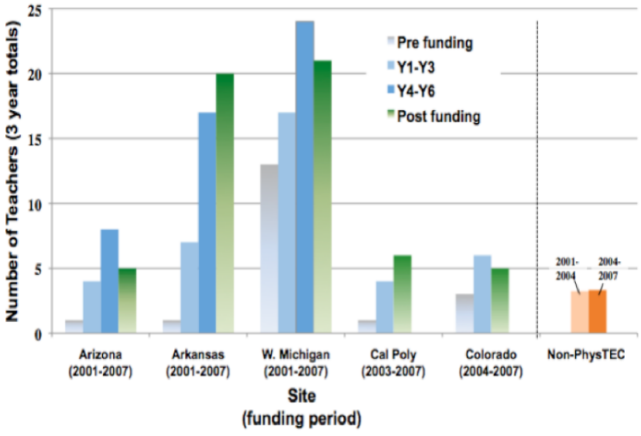

FIGURE 3. Change in physics teacher production at a number of PhysTEC sites during funding period.

VI. CONCLUSIONS

The PhysTEC program, operating since 2001 has been highly successful at increasing the recruitment and preparation of high school physics teachers at a variety of institutions of higher education in the U.S. Its success stems from its mostly faceted approach that not only directly tackles each of the challenges associated with recruitment and preparation of excellent physics teachers, but also dramatically changes the culture within the physics department and at the institution.

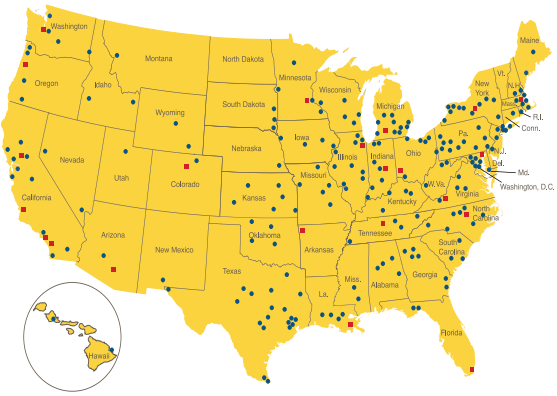

FIGURE 4. Distribution of PhysTEC and PTEC sites in the U.S.

ACKNOWLEDGEMENTS

The author wishes to thank Ted Hodapp, Beth Cunningham and Monica Plisch for providing information on PhysTEC included in this paper.

REFERENCES

[1] See http://www.aaee.org/cwt/external/wcpages/resource/
[2] See http://www.aip.org/statistics/trends/reports/hsteachers.pdf
[3] See http://www.aip.org/statistics/trends/reports/physund08.pdf
[4] Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm*, (The National Academies Press, Washington, D.C. 2007). See http://www.nap.edu/catalog.php?record_id=11463.
[5] See http://www.phystec.org/ for more information on PhysTEC.
[6] See http://nsfnoyce.org/ for more information on the Noyce Scholarship Program.
[7] McDermott, L. C. and Peter, S. Shaffer, *Tutorials in*

Introductory Physics, (Prentice Hall, Upper Saddle River, New Jersey, 2002).
[8] See http://www.phystec.org/institutions/arkansas/index.php.
[9] See http://www.phystec.org/newsletter/fall08.pdf.
[10] See http://www.PTEC.org for more information on PTEC.
[11] See http://www.PTEC.org.
[12] See http://www.ptec.org/webdocs/TaskForce.cfm.
[13] See http://www.ptec.org/features/FeaturedCollections.cfm.
[14] See http://www.ptec.org/webdocs/PtecBook.cfm.