National Task Force on Teacher Education in Physics

Pre-release of Executive Summary

Introduction

Over the past 20 years, academic, business, and governmental authorities have warned that U.S. science teacher preparation needs a drastic overhaul, particularly in physics teacher education. These increasingly urgent warnings are prompted in part by a wide and growing array of measures that show science education in the United States lags well behind much of the rest of the world, and that in some cases, the gap is growing. In addition, the preparation of qualified physics teachers has failed to keep pace with a dramatic increase in the proportion of high-school students taking physics. Consequently, more students than ever before are taking physics from teachers who are inadequately prepared.

There is a severe shortage of qualified physics teachers. The prevalence of weak standards for certification or endorsement to teach physics means that many current physics teachers lack the content knowledge and focused pedagogical preparation with which to help their students most effectively: international assessments show time and again that U.S. students lag behind their counterparts in other industrialized nations. Despite federal legislation mandating highly qualified teachers for every classroom, superintendents and principals confirm a considerable shortage of physics teachers year after year. The shortage is especially severe for those students who take either conceptual physics courses or physics as a gateway to other sciences in high school—a group of students that has experienced the largest increase in size in the last several years.

The potential negative consequences of maintaining the status quo are far-reaching for the U.S. economy and society, for physics as a discipline, and for physics departments at colleges and universities. As international competition for science and engineering talent continues to increase, the United States' ability to recruit foreign-born talent to fuel the nation's technological innovation will decrease. At a time of unprecedented scientific and technological complexity, many U.S. citizens are unable to participate in informed democratic decision-making because they fail to understand, appreciate, and support the unique perspective that physics provides to scientific endeavors and life. Uninspired by physics instruction and unprepared to accept the challenges physics offers, an ever-smaller fraction of science majors are pursuing physics.

To prepare future citizens to tackle 21st-century multi-disciplinary problems, teachers need both a deep understanding of a discipline and of the teaching of that discipline. The urgency in fulfilling this need in physics is as intense and pressing as in any other science field, if not more so. In response to the shortage of physics teachers in the U.S. and concerns over their effectiveness, the American Physical Society, American Association of Physics Teachers, and American Institute of Physics formed the National Task Force on Teacher Education in Physics. The Task Force was charged with documenting the state of physics teacher preparation and with making recommendations for the development of exemplary physics teacher education programs.

Process for Producing this Report

The Task Force engaged in a wide variety of data-gathering activities, including surveying all 758 U.S. physics departments. The survey results provided quantitative teacher-production data and helped the Task Force focus on high-producing institutions (2 or more physics teachers per year)—interviewing faculty to verify and enrich survey data. The Task Force also conducted site visits to institutions that emerged as local, regional, or national leaders in physics-teacher production and/or had promising and potentially replicable high quality programs. In addition, the Task Force consulted extant research results on teacher education, induction, teacher turnover, and physics education, as well as national reports related to student achievement in science, technology, engineering, and mathematics (STEM); analyzed multiple types of

publicly available data to take stock of the current situation in physics teacher preparation in the U.S.; sought advice from teacher education experts, foundation program officers, and policy makers; and collaborated with other organizations with a shared interest in teacher education, including the Association of Public and Land-Grant Universities, American Association of Colleges of Teacher Education, Knowles Science Teaching Foundation, and American Chemical Society.

Task Force Findings

Except for a few excellent programs, the Task Force found that, nationally, physics teacher preparation is inefficient, incoherent, and unprepared to deal with the current and future needs of the nation's students.

Finding 1. Few physics departments and schools of education are actively engaged in the recruitment and professional preparation of physics teachers.

Finding 2. Without exception, all of the most active physics teacher education programs have a champion who is personally committed to physics education. With few notable exceptions, these program leaders have little institutional support.

Finding 3. Institutional context appears to be a significant factor in the engagement of physics departments in physics teacher education. For instance, doctorate-granting institutions produce fewer physics teachers than bachelors- or masters-granting institutions, even though they produce more physics majors.

Finding 4. Few institutions demonstrate strong collaboration between physics departments and schools of education.

Finding 5. Physics teacher preparation programs do little to develop physics-specific pedagogical expertise of teachers.

Finding 6. Few programs provide support, resources, intellectual community, or professional development for new physics teachers.

Finding 7. Few institutions offer a coherent program of professional development for in-service teachers even though most current physics teachers are not adequately prepared to teach physics.

Finding 8. Thriving programs do exist that can serve as models and resources for other institutions. Such programs are characterized by several of the following features, though no institution had all:

- recognition and support of program champions dedicated to physics teacher education;
- targeted recruitment of pre-service physics teachers
- active collaboration between physics departments and schools of education;
- a sequence of courses that are focused on the teaching and learning of physics;
- early teaching experiences led by the physics department;
- individualized advising of teacher candidates by faculty knowledgeable about physics education;
- mentoring by expert physics teachers;
- a rich intellectual community for graduates.

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Task Force Recommendations

The Task Force recommendations address the findings identified throughout the two-year investigation and also reflect a synthesis of relevant results from the literature on science teacher education and development. The 12 recommendations are grouped in three categories: commitment, quality, and capacity.

Commitment

Physics and education departments, university administrators, professional societies, and funding agencies must make a strong commitment to discipline-specific teacher education and support.

1. Institutions that consider the preparation of STEM teachers an integral part of their mission must take concrete steps to fulfill that mission.

2. Physics departments should recognize that they have responsibilities related to the preparation of pre-service physics teachers.

3. Colleges of education should recognize that programs to prepare physics teachers must include pedagogical components specific to the preparation of physics teachers; broader "science education" courses are not sufficient for this purpose.

4. Federal and private funding agencies—including the National Science Foundation and the U.S. Department of Education—should develop a coherent vision for discipline-specific teacher preparation and development.

5. Professional societies should provide support, intellectual leadership, and a coherent vision for the joint work of disciplinary departments and schools of education in teacher preparation.

Quality

All components of physics teacher preparation systems should focus on improving student learning in the pre-college physics classroom.

6. Teaching in physics courses at all levels should be informed by findings published in the physics education research literature.

7. Physics teacher preparation programs should provide teacher candidates with extensive physics-specific pedagogy and physics-specific clinical experiences.

8. Physics teacher education programs should work with school systems and state agencies to provide mentoring for early career teachers.

9(a) States should eliminate the general-science teacher certification and replace it with subject-specific endorsements.

9(b) Higher education institutions should create pathways that allow prospective teachers to receive more than one endorsement without increasing the length of the degree.

10. National accreditation organizations should revise their criteria to better connect accreditation with evidence of candidates' subject-specific pedagogical knowledge and skill.

11. A coordinated physics education research agenda should be developed to identify and address key questions related to physics teaching quality and effective physics teacher preparation.

Capacity

The United States should take significant steps to alleviate the severe shortage of qualified physics teachers.

12. Physics departments and schools of education should design pathways for multiple populations to become well-prepared physics teachers: undergraduate students who have not yet chosen a major, undergraduate STEM majors, graduate students in STEM disciplines, STEM teachers who may not yet be prepared to teach physics, and STEM professionals such as engineers, scientists, and laboratory technicians.

A National Proposal: Regional Centers in Physics Education

The Task Force recommendations address crucial issues associated with individual institutions and programs. However, an effective and coordinated national strategy in physics teacher education must go beyond the individual implementation of the Task Force's recommendations listed above. An innovative national program is needed both to utilize all resources currently available, and to develop new resources, expertise, and capacity in order to meet current and future national needs. Toward this end, the Task Force recommends the establishment of regional centers in physics education. Existing exemplary programs of physics teacher preparation could serve as nuclei for such centers.

Funded by colleges, universities, private foundations, as well as by federal and state agencies, these centers would be the main regional producers of quality physics teachers and be a nexus for scholarly work on physics education. In addition to graduating early-career teachers of physics in sufficient numbers to meet regional needs, the centers also would improve student learning of physics at the elementary and middle-school levels by helping veteran science teachers at these levels deepen their knowledge of and skills in teaching physics. The scholarship conducted at regional centers would include research on teacher preparation, investigation and assessment of student learning, development of instruments to assess teacher attributes and impacts, program evaluation, and development of education policy. Finally, such regional centers may serve as models for discipline-based preparation and enhancement of other STEM-discipline teachers.