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The Role of Physics Departments in High School Teacher Education

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The Task Force on Teacher Education in Physics (T-TEP) was convened by APS, AAPT and AIP to examine high school physics teacher education in the United States and make recommendations for its improvement. T-TEP found that, except for a handful of isolated pockets of excellence, the national landscape of physics teacher preparation shows a system that is largely inefficient, mostly incoherent, and completely unprepared to deal with the current and future needs of the nation's students.* Physics departments have an indispensable role to play if every high school student is to have the opportunity to learn physics with a qualified teacher. However, most physics departments currently avoid playing an active role in physics teacher education. We believe this avoidance is not in the best interests of the physics community.

I. The impact of pre-college science education on the physics community

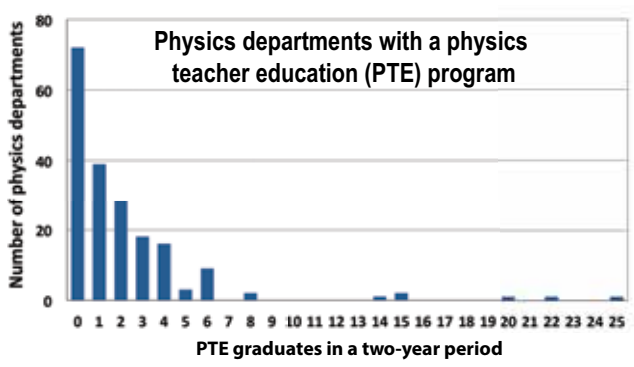
The US physics community has become habituated–perhaps unconsciously–to a pre-college science education system that is relatively weak by international standards. Several studies have confirmed that, when comparing equivalent student populations, US science students rank no better than middle-of-the-pack among developed nations, and indications are that physics students rank even lower. There is no great mystery regarding the cause: pre-college students in other countries study science–including physics–for more years than they do in the US, and other nations tend to put substantially more resources into preparing highly qualified science teachers for those students. Five years of study by T-TEP have shown that, despite the presence of many devoted and highly qualified high school physics teachers, the *overall* situation for US high-school physics students is not good.

The impacts of our weak pre-college science-education system are visible to varying degrees. Despite recent growth in the number of physics bachelor's degrees, the proportion of students who elect to major in physics has been shrinking: in fact, the number of physics bachelor's degrees awarded in 2010 was virtually identical to that in 1970, even though the overall number of bachelor's degrees had more than doubled. Among the consequences of this shrinking proportion is an increasingly successful campaign by some state education administrators to eliminate the physics major from "lower producing" departments. While there are many factors behind the low and declining proportion of physics majors, there can be little doubt that pre-university science education has a significant influence. Several studies have shown that students' decisions to major in science fields, including physics, are usually made well before their departure from high school. Moreover, college students who receive inadequate physics preparation in high school are at a substantial disadvantage when trying to complete a standard physics-major curriculum within four years. Studies have shown that US students beginning undergraduate work are not as well prepared in physics as are many of their foreign counterparts.

Many physics faculty are aware that, among US physics Ph.D graduates, US citizens are outnumbered by foreign citizens. An important contributing factor is that the number of US citizens who go on to physics graduate study tends to follow trends in the number of physics majors; fewer majors means a smaller pool to fill openings for graduate students. One might argue that there is no problem so long as foreign citizens are available to fill gaps left by domestic students. However, the supply of foreign graduate students is not assured long term as global investments in R&D continue to rise relative to US levels of spending. A weak science-education system is a potential liability in seeking to increase the domestic supply of physics students.

There are additional impacts of the science-education system. It is reasonable to assert–though difficult to prove–that weaknesses in pre-college science education undermine potential social support for the US science research enterprise. It is difficult to cultivate respect and support for a field that is neither well understood nor well liked by citizens who were denied an enjoyable and rewarding science education during their schooling. Weak science education also limits production of high school and college graduates with the skills needed for an increasingly high-tech economy.

Efforts to improve the US science-education system must include dramatic changes in physics teacher education; such changes may not be sufficient, but they are certainly necessary. T-TEP has found that the present system of U.S. physics teacher education is inadequate. To start with the most obvious problem, most physics teachers don't have adequate physics content backgrounds; about two-thirds of them did not major in physics or physics education. Of the minority who do have adequate content knowledge, only a small portion actually had specialized preparation in physics teaching, not merely in "general science" teaching. Not coincidentally, physics teacher preparation is scattered among hundreds of institutions, only a few of which can and do devote the resources necessary to do a good job.



II. The role of physics departments

Physicists tend to regard the situation of weak pre-college science education in the US with some resignation, believing that it is neither their job to deal with this situation directly, nor that it has any significant impact on the effectiveness of their own work or on the physics community. To the contrary, we argue, it does have an impact, and–while it may not be their "job"–university physics faculty bear some responsibility for both the causes of and the potential remedies for this unsatisfactory state of affairs. For one thing, most US. physics teachers received their physics education though US physics departments, if they received one at all. More to the point, if physics departments don't take substantial responsibility for this process, they can be sure that no one else will either: education schools have little motivation and few resources to address deficiencies in physics teacher education; neither do state education departments. There simply is no other "responsible" party, like it or not.

To be sure, in such a complex system as teacher education, there are plenty of potential culprits to hold responsible for poor outcomes. And, in our experience, our tendency as physicists is to do just that and engage in finger pointing at others. Though perhaps justified, this ignores a zeroth-order explanation: the typical university physics department neither actively recruits nor culturally supports prospective physics teachers, nor provides specialized preparation for their future endeavors. According to a T-TEP survey of all US physics departments, the typical department graduates exactly zero physics teachers every two years (see figure).

As long as physics departments place primary responsibility for the preparation of physics teachers somewhere else, abdicating their own role in the process, future teachers lose the guidance of the only community able to communicate the unique habits of mind that physicists possess. Worse still, high school physics education loses its most natural and ardent advocate. Physics is a relatively small player in STEM precollege education. Although physicists see physics as a special way of knowing–not just a collection of facts and formulas–policymakers tend to view physics as just another package (among many competing packages) of stuff to be learned, and therefore a dispensable luxury. The argument goes as follows: Students have to take science. Physics teachers are scarce. Let students take environmental science or more biology to fulfill their generic "science" requirement. Who, then, will stand up for the importance of physics education, if not the physicists themselves?

Many physics departments convey to their students (often unintentionally) the message that teaching is a second-class career option, that being a physics teacher is a compromise someone would make if their first option–graduate school–did not pan out. After all, the thinking goes, aren't a decent command of content, tolerance toward adolescents, and willingness to jump through education hoops the only requirements for becoming a teacher? Isn't the life of a researcher the only true and noble calling for a physics major? We want to believe that no university physics faculty member consciously communicates these shortsighted views to students. Yet, they are what many students pick up.

We envision a very different situation, one in which most physics departments see part of their mission as encouraging talented students to consider physics teaching as a career, and in which many physics faculty are actively engaged in the education of future teachers. Many of these physics departments would partner with expert practicing teachers to provide students with diverse role models of high-quality physics teaching, and together they would mentor bright students who sought careers as physics teachers. As a consequence, increasing proportions of high school students would experience exhilarating physics courses from inspirational, knowledgeable teachers before they even began university study. Moreover, at this time of national emphasis on the need for more and better prepared STEM teachers, a physics department that aligns itself with such institutional and national priorities is likely to upgrade its perceived value both within the university, and within society as a whole.

We believe that physicists and physics departments are capable of addressing the problem of high-quality physics teacher education quite effectively. Indeed, there are physics departments that graduate relatively large numbers of teachers from excellent programs; some of these are indicated by the outliers in the histogram distribution (see figure). The T-TEP recommendations for physics departments center on (i) developing strong content-knowledge background, (ii) cultivating early physics teaching experiences under expert mentorship, and (iii) developing special courses focused specifically on physics pedagogy. The US has never come close to meeting these recommendations for the great majority of its physics teachers.

III. What can be done

As physics faculty we can begin by asking: How many of our students have thought about becoming a teacher? If we do not know the answer, we should ask the students; their responses may be surprising. Our experience has been that a significant fraction of students consider teaching at some point in their undergraduate program. A physics department that offers an encouraging and supportive environment for future teachers can make a difference in what career students ultimately decide to pursue (and in the overall number of students pursuing a physics degree).

There are a number of steps physics faculty can take to get started. Many of these actions do not require a lot of time:

- Find out what courses and other requirements are needed to earn a physics degree and teaching certification at your institution. Make this information widely available, for example, on the department website, in the course catalog, and as a handout for advising.
- Make an announcement in introductory classes about physics teacher education and whom to contact if students are interested. The contact should be knowledgeable about certification pathways and prepared to help students navigate the requirements.
- Ask students with an aptitude for teaching if they have considered becoming a teacher. Share personal values about teaching and why it is important.
- Invite a local physics teacher to give a presentation and meet with students interested in teaching. It is even better if the teacher is an alumnus of the department or is close in age to the students.
- Go to lunch with the education faculty member in charge of the secondary science education program. Learn more about the certification program and look for opportunities to work together. Showing respect for the expertise of education colleagues can help build the relationship and open doors.
- Consider making early teaching experiences available through the physics department. Such opportunities can help students identify a passion for teaching and experience its intellectual challenges and rewards

An important resource is the Physics Teacher Education Coalition (PhysTEC) project, led by APS with AAPT since 2001. PhysTEC-supported sites have collectively more than doubled the number of their graduates prepared to teach physics, primarily by changing what happens in physics departments. PhysTEC has over 280 member institutions, and organizes an annual conference To learn more or become a member institution, visit ptec.org and phystec.org.

Meltzer, Plisch and Vokos are the editors of the T-TEP report. Meltzer is an APS Fellow and a faculty member of the Mary Lou Fulton Teachers College at Arizona State University. Plisch is Associate Director of Education and Diversity at APS. Vokos is T-TEP chair and professor of physics at Seattle Pacific University.

* The complete T-TEP report may be downloaded at www.ptec.org/taskforce