

Physics Teacher Preparation: The Conflict Between Recommendations and Reality

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ABSTRACT

For most of the past 200 years, one of the recognized objectives of college physics instruction has been to prepare teachers of high school physics. The physics community has long debated the appropriate nature and content of such preparation, and over time has arrived at various consensus recommendations. These recommendations have in fact been issued and re-issued at various times over the past 130 years but have been, nonetheless, highly consistent from one decade to the next. The recommendations include (1) physics content knowledge equivalent to that associated with a major or minor in physics; (2) experience and preparation adequate to guide students to deduce physical models from observations and experiment; (3) taking specialized courses designed specifically for prospective physics teachers. For the majority of U.S. physics teachers, these recommendations have not yet been realized.

HISTORICAL CONSTRAINTS ON U.S. PHYSICS TEACHER EDUCATION

- persistence of small high schools, due to the vast geographical territory and widely scattered population of the U.S. during the 1800s and early 1900s
- Physics taught in the U.S. only as single one-year course, typically for third- or fourth-year students;
- College and high school requirements for physics were (mostly) eliminated around 1900, at the same time that the number and variety of courses available for study were rapidly increasing.

TEACHING BY INQUIRY: THE "INDUCTIVE METHOD"

"...[in inductive teaching,] although the principles and laws are stated, the experiments have preceded them; many questions are asked in connection with the experiments that tend to make the student active, not passive, and allow him to think for himself before the answer is given, if it is given at all." [Wead, 1884]

"I would keep the pupil just enough in the dark as to the probable outcome of his experiment, just enough in the attitude of discovery, to leave him unprejudiced in his observations, and then I would insist that his inferences... must agree with the record... of these observations... the experimenter should hold himself in the attitude of genuine inquiry." [Hall, 1902]

"The student can get real command of a general principle only when he has arrived at it inductively through a considerable number of concrete cases, out of which he has analyzed the general principle through his own mental processes. He must have perceived in the various concrete cases the common features which the general principle describes; else he can have no real command of the principle.... So it is of fundamental importance that his teacher shall so direct him that he must do this inductive thinking himself. The crucial test of his success is ability, first to state the principle in his own words...." [Twiss, 1920]

References

- [Wead] C. K. Wead, *Aims and Methods of the Teaching of Physics* (Government Printing Office, Washington DC, 1884).
- [Hall, 1902] E. H. Hall, "The Teaching of Physics in the Secondary School," in Smith and Hall, *Teaching of Chemistry and Physics* (NY, 1902)
- [Hall, 1909] Edwin H. Hall, "The relations of colleges to secondary schools in respect to physics," *Science* **30**, 577-586 (1909).
- [Twiss] G. R. Twiss, "The reorganization of high school science," *School Science and Mathematics* **20**, 1 (1920).
- [AAAS] AAAS Cooperative Cttee. on the Teaching of Science and Mathematics, "Preparation of high school science teachers," *Science* **131** (1960)
- [NAS] Physics Survey Committee, National Academy of Sciences, *Physics: Survey and Outlook* (Washington, D.C., 1966), p. 30.
- [CCP] Commission on College Physics, *Preparing High School Physics Teachers* (College Park, MD, 1968)
- [NRC] Physics Survey Committee, National Research Council, *Physics In Perspective, Volume II* (Washington, D.C., 1973), pp. 1145-1146.
- [AAPT] AAPT, *The Role, Education, and Qualifications of the High School Physics Teacher* (AAPT, College Park, MD, 1988)

RECOMMENDATIONS OF THE PHYSICS COMMUNITY

1. Deep Content Knowledge is Necessary

1884: "...the teacher should have a knowledge far exceeding the amount he must teach..." [Wead]

1909: Physicists recommend that teacher preparation should be at level of graduate student in physics [Hall]

1968: AAPT/AIP recommend minimum of 24 hours, or 18 hours plus "in-service training" [CCP]

1988: AAPT recommends preparation equivalent to physics major [AAPT]

2009: AAPT says "ideally...major in physics," or add "one or more physics teaching methods courses."

2. Prepare Teachers to Teach through Inquiry

1884: The "weight of opinion is decidedly that at first the teaching should be inductive" although "the teacher has probably known little or nothing of it in his own [college] education" [Wead]

1920: NEA Physics Chair says "prospective teachers must approach all their teaching problems inductively...college science teachers must foster in prospective teachers the inductive rather than the cock-sure habit of mind." [Twiss]

1968: AAPT/AIP committee advocates courses for teachers using "learning by discovery" method: "This type of course leads a student to puzzle things through for himself, offering both the experience of being a scientist and the satisfaction that accompanies success." [CCP]

1973: Physics Survey Committee (NAS) says "successful use of inquiry-directed instruction requires teachers who have themselves learned to investigate in this manner" [NRC]

3. Create Special Courses for Physics Teachers

1884: "...training in teachers' classes...aims largely to give a knowledge not only of facts and their presentation but of the points of special difficulty...." [Wead]

1960: AAAS recommends second-year physics course, "preferably specially planned for the teacher" [AAAS]

1968: AAPT/AIP committee recommends physics courses specifically designed for prospective physics teachers. [CCP]

1973: Physics Survey Committee (NAS) advocates "widespread introduction of courses... intended for elementary and secondary school teachers" [NRC]

REALITY: INADEQUATE SUPPLY OF QUALIFIED PHYSICS TEACHERS

1. Most Physics Teachers Have Less Than Recommended Preparation
2. Physics Teachers Spend Much of Their Time Teaching Other Subjects
3. Physics Teacher Education Programs Produce Few Graduates

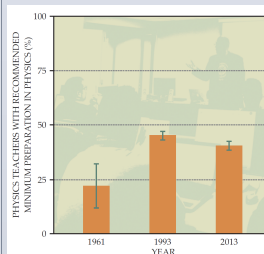


FIGURE 2. THE RANKS OF US HIGH SCHOOL PHYSICS TEACHERS trained in physics have grown over the past several decades, but fewer than half have the minimum 24 credit hours of physics preparation recommended by the Commission on College Physics. For the 1993 and 2013 data shown here, that fraction is approximated as the proportion of teachers who had earned either a major or minor in physics or physics education and error bars represent 95% confidence intervals. (For the 1961 data, error bars indicate the fraction of teachers having between 18 and 29 credit hours.) Older, statewide surveys suggest that, in the years before World War II, fewer than 20% of physics teachers had the recommended preparation. (Data from ref. 18.)

From: Otero and Meltzer, *The Past and future of physics education reform* (2017)

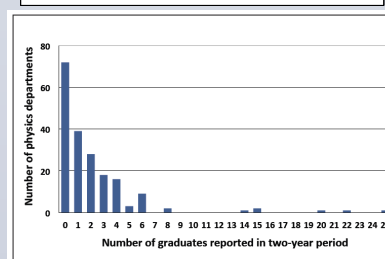
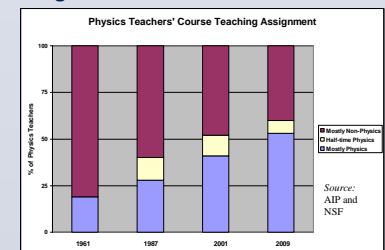


Figure 6. Distribution of graduates from teacher education programs in physics departments

From: Meltzer, Pilsch, and Vokos, *Transforming the Preparation of Physics Teachers* (2012), p. 14