North Carolina State University

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Physics Teaching: The Role of Colleges and Universities in the Preparation of Future Teachers

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Project Funding

- National Science Foundation (PHY, DUE, ESIE, DMR)
- Department of Education (FIPSE)
- APS Campaign for the 21st Century (Gordon Moore)
# Need for High School Physics Teachers

## Relative Demand by Field

### Fields with Considerable Shortage (5.00 - 4.21)

<table>
<thead>
<tr>
<th>Field</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional/Behavior Disorders</td>
<td>4.42</td>
</tr>
<tr>
<td>Severe/Profound Disabilities</td>
<td>4.35</td>
</tr>
<tr>
<td>Mathematics Education</td>
<td>4.28</td>
</tr>
<tr>
<td>Physics</td>
<td>4.26</td>
</tr>
<tr>
<td>Mental Retardation</td>
<td>4.26</td>
</tr>
<tr>
<td>Mild/Moderate Disabilities</td>
<td>4.23</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>4.21</td>
</tr>
</tbody>
</table>

### Fields with Some Shortage (4.20 - 3.41)

<table>
<thead>
<tr>
<th>Field</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>4.20</td>
</tr>
<tr>
<td>Multicategorical</td>
<td>4.20</td>
</tr>
<tr>
<td>Visually Impaired</td>
<td>4.19</td>
</tr>
<tr>
<td>Hearing Impaired</td>
<td>4.17</td>
</tr>
<tr>
<td>Bilingual Education</td>
<td>4.10</td>
</tr>
<tr>
<td>Technology Education</td>
<td>4.02</td>
</tr>
</tbody>
</table>
Teacher Shortages

Education policy researchers have been predicting a major teacher shortage for the past two decades. Based on information from the most recent national Schools and Staffing Survey (SASS), the U.S. Department of Education estimates that an additional 2.2 million teachers will be needed over the next decade, exceeding the annual production rate of new teachers. More specifically, “hard-to-staff” schools in high-poverty urban and rural districts will require more than 700,000 new teachers in the next 10 years. Many states also have identified specific subject-area shortages that exist across their schools in topics such as math and science.

Education Commission of the States
Calls to Action

• Rising Above the Gathering Storm:

**Action A-1:** Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds.

**Action C-1:** Increase the number and proportion of US citizens who earn physical-sciences, life-sciences, engineering, and mathematics bachelor’s degrees by providing 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions.
## Preparation of High School Physics Teachers

### Teacher Specialization: Academic Training and Experience

<table>
<thead>
<tr>
<th>Specialist</th>
<th>Career</th>
<th>Occasional</th>
</tr>
</thead>
<tbody>
<tr>
<td>32%</td>
<td>40%</td>
<td>28%</td>
</tr>
</tbody>
</table>

- **Specialist**: PHYSICS DEGREE AND PHYSICS TEACHING EXPERIENCE
- **Career**: NO PHYSICS DEGREE BUT EXTENSIVE PHYSICS TEACHING EXPERIENCE
- **Occasional**: NO PHYSICS DEGREE AND LITTLE PHYSICS TEACHING EXPERIENCE

### Statistics:

- **Chemistry**: 5%
- **Physical Science**: 2%
- **Math**: 5%
- **Other Science Fields**: 8%
- **Multiple Science Fields**: 8%

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*Teachers with physics degrees but insufficient physics teaching experience are excluded from this figure (3%).

**Career physics teachers include those who have taught physics as much as, or more than, any other subject, or have taught it for ten or more years. The distribution of highest degree earned by career teachers was spread evenly across the sciences, with 29% in math/engineering, 25% chemistry, 22% biology, and 14% in other science fields.*

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AIP Statistical Research Center: 2000-01 High School Physics Survey
Demographics of High School Physics Teachers

- 21,300 Physics Teachers Nationwide
- 1,000 new physics teachers each year
- ~300 of these have physics major or minor
- Number taking physics growing by 1% per year
- Need roughly 1% of 21,000 new teachers each year (~200)
Students in US Public Schools Taught by Teachers with No Major or Minor, and no Certification in the Subject Taught, 1999-2000

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Grades 5-8</th>
<th>Grade 9-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>17%</td>
<td>6%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>22%</td>
<td>9%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>41%</td>
<td>16%</td>
</tr>
<tr>
<td>Biology-Life science</td>
<td>29%</td>
<td>10%</td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
<td>9%</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td>17%</td>
</tr>
</tbody>
</table>

Teacher retention in 5 years (N = 11,787) among teachers who entered the profession in four midwestern states in 1995-1996.

- **Physics**: 13 Movers, 40 Leavers
- **Math**: 21 Movers, 31 Leavers
- **Chemistry**: 18 Movers, 32 Leavers
- **General Science**: 17 Movers, 32 Leavers
- **Biology**: 19 Movers, 19 Leavers
- **Secondary**: 21 Movers, 29 Leavers
- **Elementary**: 18 Movers, 26 Leavers
- **All Teachers**: 23 Movers, 28 Leavers

Elementary Teachers: Under-prepared to Teach Science

- Only 15% of elementary math and science lessons judged to be high quality

- Examples include:
  - A primary grade science lesson in which students drew their favorite animal, but never focused on science concepts
  - A science class where students followed the steps through laboratory procedures, but did not seem to understand why they were doing what they were doing.

PhysTEC Project Goals

• Demonstrate and provide 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 community
• Work toward transforming physics departments to re-engage in the preparation of physics teachers
PhysTEC Project

National Coalition (PTEC)
- National Conference
- Recognized Programs
- Community Leaders
- Sharing Innovative Ideas
- Broad Dissemination

Demonstration Project (PhysTEC)
- 8 National Sites
- Comprehensive Program
- Teacher-in-Residence
- Physics, Education Collaboration
Solving the Problem: High School Teacher Education

Complex Collaboration

Culture Shift

- Recruitment
- Early field experience
- Interactive engagement in intro course
- Mentoring (at all stages)

- Bridges between key groups (physics department, education school, school districts)
- Physics Education Research (PER) faculty
- Financial support for prospective teachers
- PTEC is a resource
Comprehensive Program: Examples

Learning Assistants:
- Undergraduate teaching assistants
- Express an interest in teaching
- Concurrent 1-credit, free, pedagogy course

- Recruitment
- Early field experience
- LA’s match grad student performance
- Class perf. goes up too
Teacher in Residence Activities:

• Help establish and foster Teacher Advisory Groups (TAGs) that provide linkage to practicing teachers
• Do the “leg work” of establishing and maintaining relationships, programs, recruitment efforts, etc.
• Involved (physics perspective) in secondary methods courses
• Provide “reality” check on teacher education programs
• Act as mentor during year and following years to existing local (sometimes distant) physics teachers (~10-20 hrs/wk)
• 1-on-1 interaction with prospective teachers
• Teaching or co-teaching methods and other courses (5 of 7 in 2006, all involved at some level, ~16-20 hrs/wk)
• Classroom placement and observation
Mentoring

Having a mentor during the first year of teaching significantly increases the odds that a teacher will stay in the profession. Half of teachers (50%) who plan to remain in the profession were assigned or matched with a mentor during their first year of teaching, compared to only 29% of those who plan to leave.

2006 Met Life Survey
Physical Science for Elementary and Middle School

Three research-tested curricula

• PET (Physics for Elementary Teachers, SDSU)
• PIPS (Powerful Ideas in Physical Science, AAPT)
• PbI (Physics by Inquiry, U Washington)

Adopting curriculum is relatively easy

• Fits science requirement in most schools
• Known curriculum w/ supporting materials
• Faculty development workshops available
• Education department can require course
• Standard service load
PhysTEC: Producing More Secondary Physics Teachers

- Total Production Rate: 1.3 ⇒ 2.8 (/year /site) (>2x increase)
- Teachers Produced 2006: 22 (~7% of nation) (21 est. for 2007)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Prior to Project Start</th>
<th>2002-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Arizona</td>
<td>0.7</td>
<td>1.8</td>
</tr>
<tr>
<td>University of Arkansas</td>
<td>0.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Cal Poly, San Luis Obispo</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>1.0</td>
<td>1.0*</td>
</tr>
<tr>
<td>Western Michigan</td>
<td>4.3</td>
<td>7.8</td>
</tr>
</tbody>
</table>

*Only 2nd year in project, pipeline numbers significantly better
PhysTEC Project Successes

- Elementary Teachers: 1,400 (Towson, Cal Poly, Ball State, Colorado, Arkansas) (420/year)
- 0.46 FCI, 0.42 CSEM Averaged normalized gain scores (Hake method) for reformed introductory courses
- Teacher-In-Residence funded internally at 6 institutions
- Established national coalition of institutions (PTEC) and annual conference for sharing best-practice ideas (72 member institutions)
Coalition Activities

- National Conference on Physics and Physical Science Teacher Education:
  
  **3-4 Mar 2007** Theme: *Recruitment* (Boulder, CO)
  
  **22-23 Feb 2008** Theme: *Master Teachers* (Austin, TX)

- Physics Teacher Education Digital Library [www.PTEC.org](http://www.PTEC.org)
  - Feature nationally recognized programs and program elements, share ideas, products, events

- Visiting Scholar Program

- Best-practice book to bring together information on Physics Teacher Education, **Editor: David Meltzer**
Final Thoughts

• Recent expansion of PhysTEC netted 45 applicants in solicitation that went out October 2006. Currently expanding PhysTEC supported sites to include:
  • Cornell University
  • Florida International University
  • University of Minnesota
  • University of North Carolina - Chapel Hill

• **PTEC-NC: 3 August 2007, Greensboro, NC**

*I am learning that to be effective, I need to be affective, meaning I need to work hard to get to know my students, then I can better help them grow as students.*

Wayne Fisher, Physics Teacher, Charlotte, NC