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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>

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Need for High School Physics Teachers

“Up to 162 Iowa high school physics teachers will be eligible to retire in the next four years — 28 percent of all physics teachers in the state. Meanwhile, only 64 to 68 Iowa college students are in the pipeline to replace them, according to the Iowa Department of Education.”

Des Moines Register, 30 October 2005

“In about five years, we're not going to have anybody to teach physics”

Iowa Gov. Tom Vilsack, October 2005
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></td>
<td>40%</td>
<td>28%</td>
</tr>
</tbody>
</table>

- Specialist: 32%
  - Physics degree and physics teaching experience*
- Career: 40%
  - No physics degree but extensive physics teaching experience**
- Occasional: 28%
  - No physics degree and little physics teaching experience
  - Chemistry 5%
  - Physical science 2%
  - Math 5%
  - Other Science fields 8%
  - Multiple science fields 8%

*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.

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

- 21,300 Physics Teachers Nationwide
- 29% Physics teachers are women
  - 46% of HS physics students are female
  - 25% of those taking Physics AP C are women
- 1,000 new physics teachers each year
- ~300 of these have physics major or minor

- 3.5 M students in each HS class
- 1 M taking physics
- Number taking physics growing by 1% per year
  - Need roughly 1% of 21,000 new teachers each year (~200)

Source: AIP Statistics, College Board
Demographics of High School Physics Students

% HS Students Taking Physics

Year

Source: AIP Statistics
Students Taking Advanced Science Courses: 1990-2000

Science


Science and Engineering Indicators 2006
Demographics of High School Physics Students

High School Physics: Enrollment Distribution

<table>
<thead>
<tr>
<th>Year</th>
<th>Conceptual</th>
<th>Regular 1st year</th>
<th>Honors</th>
<th>AP/2nd year</th>
<th>Total Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>4</td>
<td>81%</td>
<td>11</td>
<td>4</td>
<td>624,000</td>
</tr>
<tr>
<td>1990</td>
<td>10</td>
<td>73%</td>
<td>12</td>
<td>5</td>
<td>623,000</td>
</tr>
<tr>
<td>1993</td>
<td>8</td>
<td>67%</td>
<td>13</td>
<td>6</td>
<td>697,000</td>
</tr>
<tr>
<td>1997</td>
<td>11</td>
<td>58%</td>
<td>15</td>
<td>8</td>
<td>807,000</td>
</tr>
<tr>
<td>2001</td>
<td>11</td>
<td>55%</td>
<td>13</td>
<td>11</td>
<td>931,000</td>
</tr>
<tr>
<td>2005*</td>
<td>14</td>
<td>45%</td>
<td>16</td>
<td>12</td>
<td>&gt;1,000,000</td>
</tr>
</tbody>
</table>

* Percent of students in regular first-year physics courses that use conceptual physics textbooks.

**Preliminary estimate


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The Center for the Study of Teaching\(^1\) reported that the most consistent and powerful predictor of student achievement in science and mathematics was the presence of teachers who were fully certified and had at least a bachelor’s degree in the subject taught.

Teachers with content expertise, like experts in all fields, understand the structure of their disciplines and have cognitive “roadmaps” for the work they assign, the assessments they use to gauge student progress and the questions they ask in the classroom\(^2\).


Physics and Physical Science Certification

Public School Certification Rates in Assigned Teaching Fields

Source: Council of Chief State School Officers, State Indicators of Science and Mathematics Education: 2003

% Certified

- High School Physics
- Middle School Science

Year


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## Physics and Physical Science Certification

**Students in US Public Schools Taught by Teachers with No Major or 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>58%</td>
<td>30%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>93%</td>
<td>63%</td>
</tr>
<tr>
<td>Biology-Life science</td>
<td></td>
<td>45%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>61%</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td>67%</td>
</tr>
</tbody>
</table>

Elementary Teachers: Under-prepared to teach Science

- Only 4% have degrees in science
- Only 56% have had a science methods course and education in each science discipline (recommended by the NSTA)
- Only 14% feel “very well qualified” to teach science, and 27% reported “not well qualified” (compare to 1% who said same for either math or reading). Physical science ranks the worst of all disciplines in this way.
- Two-thirds (65%) are unfamiliar with the national (NRC) standards
- 30% felt they were well prepared to use the Internet
- Large fractions of elementary teachers perceived a substantial need for professional development in science instruction
  - 84%: Improved use of technology/Internet
  - 72%: Deepen content knowledge
  - 65%: Learn how to use inquiry in the classroom

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 lesson that attempted to teach a 3rd grade class about buoyancy, clearly not developmentally appropriate for these students
  - 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.

Solving the Problem: Elements of Successful Programs

- Recruitment
- Interactive engagement in intro course
- Early field experience
- Mentoring (in-service activities)

- Bridges between key groups (physics department, education school, school districts)
- PER faculty
- Financial support for prospective teachers
PhysTEC Project

- Funding: NSF, APS, Dept. of Education (total: ~8M)
- Collaborative effort between APS, AAPT, AIP
- 8+ year effort to demonstrate and disseminate models of effective physics teacher preparation
- Goals:
  - Educate more better-prepared physics and physical science teachers
  - 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)
- Recognized Programs
- Community Leaders
- Sharing Innovative Ideas
- National Conference
- Broad Dissemination

www.PTEC.org

Demonstration Project (PhysTEC)
- 8 National Sites
- Comprehensive Program
- Teacher-in-Residence
- Physics, Education Collaboration

www.PhysTEC.org
PhysTEC Project: Diverse Institutional Types

- University of Colorado
- University of Arkansas
- University of Arizona
- Oregon State University
- Cal Poly San Luis Obispo
- Ball State University
- Western Michigan University
- Towson University
- Xavier University of Louisiana
- Seattle Pacific University

Diverse Institutional Lessons

www.PTEC.org  www.PhysTEC.org
PhysTEC Project: Comprehensive Program

- Recruitment
- Early teaching experiences
- Reformed courses
- Collaborative engagement
  - Physics department (*content and pedagogy*)
  - Education department (*pedagogy in context*)
  - School districts (*reality*)
- Induction and mentoring

- **Teacher-in-Residence**
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
Comprehensive Program: Examples

Teacher in Residence (TIR):

- PhysTEC parameters:
  - 1 year appointment, on-leave from classroom
  - Stationed in the physics department (attend faculty meetings, supported strongly by faculty member)
  - Typically a “master” teacher
  - Salary paid to the school district to avoid sense of separation, loss of seniority, etc.
  - Return to classroom after 1 year
  - Provide non-threatening perspective to faculty
  - Provide bridge to schools, education department
Comprehensive Program: Examples

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 (with a 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)
Comprehensive Program: Examples

Physical Science for Elementary Teachers:

- Three research-tested curricula
  - PET (Physics for Elementary Teachers, SDSU)
  - PIPS (Powerful Ideas in Physical Science, AAPT)
  - PbI (Physics by Inquiry, U Washington)
PhysTEC: Producing More Secondary Physics Teachers

- Total Production Rate: 1.1 ⇒ 3.3 (per year, per site) (3x increase)
- Teachers Produced 2006: 26 (~10% of nation)

<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>2.5</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Western Michigan</td>
<td>4.3</td>
<td>7.5</td>
</tr>
</tbody>
</table>
PhysTEC
Project Successes

- Elementary Teachers: 962 (Cal Poly, Towson, Ball State) (390/year)
- 0.41 Averaged Normalized Gain Scores (Hake method) for reformed introductory courses
- PhysTEC Enrollment: Conceptual (3900), Algebra (3500), Calculus (5700), Total (13,100)
- Teacher-In-Residence funded internally at Cal Poly, OSU, Colorado
- Physics Education Research (PER) Faculty line at WMU (8 of 10 institutions have PER faculty)
- Conversation, collaboration instead of antagonism at Arkansas
PhysTEC
Lessons Learned

• Results from SPIN-UP apply here too: *Compassion is key*
• School districts reluctant to give up master teachers, new term length for TIR may be more effective
• PER faculty bring drive, knowledge to project
• Upper administration support key (typically at the dean or provost level)
• Recruitment works... Must be genuine
• Other funds are available; National Academy’s “*Rising Above the Gathering Storm*” is helping this
• Standards, certification, financial assistance is all complex: Need someone to help students in this
Sustainability: Next Steps

• Publishing innovative best-practice results from the project
• Seeding institutions ready to take steps toward building national or regional programs of excellence
• Building a national coalition of institutions committed to educating future teachers
• PTEC (Physics Teacher Education Coalition)
PTEC Membership

15 March: 39

Number of Institutions

Jan-03  Jan-04  Jan-05  Jan-06
Coalition Activities

- Physics Teacher Education Digital Library
  - Feature nationally recognized programs and program elements
  - Share ideas, products, events
- Visiting Scholar Program
- Travel support to attend National workshops on teacher preparation
Web Resources

http://www.ptece.org/conferences (PTEC 06 Conference)

http://www.phys.washington.edu/groups/peg (Physics by Inquiry, Tutorials in Physics)

http://petproject.sdsu.edu (Physics for Elementary Teachers Project)

http://www.aapt.org/Publications/pips.cfm (Powerful Ideas in Physical Science)

http://www.aapt.org/Projects/ntfup.cfm (National Task-Force on Undergraduate Physics report)

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

To the world you may be only one person; but to one person you may be the world!

Anonymous