Doubling the number of physics majors who teach

Michael Marder
Chair, APS Committee on Education, 2006-2008
Co-Director of UTeach
Professor of Physics, UT Austin
Physics over Time

Number Bachelor's Degrees

- Biological Sciences
- Computer Science
- Mathematics and Statistics
- Chemistry
- Physics

Grad school ratios

First-Year Domestic Graduate Enrollment per Bachelor's Graduate

- Physics
- Chemistry
- Mathematics and Statistics
- Biological Sciences
- Computer Science


3/15/2009 APS Doubling
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• Proposed Elimination of B.S. and B.A. Degrees in Physics

• As part of the Academic Program Prioritization Process, the university has issued a preliminary recommendation to discontinue the Bachelor of Science and Bachelor of Arts degree programs in physics.
Curriculum and Enrollment

Physics Bachelors Degrees as a Fraction of Total Bachelors Degrees Granted

- Harvard
- UVirginia
- UC California, Berkeley
- Cal Poly, San Luis
- Seattle Pacific
- U Washington
- UC California, San
- Cornell
- U Colorado, Boulder
- U Arizona
- UT Austin
- U Arkansas
- U Minnesota, Twin
- U California, Davis
- Ball State
- Western Michigan
- U North
- Towson
- Indiana, Bloomington
- Florida International

University
Curriculum and Enrollment

Physics Graduates vs Hours of Physics Classes Available

Number of Hours of Physics Classes Available

Percent of Physics Graduates
Curriculum and Enrollment

Physics Graduates vs. Hours Required in Math and Science

Percent of Physics Graduates

4% 3% 2% 1% 0%

40 50 60 70 80 90 100 110

Average Hours Required in Math and Science

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Curriculum and Enrollment

Physics Graduates vs Lower Division Classes Required

Percent of Physics Graduates

Average Lower Division Hours Required

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Physics Graduates vs Hours of Physics Classes Available

Percent of Physics Graduates

0% 1% 2% 3% 4%

Number of Hours of Physics Classes Available

75 125 175 225 275
Curriculum and Enrollment

Physics Graduates vs. Minimum Required Hours

Percent Physics Majors

Minimum Hours Required

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Curriculum and Enrollment

Physics Graduates vs. Required Hours of Upper Division Classes

Percent of Physics Graduates

Average Upper Division Hours Required
Unifying Theme: Double the number of bachelor degrees in physics to address critical national needs including K-12 education, economic competitiveness, energy, security, and an informed electorate

Special Objectives:
- Increase the number of highly-qualified high school physics teachers
- Increase the fraction of both women and under-represented minorities who major in physics

Three critical areas of action (in ranked priority order):
- Preparation of high school teacher physics teachers
- Under-representation of minorities and women in physics
- The undergraduate physics major
[T]he country must … adopt measures that increase the supply of high-quality teachers — especially in math and science — while cutting down on the distressingly large number of teachers who bail out of the profession early.

Public colleges and universities, which rely heavily on tax dollars, are a good place to start. The government should require them to turn out more high quality teachers of all kinds, especially math and science teachers. Ideally, the enrollments at these colleges of education should be based not on whim, but on projected need. The states should find ways to reward colleges that turn out excellent graduates, while shutting down diploma mills. The states and localities should also develop comprehensive plans not just for hiring, but for mentoring and retaining teachers as well.

NY Times Editorial, August 29, 2007
“SEC. 205. ACCOUNTABILITY FOR PROGRAMS THAT PREPARE TEACHERS.

“(a) INSTITUTIONAL AND PROGRAM REPORT CARDS ON THE QUALITY OF TEACHER PREPARATION. —

“(1) REPORT CARD.—Each institution of higher education that conducts a traditional teacher preparation program or alternative routes to State certification or licensure program and that enrolls students receiving Federal assistance under this Act shall report annually to the State and the general public, in a uniform and comprehensible manner that conforms with the definitions and methods established by the Secretary, the following:

“(H) For the State as a whole, and for each teacher preparation program in the State, the number of teachers prepared, in the aggregate and reported separately by—

“(i) area of certification or licensure;

“(ii) academic major; and

“(iii) subject area for which the teacher has been prepared to teach.

“(I) A description of the extent to which teacher preparation programs are addressing shortages of highly qualified teachers, by area of certification or licensure, subject, and specialty, in the State’s public schools.

“SEC. 206. TEACHER DEVELOPMENT.

“(a) ANNUAL GOALS.—Each institution of higher education that conducts a traditional teacher preparation program (including programs that offer any ongoing professional development programs) or alternative routes to State certification or licensure program, and that enrolls students receiving Federal assistance under this Act, shall set annual quantifiable goals for increasing the number of prospective teachers trained in teacher shortage areas designated by the Secretary or by the State educational agency, including mathematics, science, special education, and instruction of limited English proficient students.
## Teacher Shortage

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total schools with grades 9-12</td>
<td>15,400</td>
<td>1846</td>
</tr>
<tr>
<td>Total individuals teaching physics</td>
<td>20,000</td>
<td>1852</td>
</tr>
<tr>
<td>Teachers out of field</td>
<td>~5000</td>
<td>524</td>
</tr>
<tr>
<td>Students per secondary grade</td>
<td>3,000,000</td>
<td>300000</td>
</tr>
<tr>
<td>Teachers required to teach 1 physics to each student</td>
<td>28,000</td>
<td>2,800</td>
</tr>
<tr>
<td><strong>Shortage</strong></td>
<td>~13,000</td>
<td>~1500</td>
</tr>
<tr>
<td>New physics teachers/year</td>
<td>~1000</td>
<td>?</td>
</tr>
<tr>
<td>Physics majors entering teaching</td>
<td>~300</td>
<td>25?</td>
</tr>
</tbody>
</table>

### Table: Total Individuals Teaching Each Subject

<table>
<thead>
<tr>
<th></th>
<th>Physics</th>
<th>Chemistry</th>
<th>Biology</th>
<th>Math</th>
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<tbody>
<tr>
<td>Total individuals teaching</td>
<td>1852</td>
<td>3657</td>
<td>4967</td>
<td>10262</td>
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<tr>
<td>Number individuals out of field</td>
<td>524</td>
<td>1069</td>
<td>1588</td>
<td>1539</td>
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<tr>
<td>Teachers required to teach one of each science and 4 math courses to each high school student, with 20 students per class.</td>
<td>2889</td>
<td>2889</td>
<td>2889</td>
<td>12165</td>
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<tr>
<td><strong>Shortage</strong></td>
<td>1561</td>
<td>301</td>
<td>None</td>
<td>3442</td>
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</table>
## Targets for Doubling

<table>
<thead>
<tr>
<th>Institution</th>
<th>Actual Physics</th>
<th>Actual STEM</th>
<th>Target Physics Majors</th>
<th>Actual/Target Physics Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Institute of Technology</td>
<td>45</td>
<td>217</td>
<td>5</td>
<td>900%</td>
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<tr>
<td>Hastings College</td>
<td>7</td>
<td>48</td>
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<td>700%</td>
</tr>
<tr>
<td>Reed College</td>
<td>14</td>
<td>100</td>
<td>2</td>
<td>700%</td>
</tr>
<tr>
<td>Coe College</td>
<td>7</td>
<td>64</td>
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<tr>
<td>Harvey Mudd College</td>
<td>24</td>
<td>159</td>
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<td>600%</td>
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<tr>
<td>Hampden-Sydney College</td>
<td>10</td>
<td>74</td>
<td>2</td>
<td>500%</td>
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<tr>
<td>Augsburg College</td>
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<td>109</td>
<td>2</td>
<td>500%</td>
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<tr>
<td>Roanoke College</td>
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<td>72</td>
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<tr>
<td>Grinnell College</td>
<td>14</td>
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<tr>
<td>Whittier College</td>
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<tr>
<td>Georgetown College</td>
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<tr>
<td>Knox College</td>
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<td>108</td>
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<tr>
<td>Lycoming College</td>
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<tr>
<td>Ouachita Baptist University</td>
<td>4</td>
<td>62</td>
<td>1</td>
<td>400%</td>
</tr>
<tr>
<td>University of Dallas</td>
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<td>62</td>
<td>1</td>
<td>400%</td>
</tr>
<tr>
<td>New Mexico Institute of Mining and Technology</td>
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<td>174</td>
<td>4</td>
<td>375%</td>
</tr>
<tr>
<td>Morehouse College</td>
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<td>161</td>
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<td>375%</td>
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<tr>
<td>Hamline University</td>
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<td>350%</td>
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<td>Bates College</td>
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<td>4</td>
<td>325%</td>
</tr>
<tr>
<td>Occidental College</td>
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<td>164</td>
<td>4</td>
<td>325%</td>
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<tr>
<td>Massachusetts Institute of Technology</td>
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<td>964</td>
<td>26</td>
<td>308%</td>
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<tr>
<td>Austin College</td>
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<td>2</td>
<td>300%</td>
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<td>101</td>
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<tr>
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<td>110</td>
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<td>Westminster College (New Wilmingtn, PA)</td>
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<tr>
<td>Houghton College</td>
<td>3</td>
<td>65</td>
<td>1</td>
<td>300%</td>
</tr>
</tbody>
</table>
## Targets for Doubling

<table>
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<th>Target Physics Majors</th>
<th>Actual/Target</th>
<th>Physics Teachers</th>
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<tbody>
<tr>
<td>New York University</td>
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<td>43%</td>
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<td>Boston University</td>
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<tr>
<td>Ball State University</td>
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<tr>
<td>SUNY College at Brockport</td>
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<tr>
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<tr>
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<td>Jackson State University</td>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
<td>University of Minnesota - Twin Cities</td>
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<td>2622</td>
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<tr>
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<td>71</td>
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<td>University of Oklahoma, Norman Campus</td>
<td>13</td>
<td>1235</td>
<td>33</td>
<td>39%</td>
<td>4</td>
</tr>
</tbody>
</table>
UTeach
Hallmarks of UTeach

- **Collaboration** between Colleges of Sciences, Education, and Liberal Arts
- **Active recruitment** of science and mathematics majors to take the two initial one-hour UTeach courses free of charge
- Early and intensive **field experiences** throughout the program
- **Compact degree plans** that allow most students to graduate with a degree and certification in four years
- A focus on developing deep-level understanding of the **subject material** and incorporating effective approaches using technology in teaching
- Guidance and inspiration provided by faculty and highly experienced public school teachers who serve as **Master Teachers** in the program
- Courses taught by **faculty** who are actively engaged in research in mathematics and science and in the teaching and learning of mathematics and science
- Integrated **professional development courses** that all focus on teaching both mathematics and science, and are based on recent research in science and mathematics teaching and learning
- An array of **student benefits**, including paid internships that offer opportunities for community outreach in education
- All essential program elements on **permanent budget** or endowment.
UTeach Enrollment

Enrollment from Fall 1997 to Fall 2007.
Math and Science Teachers
graduating from UT Austin

1996-1997
1997-1998
1998-1999
1999-2000
2000-2001
2001-2002
2002-2003
2003-2004
2004-2005
2005-2006
2006-2007
2007-2008

Science
Math

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UTeach requires a 2.5 GPA or higher for certification.
UTeach Retention

Percentage teachers left in classroom, SASS vs UTeach

- Retention for SASS cohort of 1991
- Retention for SASS cohort of 1994
- Retention for SASS cohort of 2000
- Retention for SASS cohort of 2004
- Retention for UTeach

Years Teaching

Percent Remaining

50% 60% 70% 80% 90% 100%

1 2 3 4 5
# UTeach Course Sequence

<table>
<thead>
<tr>
<th>University Provider</th>
<th>Professional Development Courses</th>
<th>One-hour Courses: STEP 1, 2 **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Sciences</td>
<td><strong>Research Methods</strong></td>
<td>Research Methods</td>
</tr>
<tr>
<td>College of Education</td>
<td>Apprentice Teaching **</td>
<td>Apprentice Teaching</td>
</tr>
<tr>
<td>College of Liberal Arts</td>
<td>Knowing &amp; Learning</td>
<td>Knowing &amp; Learning</td>
</tr>
<tr>
<td></td>
<td>Classroom Interactions **</td>
<td>Classroom Interactions</td>
</tr>
<tr>
<td></td>
<td>Project-Based Instruction **</td>
<td>Project-Based Instruction</td>
</tr>
<tr>
<td>Freshman Pathway</td>
<td>Perspectives in Math &amp; Science</td>
<td>Perspectives in Math &amp; Science</td>
</tr>
<tr>
<td>Sophomore Pathway</td>
<td>Step 1</td>
<td>Step 1</td>
</tr>
<tr>
<td></td>
<td>Step 2</td>
<td>Step 2</td>
</tr>
<tr>
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<td>Knowing &amp; Learning</td>
<td>Knowing &amp; Learning</td>
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<td></td>
<td>Classroom Interactions</td>
<td>Classroom Interactions</td>
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<tr>
<td></td>
<td>Perspectives in Math &amp; Science</td>
<td>Perspectives in Math &amp; Science</td>
</tr>
<tr>
<td>Junior/Senior Pathway</td>
<td>Project-Based Instruction</td>
<td>Project-Based Instruction</td>
</tr>
<tr>
<td></td>
<td>Perspectives in Math &amp; Science</td>
<td>Perspectives in Math &amp; Science</td>
</tr>
</tbody>
</table>

** includes field experience
UTeach Replication Sites
UTeach: 8-12 Composite Science

**MAJOR REQUIREMENTS:** All major requirements must be taken on a letter-grade basis. A GPA of at least 2.0 in these physics courses is required.

**LOWER-DIVISION PHYSICS:**
- PHY 301 + 101L
- PHY 316 + 116L
- PHY 315 + 115L
- PHY 319

**UPPER-DIVISION PHYSICS:**
15 semester hours of upper-division Physics courses consisting of:
- PHY 341: Topic: Research Methods-W
- PHY 353: Junior Lab: Introduction to Quantum Phenomena

Three of the following:
- PHY 333: Modern Optics
- PHY 352K: Classical Electrodynamics
- PHY 373: Quantum Mechanics
- PHY 338K: Electronic Techniques
- PHY/SCI 360: Topic: Physics by Inquiry
- PHY 329: Computational Physics
- PHY 336K: Classical Dynamics I

**COMPOSITE SCIENCE CERTIFICATION REQUIREMENTS:** Courses intended for non-science majors may not be counted toward this requirement.

- **6 semester hours in Biology courses including:** BIO 311C + BIO 311D
- **6 semester hours in Geological Sciences:**
- **6 semester hours in Chemistry:**
  - CH 301
  - CH 302

Enough additional hours in Biology, Chemistry or Geological Sciences for a total of 12 semester hours required for second field composite science.

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**Course Code and Description:**
- TS 101: Step 1 & UTS 110 Step 2
- DC 365C: Knowing & Learning in Math & Science
- DC 365D: Classroom Interactions
- DC 365E: Project Based Instruction
- DC 650S: Apprentice Teaching in Secondary Schools
- TS 170: Apprentice Teaching Seminar
UTeach Engineering

UTeach
THE UNIVERSITY OF TEXAS AT AUSTIN
NATURAL SCIENCES

+ √ Cockrell School of Engineering

+ Austin
Independent School District

UTeach Engineering
Preparing Secondary School Teachers to Deliver Design-Based Engineering Courses
Need for Engineering: Texas allows Engineering as 4th year science class under 4x4 plan [and is considering making physics optional]

4 pathways to engineering certification:
   a) Summer institutes for inservice teachers
   b) Summer Master’s program for inservice teachers
   c) Undergraduate certification
   d) Post-baccalaureate certification

4 new courses developed:
   a) Knowing and Learning in Engineering
   b) Principles of Engineering Design
   c) Engineering Energy Systems
   d) Design of Machines and Systems

Aim to certify an additional 20 UTeach students per year with engineering certification, perhaps 10 of them physics majors.
Either we respond to the national calls to greatly increase the numbers of physics majors who become teachers

Or

Our universities may be penalized for failing to produce teachers in critical areas, undergraduate physics programs may be closed, states may back off on requirements that students learn physics, and the U.S. physics community may suffer irreparable damage.