The State of High School Physics and Physics First

Paul Hickman
"Ninth grade physics is the proper discipline to introduce students to science. A key concept is the simplification of phenomena... which leads to crisp and reasonably accurate applications of basic concepts to simple systems...

Ultimately, the goal of such a high school experience is to embed in all high school graduates, a 'science way of thinking' that will endure forever."

Physics Students

- 3.5 Million students in each HS class
- Over 1 Million taking physics
- Number taking physics growing by 1% per year
- 46% of HS physics students are female
- 25% of those taking Physics AP C are female

Source: AIP Statistics, College Board
The State of Science Education Reform
November 20, 2007

% HS Students Taking Physics

www.PTEC.org  www.PhysTEC.org
Physics First Dissemination Efforts

Massachusetts (1985)
**ARISE Workshop** (1995)
Maryland (1999 and 2007)
Physics First Web Site (2000)
Missouri and Rhode Island (2005)
AAPT Physics First Informational Guide (2007)
Physics First Schools

Represents:

Private - ~330 Schools
290 physics first for all
40 physics first for some

Public - ~450 Schools
260 physics first for all
190 physics first for some
Physics Teachers

- 21,300 Physics Teachers Nationwide
- 29% Physics teachers are women
- 1,000 new physics teachers each year
- ~300 of these have physics major or minor
- Significant shortages in many states

Source: AIP Statistics, College Board
Teacher Specialization: Academic Training and Experience

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialist</td>
<td>32%</td>
</tr>
<tr>
<td>Career</td>
<td>40%</td>
</tr>
<tr>
<td>Occasional</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.

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

Iowa Governor, Tom Vilsack, October 2005

“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, 10/30/05
Relative Demand by Field

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

<table>
<thead>
<tr>
<th>Field</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe/Profound Disabilities (Spec. Ed.)</td>
<td>4.42</td>
</tr>
<tr>
<td>Multi-categorical (Spec. Ed.)</td>
<td>4.36</td>
</tr>
<tr>
<td>Emotional/Behavioral Disorders (Spec. Ed.)</td>
<td>4.32</td>
</tr>
<tr>
<td>Mild/Moderate Disabilities</td>
<td>4.32</td>
</tr>
<tr>
<td><strong>Physics</strong></td>
<td>4.31</td>
</tr>
<tr>
<td>Mental Retardation (Spec. Ed.)</td>
<td>4.23</td>
</tr>
<tr>
<td>Learning Disability (Spec. Ed.)</td>
<td>4.22</td>
</tr>
<tr>
<td>Mathematics Education</td>
<td>4.21</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Field</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visually Impaired</td>
<td>4.20</td>
</tr>
<tr>
<td>Chemistry</td>
<td>4.16</td>
</tr>
</tbody>
</table>

2004 AAEE *American Association of Employment in Education*
Educator Supply and Demand in the United States Report
Teacher turnover in 5 years (N = 11,787) among teachers who entered the profession in four midwestern states in 1995-1996.

The PhysTEC Project

PhysTEC was initiated by APS, in partnership with AAPT and AIP, to respond to national reports calling for the improvement of K-12 science teaching. The project is supported by funding from NSF, FIPSE and The APS Campaign for Physics.

PhysTEC’s mission is to improve and promote the education of future physics and physical science teachers.
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
The State of Science Education Reform
November 20, 2007

Diverse PhysTEC Institutions

Oregon State University                       Ball State University (Indiana)
University of Arkansas                        Western Michigan University
University of Arizona                         Cal Poly, San Luis Obispo
University of Colorado, Boulder               Towson University (Maryland)

Seattle Pacific University
Xavier University of Louisiana

Cornell University
Florida International University
University of Minnesota, Twin Cities
University of North Carolina at Chapel Hill

www.PTEC.org                              www.PhysTEC.org
Physics First: Not a New Idea!

“Should the study of physics precede that of chemistry?”
(Griffis, The Academy, 1887)

Thanks to Keith Sheppard
Physics First: Not a New Idea!

• Physics and the High School Sophomore (Hamilton, TPT, 1970)
• Physics in the Tenth Grade (Sousanis, TPT, 1971)
• The Illogic of Teaching Bio Before Chem and Physics (Palombi, TPT, 1971)
• Take Physics to Ninth Graders With Budget Savers (TPT, 1974)
• High School Physics Should be Taught Before Chemistry and Biology (Haber-Schaim, TPT, 1984)
• Physics Before Chemistry (Bolton, TPT, 1987)
• A Case for a Better High School Science Sequence in the 21st Century (Myers, TPT, 1987)
• Freshman Physics (Hickman, The Science Teacher, 1990)

Source: Physics-Chemistry-Biology: A Logical and Effective Sequence.
Rex Rice, Clayton, MS
“As early as the 1970s, science educators began toying with the idea that maybe by changing the sequence of science courses students could be provided with the tools—cell chemistry and the study of motion, for example—to understand how organisms really work instead of just memorizing a book full of terminology.

The Science Department now has the second highest enrollment in the school, trailing only English. Besides the curriculum, some of the credit can go to our outstanding facilities but the fact remains that more students are sticking with science.”

Choate Rosemary Hall, CT - "In Brief" 1999
In the early days of the movement there was not too much information about Ninth Grade Physics out there!

"Questions such as, Why is the sky blue? Why are sunsets red? How does a lightning rod protect your house? How can a bird sit on a power line and not get zapped? Which part of the pizza burns your mouth when you bite it too soon?"

Six years later the articles about Physics First started popping up!

“...many activities are designed around practical questions, like why sunsets are red, how a lightning rod protects a house, which part of a hot pizza burns your mouth, or why a bird can sit on a power line without being zapped."

"Push to Reorder Sciences Puts Physics First,"
The New York Times, January 24, 1999
Advantages of Physics First

• Algebra is still fresh in students’ minds
• Freshmen are enthusiastic and motivated
• More students who start with physics complete the science sequence
• Increased interest in math courses
• Enrollment in AP STEM courses increases
• AP Biology can be the first biology course if physics and chemistry have been studied
Problems with Physics First

- Continuing shortage of qualified physics teachers
- Opposition to change from by parents, teachers, administrators, school boards
- Freshmen are more active, noisier, less coordinated
- Measurement and estimation skills are not developed
- Trigonometry has not been studied
- Transition of from MS to HS level course work
- Lack of problem solving and test taking skills
Arguments Supporting Physics First

Pedagogical

Developmental

Reform and Research Based

Outcomes

www.PTEC.org

www.PhysTEC.org
PEDAGOGICAL

- Physics is the foundation of all science
- Phenomena are easiest to observe through experiments
- Gives students the opportunity to apply their mathematical skills to real situations
- Deals with concepts that relate directly to the students’ world
DEVELOPMENTAL

• Provides concrete science experiences
• Improves problem-solving skills
• Ninth graders are curious and eager students
• Additional mathematics can be introduced as needed
• Improves oral and written communication skills
REFORM and RESEARCH

- Teach for Conceptual Understanding
- Use Cooperative/Collaborative Learning
- Increase Opportunities for Inquiry
- Misconceptions are less Entrenched
- Recent Understanding of How People Learn
- Use Writing to make Thinking Visible
- Mathematics is Essential
- Extensive use of Formative Assessment
- Improve Teaching Practice (RTOP)
OUTCOMES

• More females take physics
• Students take more science courses
• Greater success in Chemistry and Biology
• Students take more AP courses
• Increased student interest in STEM careers
• Test scores on State exams are as good or better
• Greater mathematical proficiency
• More students participate in academic competitions
• Less competition for “best” students from private schools
• Parents perceive PCB as more rigorous
“Physics First makes sense in every way except in the logistics of making it work in a school system. So far, the schools that have had the most success in making Physics First work have had a core group of educators (or one) who have launched and sustained it.”

Michael Neuschatz, AIP (2006)
A Personal Perspective

I had the opportunity to start Physics First in two, very similar, affluent, suburban schools. Both were recently listed in Newsweek’s top 100 high schools. The first was:

Cold Spring Harbor HS, NY (About 800 students)
Began as a single class pilot and grew to four sections
Physics First introduced 1979 – discontinued 1989

I arrived at CSHHS in 1973 – left 1988
A Personal Perspective

*In the second school I was *specifically hired* to build a Physics First program.*

**Belmont HS, MA** (About 1100 students)
Physics First introduced 1989
Began as a single class pilot and grew to full Physics First implementation in 2004 with all ninth graders taking College Prep and Honors Physics courses.

*I began teaching there in 1988 and retired in 1998*
Some Hard Data

At Farmington High School in Connecticut, where Physics First has been in place for ten years:

- 100% of students complete a full-year Physics course
- The number of freshmen enrolled at the honors level has more than doubled
- Enrollment in AP science courses has more than tripled
- Freshman taking the SAT II Physics Achievement Test (2003) had a mean score of almost 700
But…

“With regard to the Physics First movement, the lack of a relationship between the previous study of physics and later chemistry performance, or previous study of chemistry and later biology performance casts doubt on the impact of changing the traditional high school sequence.”

Call for more Hard Data

Anecdotal evidence alone cannot support the change to a Physics First curriculum. Richard Feynman spoke of this lack of credible studies in science education almost 40 years ago:

"There are an enormous number of studies and a great deal of statistics but they are mixtures of anecdotes, uncontrolled experiments, and very poorly controlled experiments, so that there is very little information as a result."
Call for more Hard Data

“The Physics First curriculum sequence cannot be declared a complete success without well-controlled studies showing its utility in raising science literacy.”

"Physics First in Science Education Reform”
Pattanayak, 2003
The State of Science Education Reform
November 20, 2007

hickmanp@comcast.net

Thank you!

www.PTEC.org www.PhysTEC.org