Education for a World Based in Science and Technology

Shirley M. Malcom
Human Resources Challenges

- An adequate base of scientists, mathematicians, engineers and technicians
- Science and mathematics for related fields (e.g., health care)
- Science and mathematics for the rest of us
STEM Workforce as a Percentage of the Total Workforce in the U.S., 2001
(Total Workforce = 135,073,000)
Percentage of Bachelor’s Degrees Awarded in STEM and Other Fields, 1980-2000

- All STEM Fields
- All Other Fields
- Natural Sci & Eng
Bachelor’s Degrees Awarded in STEM and Non-STEM Fields, 1980-2000

- All STEM Fields
- All Other Fields
- STEM Fields w/out Soc Sci and Psych
- Psych and Soc Scis
Bachelor’s Degrees Awarded in Engineering, 1980-2002
Bachelor’s Degrees Awarded in Physical Sciences, 1980-2002
Bachelor’s Degrees Awarded in the Biological Sciences, 1980-2002
Bachelor’s Degrees Awarded in Computer Science, 1983-2002
Education for a World Based in Science and Technology

Bachelor’s Degrees Awarded in Psychology, 1980-2002
Bachelor’s Degrees Awarded in the Social Sciences, 1980-2002
Bachelor’s Degrees Awarded in the Health Professions, 1980-2002
The Rest of Us

- Teachers
- Lawyers
- Policymakers
- Consumers of Science and Technology
Bachelor’s Degrees Awarded in Education, 1980-2002
Bachelor’s Degrees Awarded in Business, 1980-2002
Challenges of Education (K-12)

- The education pathway for citizen and scientist is initially the same
- The size of the talent pool decreases over time, and its composition changes
- The capacity of the system to provide appropriate, high quality education is limited
- The components of the education systems are poorly aligned
Percent of Public High School Graduates Taking Selected Mathematics Courses in High School, 1982-2000

- Algebra
- Geometry
- Algebra II
- Calculus
Percent of Public High School Graduates Taking Selected Science Courses in High School, 1982-2000
Percent of High School Graduates Taking Selected Math and Science Courses in High School, by Race/Ethnicity, 2000
Percent of High School Graduates taking Selected Math and Science Courses in High School, by Gender, 2000

<table>
<thead>
<tr>
<th>Course</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP Calculus</td>
<td>7.3</td>
<td>2.5</td>
</tr>
<tr>
<td>AP Physics</td>
<td>2.5</td>
<td>5.7</td>
</tr>
<tr>
<td>AP Chemistry</td>
<td>13.8</td>
<td>8.5</td>
</tr>
<tr>
<td>AP Biology</td>
<td>5.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Bio, Chem &amp; Phys</td>
<td>5.4</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Challenges of Education (Collegiate)

- Articulating a clear set of learning goals in science, mathematics, and technology
- Scientific, technological, and quantitative literacy as a component of liberal education
Challenges of Education (Graduate)

- Mismatch between graduate education and career opportunities
- Mismatch between training experiences and skills needed for jobs BEYOND ACADEMIC
Workforce Development

- “Do we need more scientists?” (Teitelbaum)
- Composition of STEM workforce
- Nature of education and career development
Employed Scientists and Engineers by Age, 1999

- <30 yrs old: 7%
- 30-39 yrs old: 29%
- 40-49 yrs old: 26%
- 50-59 yrs old: 17%
- 60+ yrs old: 21%
Scientists & Engineers in the Labor Force, by Sex and Race/Ethnicity, 1999

- **White Men**: 63%
- **White Women**: 19%
- **Asian American**: 11%
- **African American**: 3%
- **Hispanic American**: 3%
- **Native Am/Alaskan Native**: 3%

Education for a World Based in Science and Technology
Challenges in Education and Career Development

- Mismatch between education and workplace skills
- Lack of cross-sector experiences
- Lengthening time to independence
### Percentage of NIH Traditional Research Project Applications, by Age of Investigator, 1980-2001

<table>
<thead>
<tr>
<th>Year</th>
<th>35 and Younger</th>
<th>36-45 years old</th>
<th>46-55 years old</th>
<th>Over 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>22.6</td>
<td>45.8</td>
<td>21.9</td>
<td>6.0</td>
</tr>
<tr>
<td>1984</td>
<td>17.9</td>
<td>49.1</td>
<td>23.0</td>
<td>0.9</td>
</tr>
<tr>
<td>1988</td>
<td>13.5</td>
<td>49.5</td>
<td>25.3</td>
<td>2.7</td>
</tr>
<tr>
<td>1992</td>
<td>8.6</td>
<td>47.2</td>
<td>31.5</td>
<td>3.6</td>
</tr>
<tr>
<td>1996</td>
<td>6.1</td>
<td>42.8</td>
<td>36.8</td>
<td>3.3</td>
</tr>
<tr>
<td>2001</td>
<td>3.8</td>
<td>36.0</td>
<td>39.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>
NIH Traditional Research Project Awards, by Age of Investigator, 1980-2001

- Under 36
- 36-45 years old
- 46 years old and older
Is There Shortage? Considering the Evidence

- Unemployment rates
- Salaries
- Importing talent – exporting jobs
Limits of Supply-Demand Models

- Quality
- Demographics
- Skills and Know How
Composition as the Issue
Faculty of the Future
The Business Case for Diversity
PhDs in S&E by Gender, 1975-2001
(U.S. Citizens and Permanent Residents Only)

Source: CPST, data derived from National Science Foundation
Education for a World Based in Science and Technology

PhDs in NS&E by Gender, 1975-2001
(U.S. Citizens and Permanent Residents Only)

Source: CPST, data derived from National Science Foundation
PhDs Awarded in S&E by Race/Ethnicity, 1975-2001
(U.S. Citizens & Permanent Residents Only)

Source: CPST, data derived from National Science Foundation
Retention

Not Just Getting Them In, but Keeping Them In
Advancement

Not Just Getting Them In, but Also Keeping Them In and Getting Them Up
Policy Implications

- K-12
- Collegiate
- Ph.D.
- Postdoctoral
Policy Implications (K-12)

- Meeting national needs for STEM relies on a distributed system of production
- Successful distributed production relies on
  - Shared goals and agreed-upon standards
  - Reliable measurement to determine if these are being met
  - Distributed capacity (SES, geographic, demographic)
Policy Implications (K-12, continued)

- Challenges to capacity building
  - Shortage of quality teachers of STEM
  - Inappropriate science and mathematics curriculum “mile wide and an inch deep”
  - Inadequate funding and/or inefficient use of funds
  - Poor bridging from research to practice
  - Poor assessments
  - Focus of assessment on accountability rather than improvement of instruction
  - Poor articulation across K-21
  - Not everyone gets a fair shake
Policy Implications (Collegiate)

- Policies based on an outdated model of the make up of student populations of colleges and universities
  - Nontraditional students
  - Part-time students
  - Changing demographics
  - The role of community colleges
  - The rise of proprietary schools
Policy Implications (Ph.D.)

- Appropriate preparation (beyond technical know-how)
- Full disclosure of career opportunities and educational needs
- Integration of research and education
- Diversity
Responses

- Professional science masters
- Science’s Next Wave, MiSciNet
- IGERT, CAREER, and GOALI
- ADVANCE & AGEP
Education for a World Based in Science and Technology

Science and Engineering Postdoctorates, 1977-2001

Source: CPST, data derived from NSF, WebCaspar
Comparison of Bioscience Postdocs with All Other S&E Postdocs, 1977-2001
(U.S. Citizens & Permanent Residents only)

Source: CPST, data derived from NSF, GSS
Percentage of U.S. PhDs Holding Tenured or Tenure-Track Positions by Field

- Social/Behavioral Sciences
- Physical Sciences
- Biomedical Sciences

Source: CPST, data derived from NSF, Survey of Doctorate Recipients
Policy Implications (Postdoctoral)

- “What new skills do you get in the third postdoc, and why didn’t you get them earlier?”
Percentage of U.S. Biomedical Science PhDs in Postdoctoral Appointments, 1973-2001

- **1-2 Years Post Graduation**
- **3-4 Years**
- **5-6 Years**
- **7-8 Years**
- **9-10 Years**
Education for a World Based in Science and Technology

![Percentage of U.S. Physical Science PhDs in Postdoctorates, 1973-2001](chart)

- **1-2 Years Post Graduation**
- **3-4 Years**
- **5-6 Years**
- **7-8 Years**

**Source:** CPST, data derived from NSF, Survey of Doctorate Recipients
Median Salary in 2001 of U.S. Doctorates 1-3 Years after Degree: Postdoc and Non-Postdoc

Source: CPST, data derived from NSF, Survey of Doctorate Recipients
Students as Product?

Students as “By-Product”?
Acknowledgments

Eleanor Babco
Nathan Bell
Howard Garrison
Jolene Jesse
Marty McGihon