Trends and Perspectives about Materials Education in the United States

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Statistics in Materials Education
Global Trends
Trends Influencing an MSE Education
Some questions
The members of the University Materials Council are the heads or chairs of the Materials Science and Engineering departments in the United States and Canada. MSE departments represented by the UMC are responsible for the education of the leaders who will create technological change in industry, government, and academia.

Executive Committee
Gary L. Messing, Chair
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Peter Davies, at large member (2005-2006)
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Greg Rohrer, Past chair (2005-2006)
The UMC has three primary functions

• Provide a forum of the exchange of ideas and best practices that allow MSE education to continually develop and adapt to new opportunities and challenges.

• Advocate for MSE by representing the interests of MSE departments to professional societies, accreditation organizations, industry associations, government and non-governmental organizations.

• Carry out annual surveys about factors impacting an MSE education
Between 1993 and 2000, fifteen departments out of 107 in North America were merged or consumed by other departments. Examples:

- Mat Sci and Eng → Chemical & Materials Eng
- Interdisciplinary Program → Chemical & Biochem Eng
- Mat Engineering → Mech & Mat Eng
- Met & Mat Eng → Mech, Mat & Aero Eng

Source: ASM Education Yearbook, 1993 and 2000
<table>
<thead>
<tr>
<th>Department</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallurgical Engineering</td>
<td>11</td>
</tr>
<tr>
<td>Metallurgical and Materials Engr.</td>
<td>5</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>12</td>
</tr>
<tr>
<td>Materials Science</td>
<td>4</td>
</tr>
<tr>
<td>Materials Science and Mineral Engr.</td>
<td>1</td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>25</td>
</tr>
<tr>
<td>Materials Option under Chemical Engr.</td>
<td>4</td>
</tr>
<tr>
<td>Materials Option under Mechanical Engr.</td>
<td>5</td>
</tr>
<tr>
<td>Ceramic Engineering</td>
<td>7</td>
</tr>
<tr>
<td>Polymer Science &amp; Engr.</td>
<td>4</td>
</tr>
</tbody>
</table>

Total = 69
Diversity and Trends in MSE ABET Accreditation

((In comparison, over 99% of around 230 ME departments are accredited in Mech Eng.))
Recent reports indicate that “Ceramics” will disappear in Department names.
Faculty size in MSE Departments

Average Faculty FTE 15.1 for 28 representative departments

Faculty Head Count Average of 107 Departments:
16.4 in 1993 vs 18.3 in 2000

Source: ASM Education yearbook, 1993 and 2000
Senior Undergraduate Enrollments in MSE Departments

15 departments account for 50% of BS grads

Avg. Dept Size = 19.1 Students/yr.

Number of Seniors

Number of Departments
Graduation Rates in MSE Departments


Number

B.S.
M.S.
Ph.D.
Materials Degrees Per Year

- **B.S. degree**
- **M.S. degree**
- **Ph. D degree**
Conclusion. The MSE education system, including K-12 mathematics and science education, will have to evolve and adapt so as to ensure a supply of MSE professionals educated to meet U.S. national needs for MSE expertise and to compete on the global MSE R&D stage. The evolution of the U.S. education system will have to take into account the materials needs identified by the federal agencies that support MSE R&D as well (as) the needs of the materials industry.
Conclusion. Globalization of MSE R&D is proceeding rapidly, in line with broader trends towards globalization. As a result of increasing trade and investment, the emergence of new markets, and the growth of the Internet and the global communications system, MSE R&D in the United States is an internationalized activity with a diverse set of international partners.
U.S. Lags Other Nations in Share of 24-Year-Olds With Natural Science, Engineering Degrees

SOURCE: National Science Foundation, Science and Engineering Indicators 2000
Doctoral Degrees Earned By Korean Students

Number

Year

at Korean Universities

at U.S. Universities
Doctoral Degrees Earned By Chinese Students

- Number
- Year
- 0
- 1000
- 2000
- 3000
- 4000
- 5000
- 6000
- 7000
- 8000

at Chinese Universities

at U.S. Universities

Year


Number
Core Elements of a Materials Science and Engineering Education

Source: Materials Science and Engineering for the 1990s, NRC, 1989
Federal Funding Priorities has a Profound Impact

- Economy and Commerce
- Nanotechnology
- Energy
- National Security
- Health Care (Biological sciences)
Technological Leadership

More Funding Will Bring Students into the Physical Sciences

Federal R&D, $M, non-biomedical (constant 1996 dollars)

Bachelor’s Degrees in Physical Sciences, Math, Engineering

Dollars

Students

Mayo, Brugggeman, Sargent

Year

MSE is being Stretched by Interdisciplinarity

Diagram:

- MSE
- Bio
- Nano
- Computation
- Homeland Security
- Energy
Undergraduate Curriculum (Based on 11 departments)

- Science topics: 28-37 credits, average 33
- Humanities: 31-37, average 24
- Engineering: 13-19, average 16
- Materials: 27-53, average 37
- Tech Electives: 8-24, average 11
- Free Electives: 0-15
- Specialization: yes and no

Total credits reduced to 128 credits

Many departments adding electives in Nano and Bio, and some are adding a new specialization in Bio.
Core Topics for MSE Undergraduate Curriculum

- Introduction to Materials
- Experimental Techniques
- Thermodynamics
- Transport Properties
- Phase Equilibria
- Phase Transformation
- Kinetics
- Structure
- Characterization
- Mechanical Behavior
- Electronic, Magnetic, and Optical Behavior
- Synthesis, Processing, and Manufacturing
- Materials Selection and Design
- Failure Analysis

Coverage over all material classes limits the depth of the B.S. MSE graduate
Impact of 128 credit limits in MSE

Fundamental courses “lost”

• Analytical Chemistry
• Physical Chemistry
• Statistics
• Static
• Strength of Materials
• Mass and Energy Balances
• Deformation Processing
• Joining
• Melting and Refining
• Thermal Processing

The larger departments can afford to offer many courses as electives and have enough students to justify them. Smaller departments cannot.

After Reza A.
MATRIX COVERAGE OF MATERIALS SCIENCE AND ENGINEERING

Intro Materials → Characterization → Mechanical Behavior → Mats Lab → Energetics/Kinetics → Transformations → Stability → Selection/Failure → 2 courses Research/Design → 6 - 9 Hours Electives

- Metals Engineering
- Ceramics Engineering
- Polymers Science
- Electronic Behavior

15 - 18 semester hours in one specialization
- Metals Specialization
- Ceramics Specialization
- Polymer Specialization
- Electronic specialization

Nano and Bio

R. Abbaschian
Core Topics for MSE Graduate Curriculum

Typically at least three courses are required

- Material Structure/Defects
- Diffusion, Kinetics and Transport
- Materials Thermodynamics

Some require more such as ….

- Materials Characterization
- Solid State Physics
- Mechanical Behavior of Materials.
- Mathematical Foundations in Materials Science

Graduate students from non-MatSE backgrounds do not take undergrad material-specific courses.
Graduate Student GRE Scores

GRE Scores

Score

25 Percentile  50 Percentile  75 Percentile  90 Percentile

Percentiles

Verbal  Analytical  Quantitative

UMC 2004 survey
Source: ASEE Engineering Statistics 2001
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<table>
<thead>
<tr>
<th>Discipline</th>
<th>Graduates ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioMed</td>
<td>1:6</td>
</tr>
<tr>
<td>Chem Eng</td>
<td>1:9</td>
</tr>
<tr>
<td>EE</td>
<td>1:11</td>
</tr>
<tr>
<td>Industrial</td>
<td>1:14</td>
</tr>
<tr>
<td>Mech Eng</td>
<td>1:15</td>
</tr>
<tr>
<td>MSE</td>
<td>1:2-2.5</td>
</tr>
</tbody>
</table>

Materials is a research intensive discipline
Some questions

• Constant graduation rates parallel loss of jobs?
• Should we increase the numbers of materials graduates or just ‘export’ jobs (even research jobs)?
• Is broadening of materials healthy?
• Should we consider expanding to International UMC (IUMC) to bring global community together?