Trends and Perspectives about Materials Education in the United States

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The Talk

Statistics in Materials Education

Global Trends

Trends Influencing an MSE Education

Some questions

The University Materials Council (UMC)

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
Mufit Akinc, 1st Vice Chair
Alex King, 2nd Vice Chair
Peter Davies, at large member (2005-2006)
Ian Robertson, at large member (2005-2007)
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

Consolidation of Departments

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

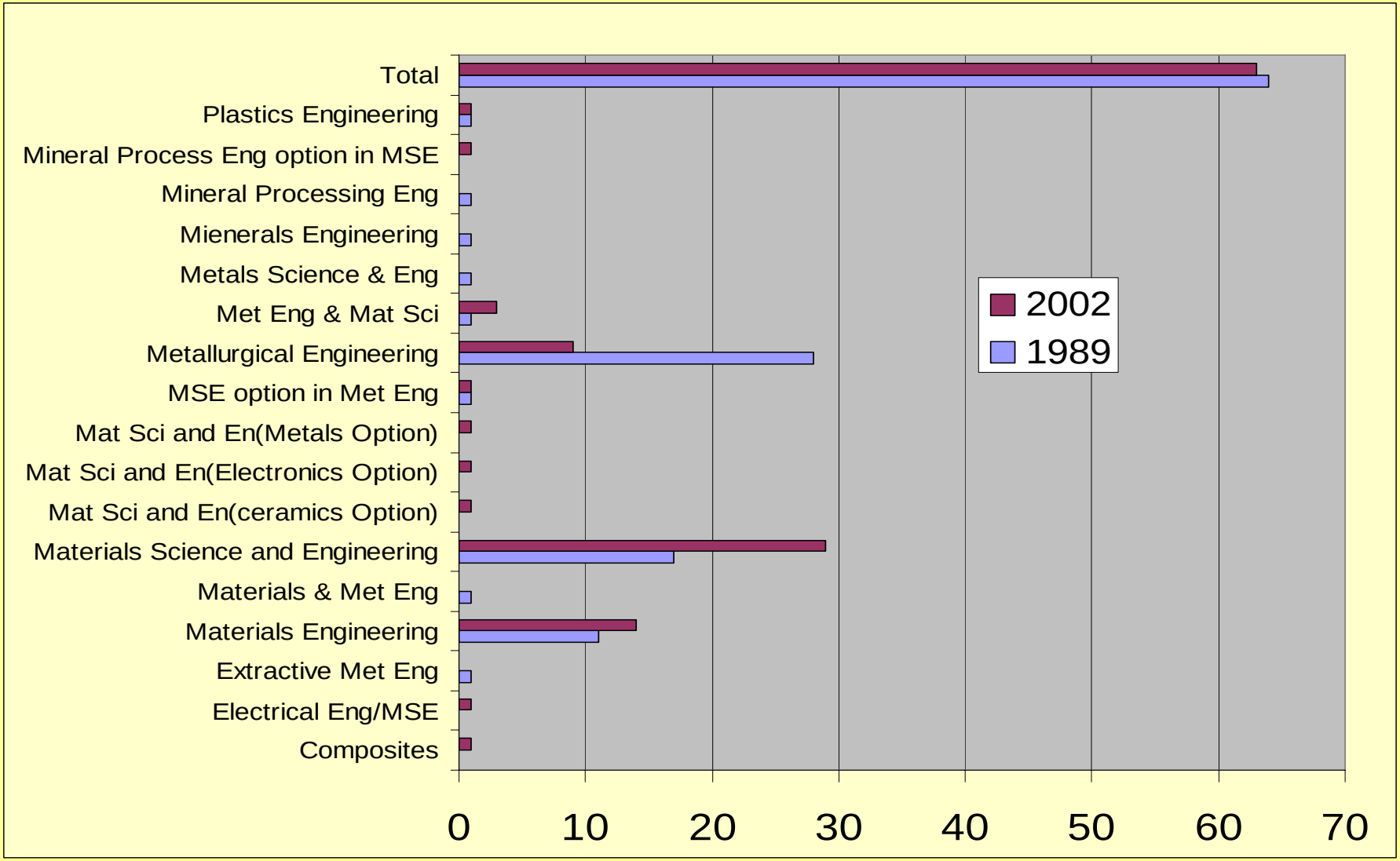
Source: ASM Education Yearbook, 1993 and 2000

Departments Offering an Undergraduate Education in Materials

Metallurgical Engineering	11
Metallurgical and Materials Engr.	5
Materials Engineering	12
Materials Science	4
Materials Science and Mineral Engr.	1
Materials Science and Engineering	25
Materials Option under Chemical Engr.	4
Materials Option under Mechanical Engr.	5
Ceramic Engineering	7
Polymer Science & Engr.	4

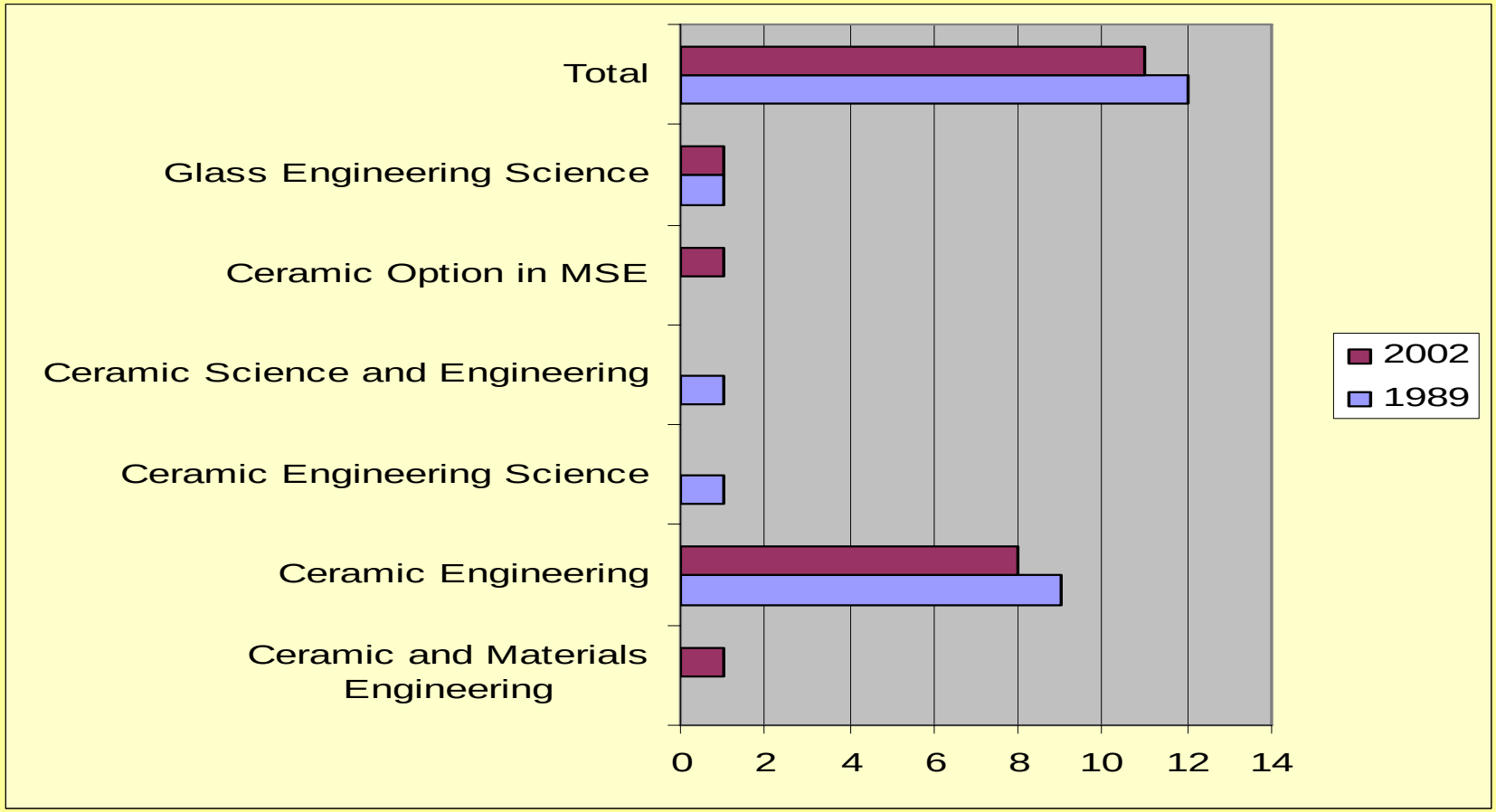
Total = 69

Diversity and Trends in MSE ABET Accreditation



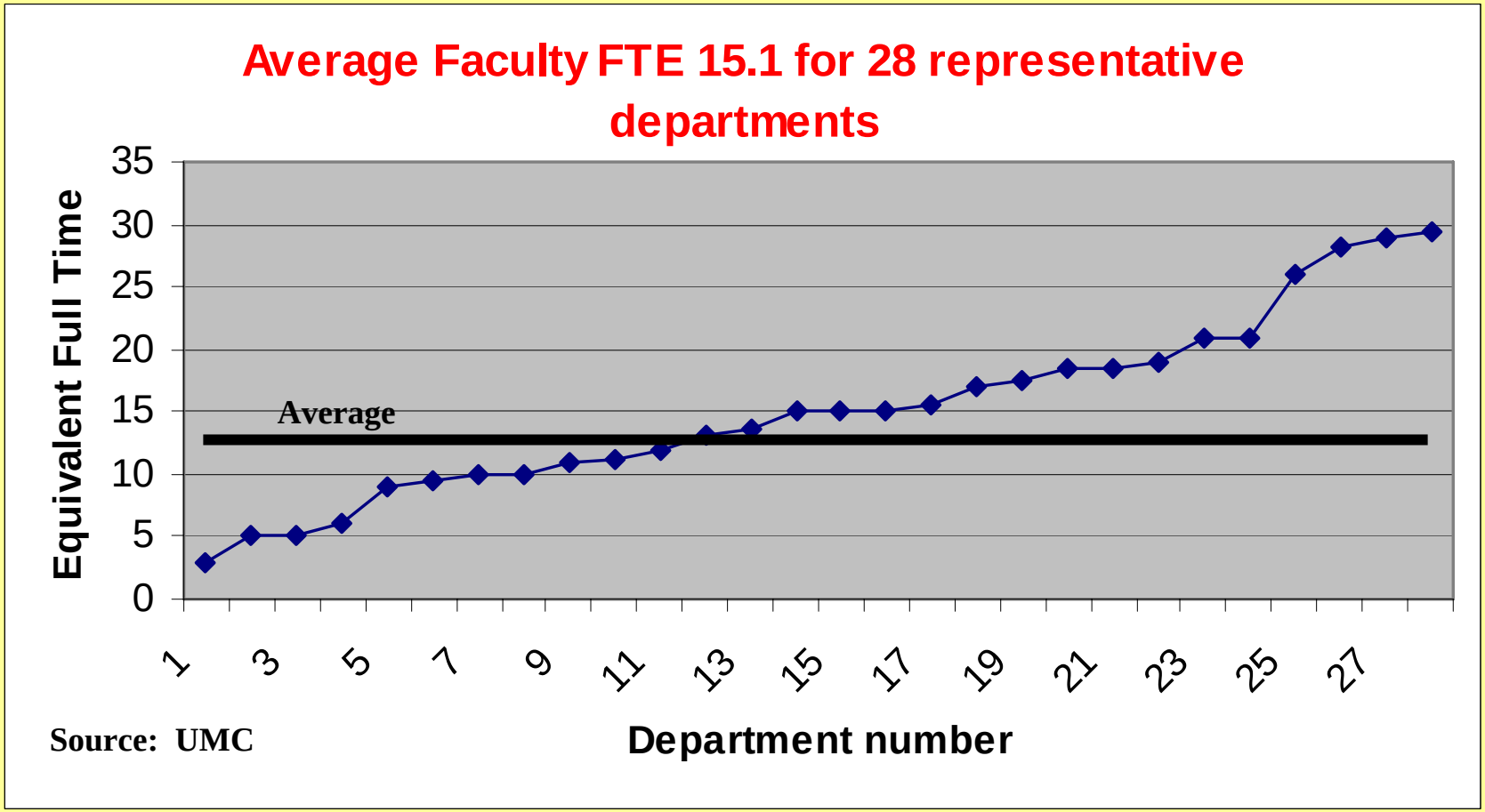
((In comparison, over 99% of around 230 ME departments are accredited in Mech Eng.))

Trends in ABET Accreditation - Ceramic Programs



Recent reports indicate that "Ceramics" will disappear in Department names

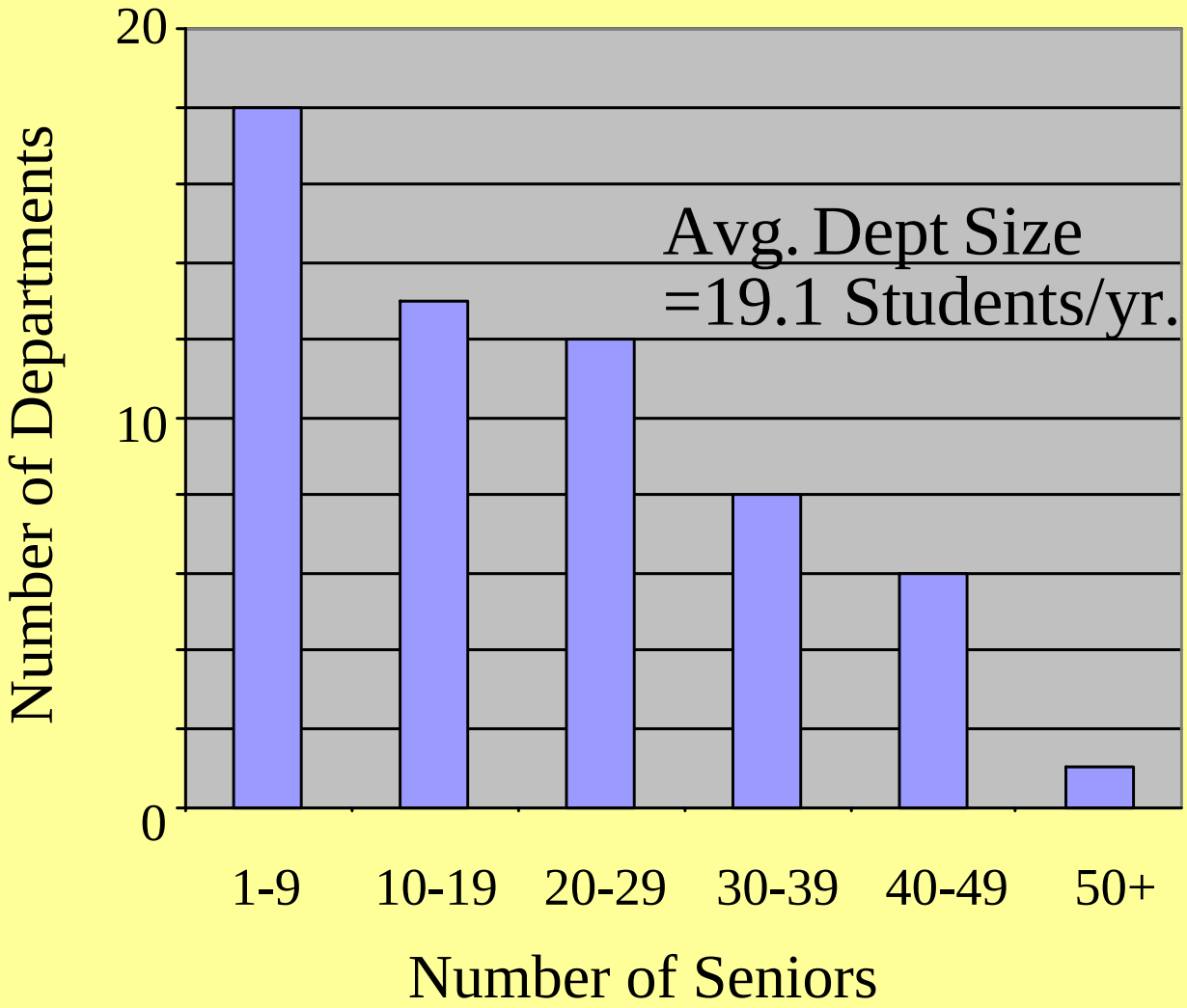
Faculty size in MSE Departments



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

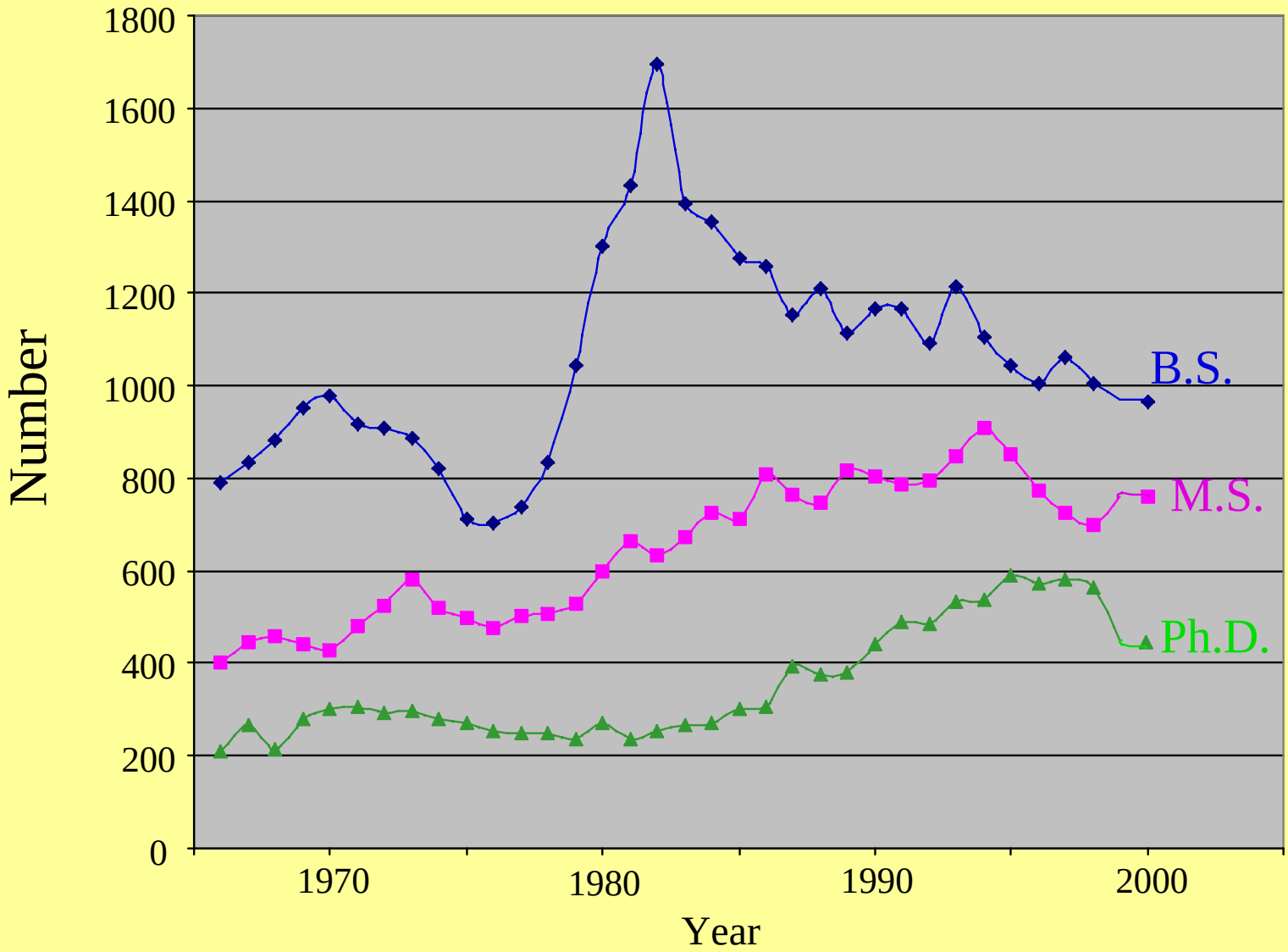
Source: ASM Education yearbook, 1993 and 2000

Senior Undergraduate Enrollments in MSE Departments

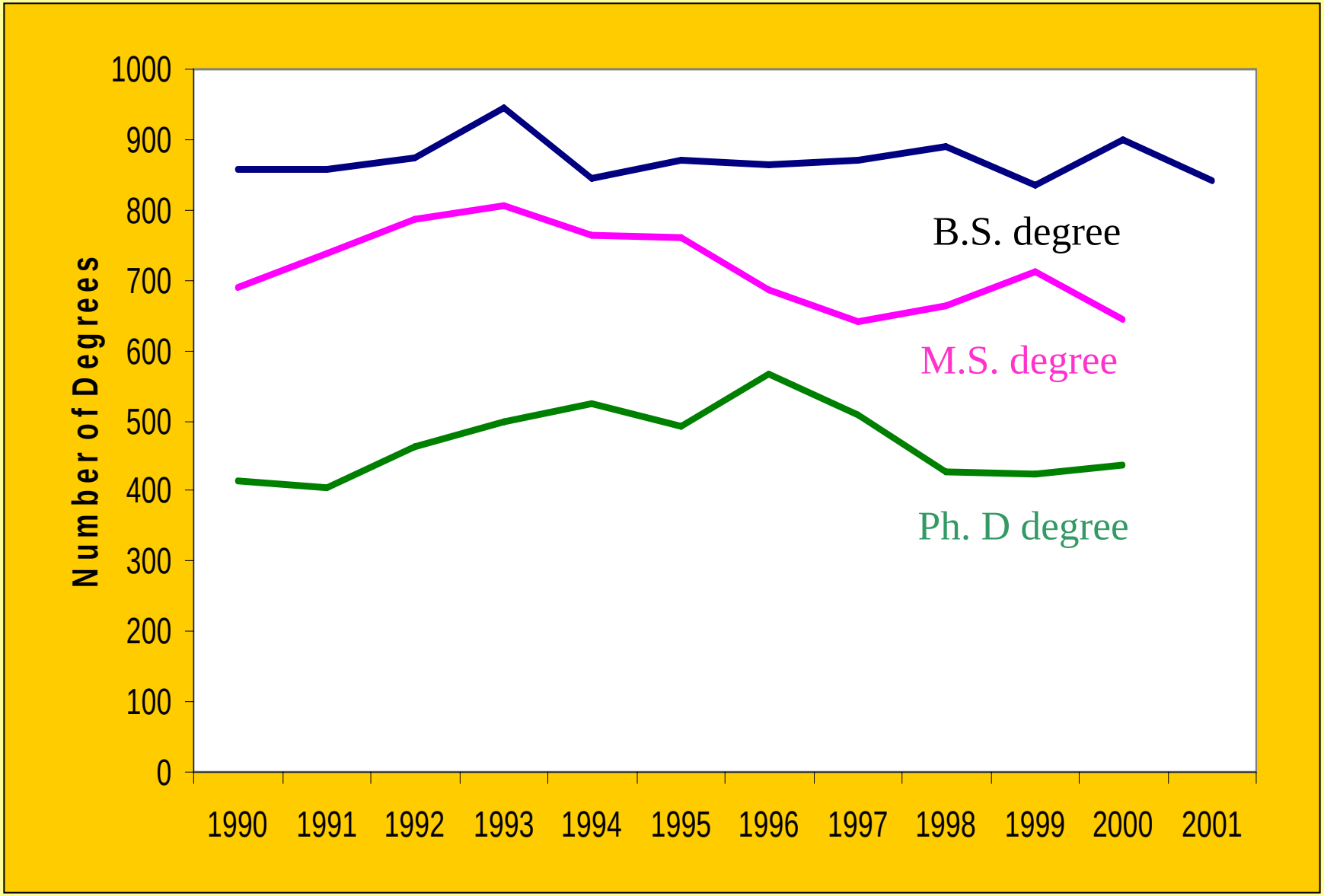


15 departments account for 50% of BS grads

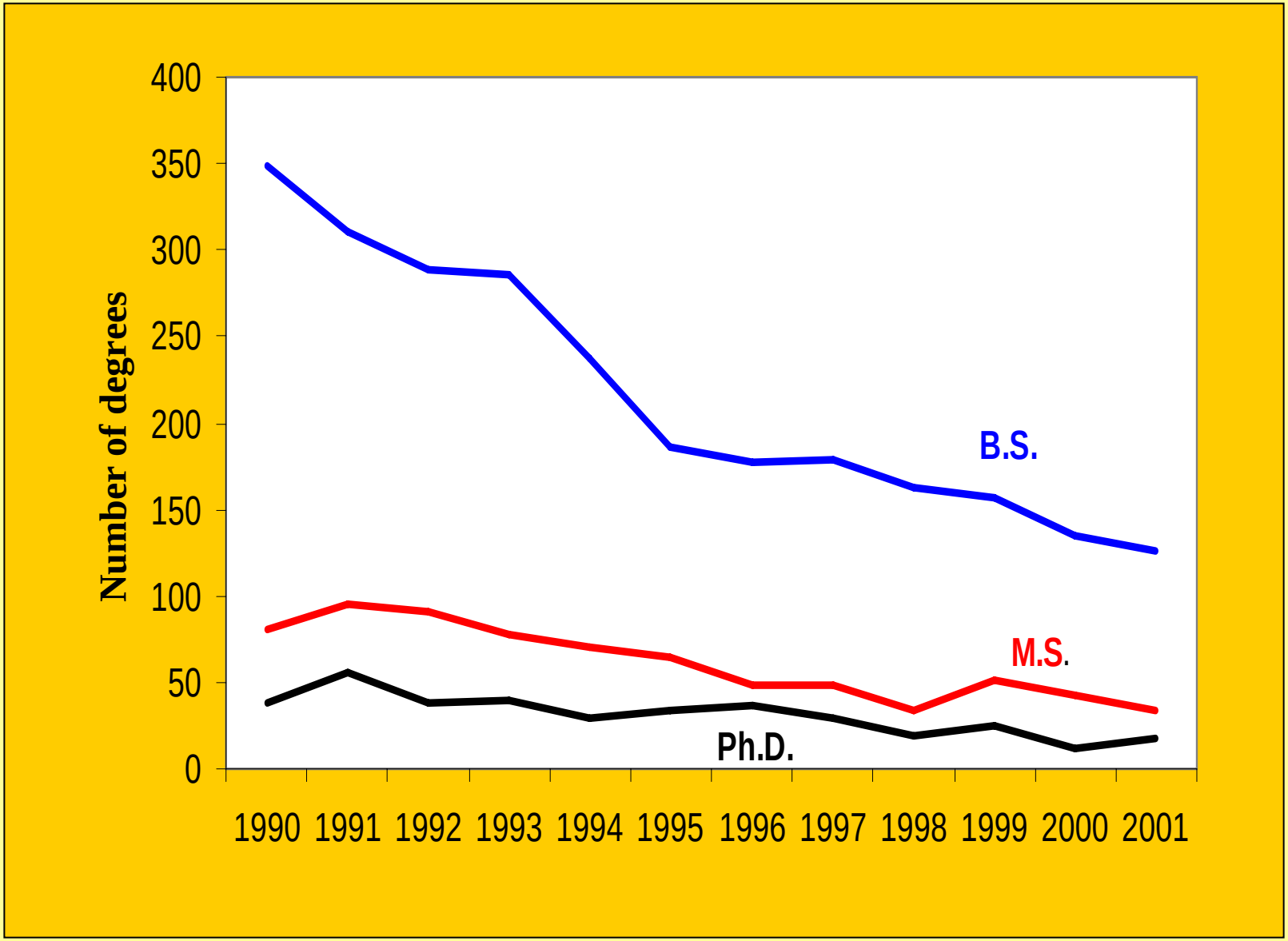
Graduation Rates in MSE Departments



Materials Degrees Per Year



Ceramic Engineer Trends



Globalization of Materials R&D

TIME FOR A NATIONAL STRATEGY

Conclusion. The MSE education system, including K-12 mathematics and science education, will have to evolve and adapt so as 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.

National Research Council, 2005

Globalization of Materials R&D

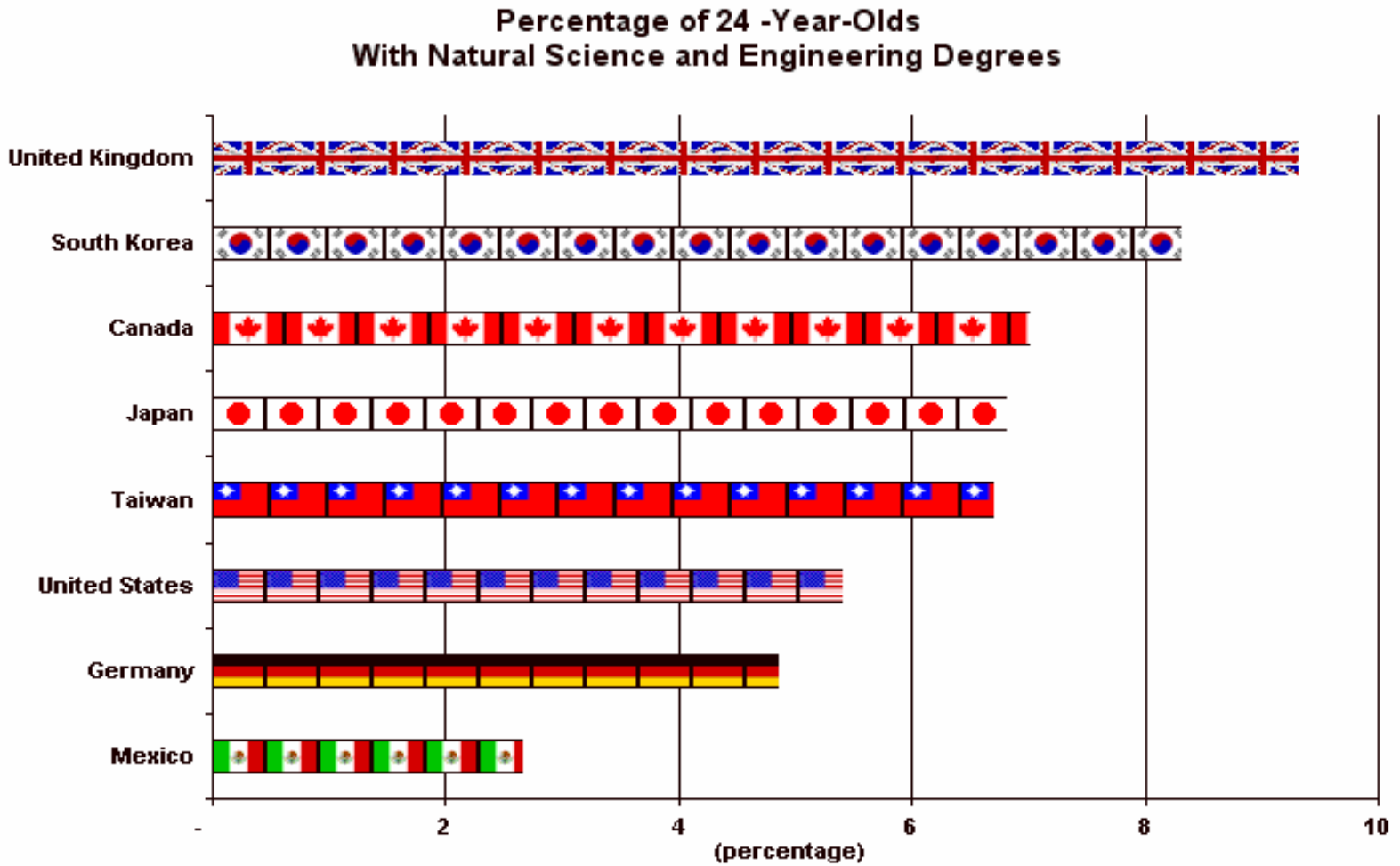
TIME FOR A NATIONAL STRATEGY

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**.

National Research Council, 2005

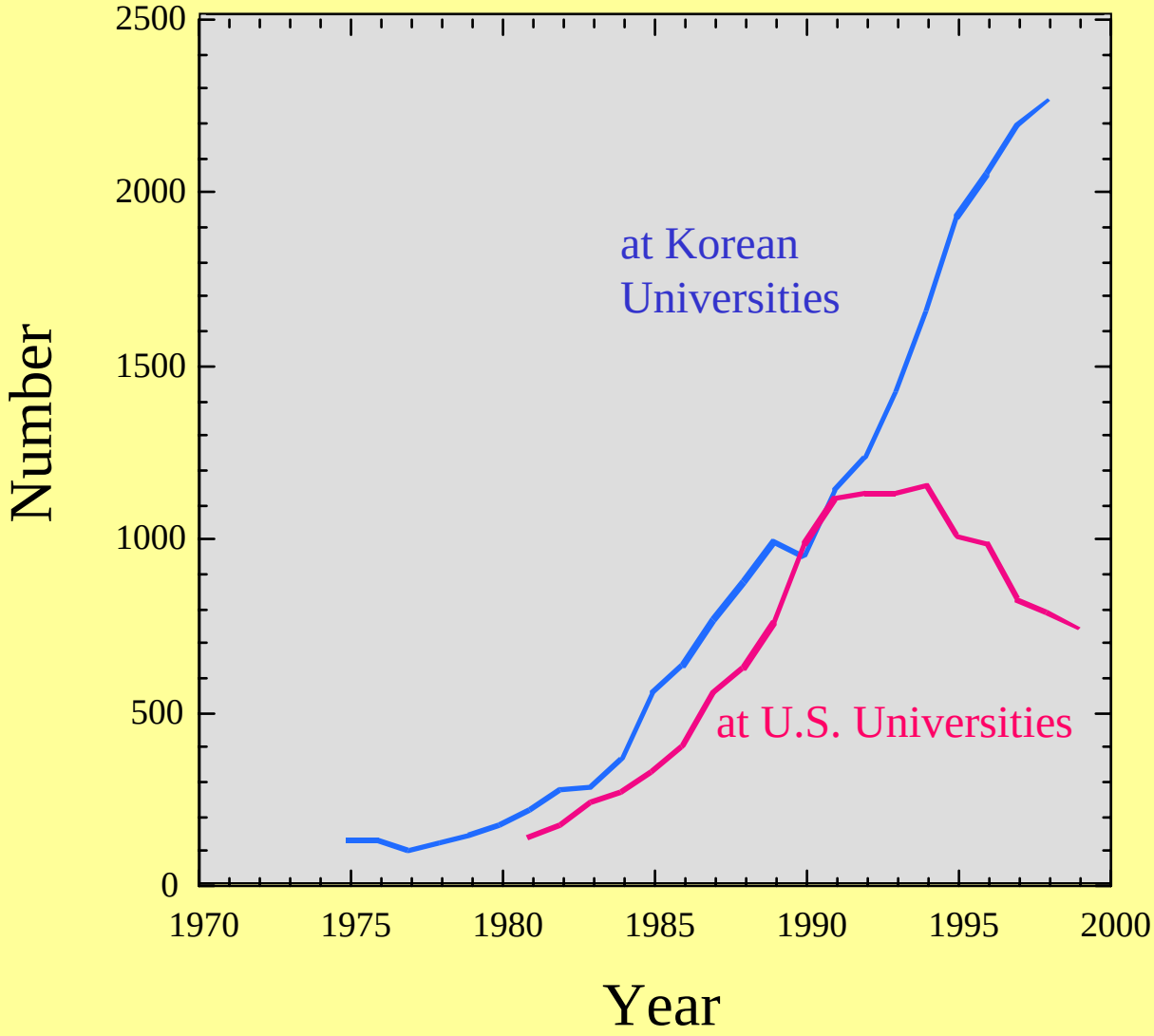
Global Competitiveness: Workforce

U.S. Lags Other Nations in Share of 24-Year-Olds With Natural Science, Engineering Degrees

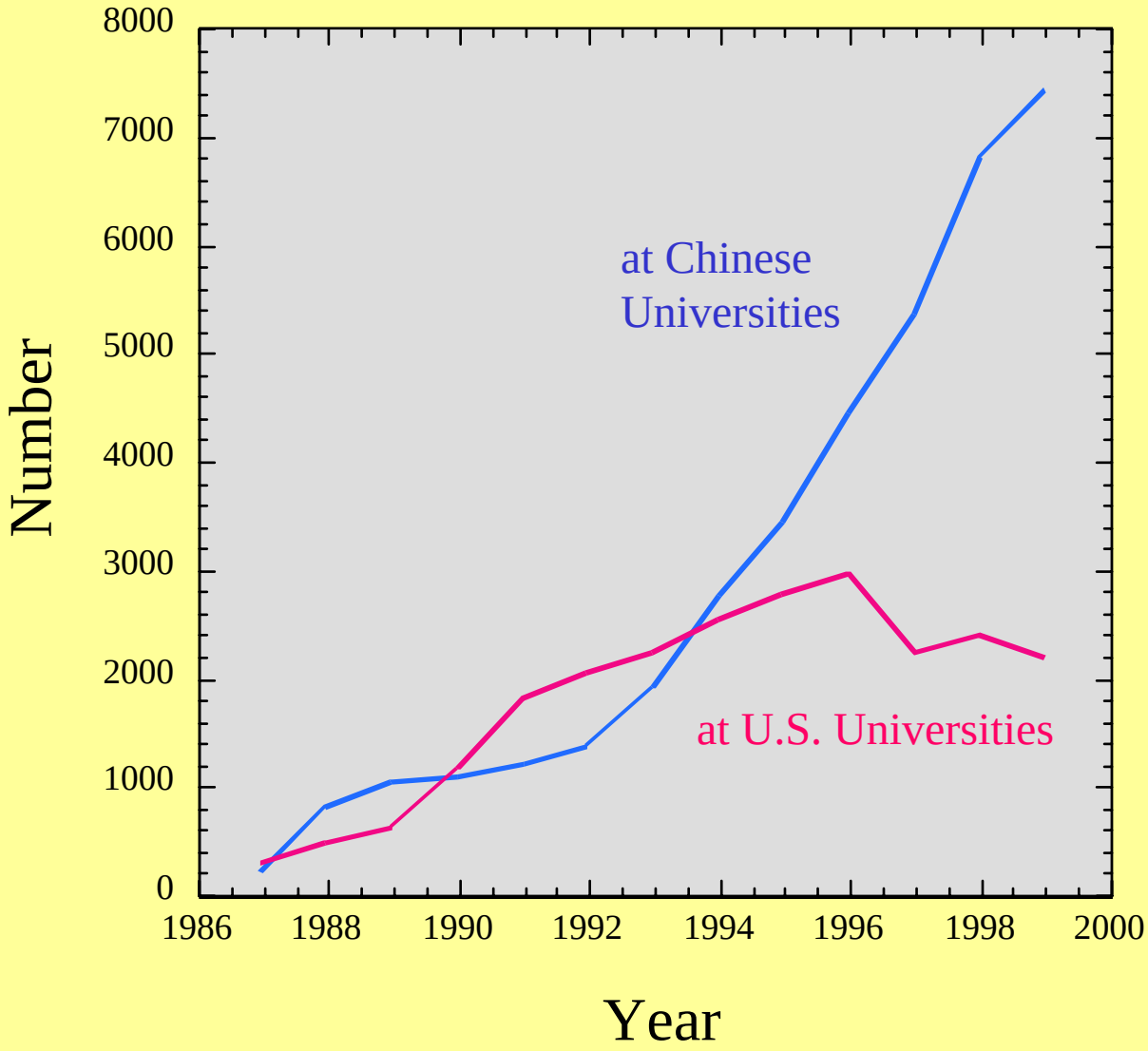


SOURCE: National Science Foundation, Science and Engineering Indicators 2000

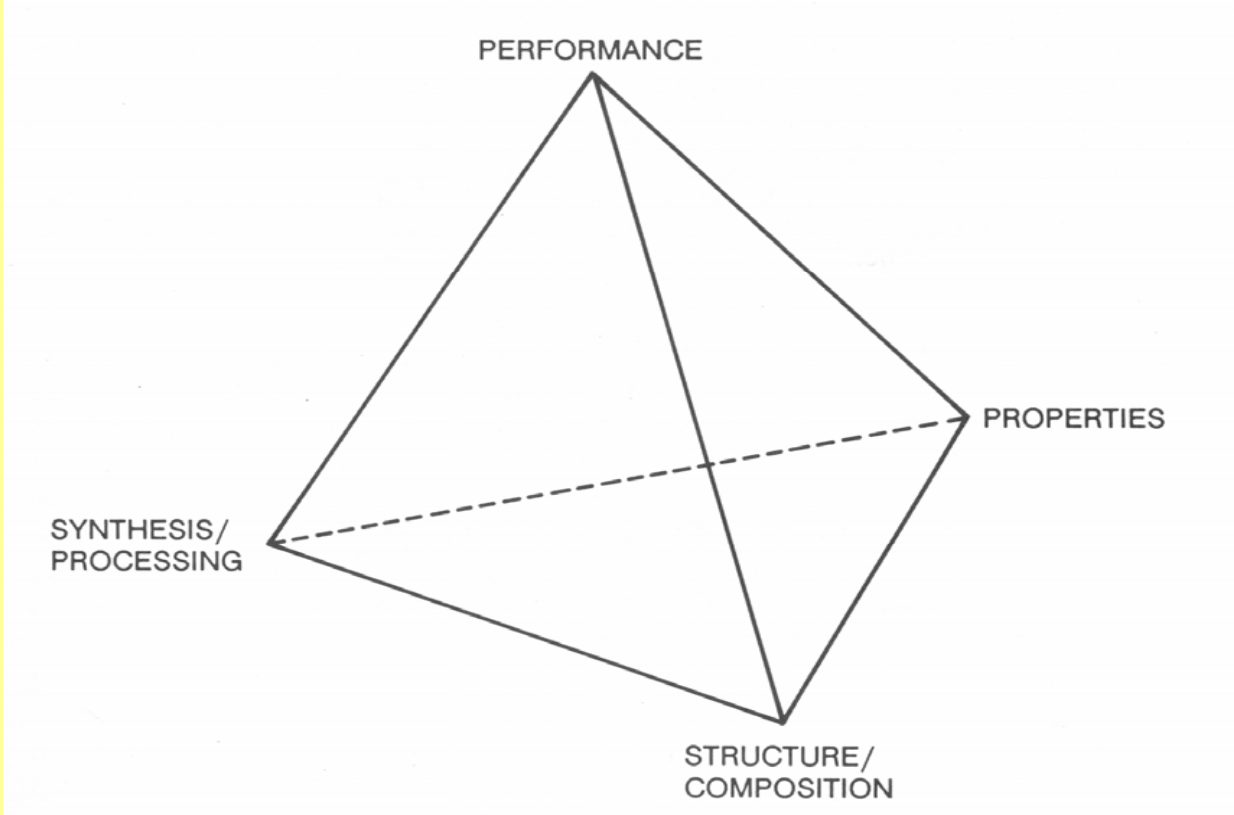
Doctoral Degrees Earned By Korean Students



Doctoral Degrees Earned By Chinese Students



Core Elements of a Materials Science and Engineering Education

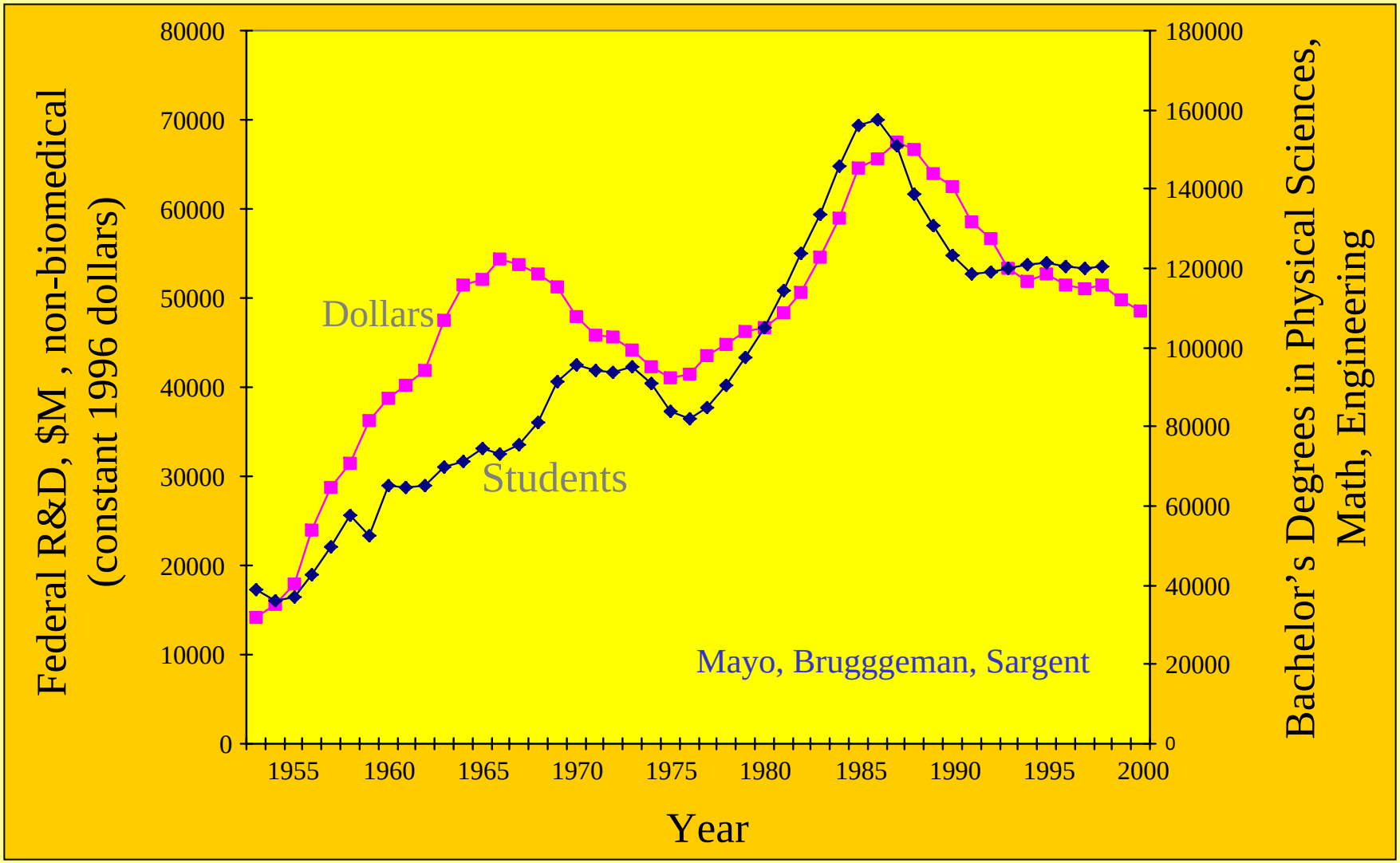


Source: Materials Science and Engineering for the 1990s, NRC, 1989

Federal Funding Priorities has a Profound Impact

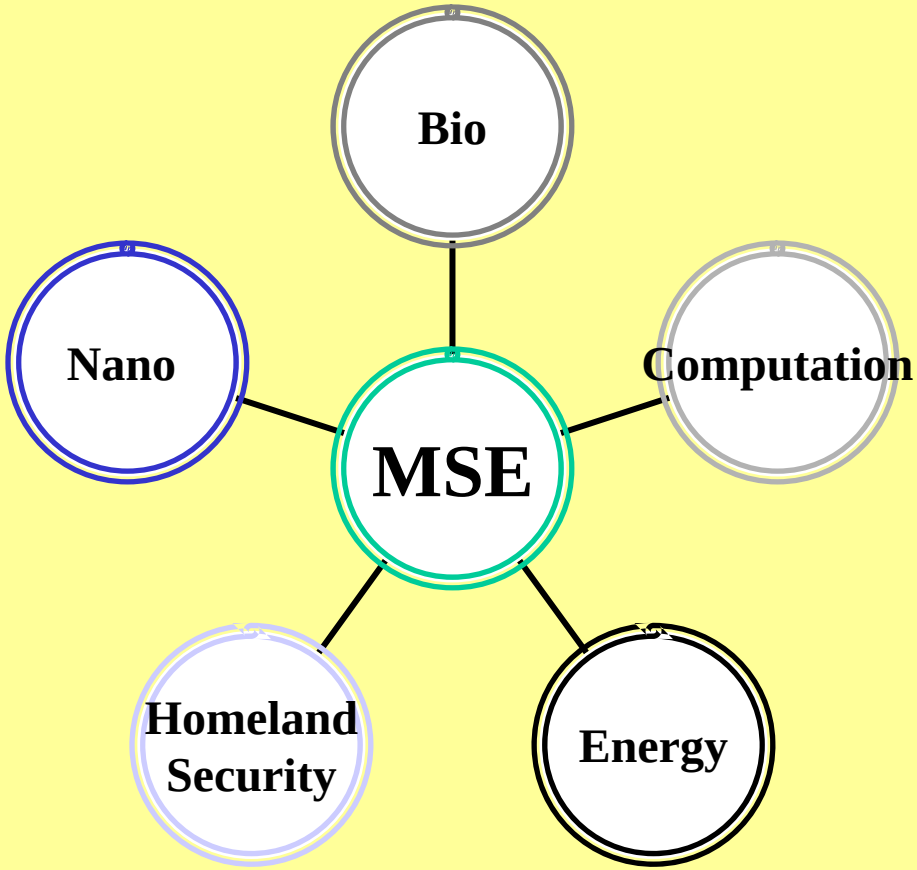
- Economy and Commerce
- Nanotechnology
- Energy
- National Security
- Health Care (**Biological sciences**)

Technological Leadership



More Funding Will Bring Students into the Physical Sciences

MSE is being Stretched by Interdisciplinarity



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

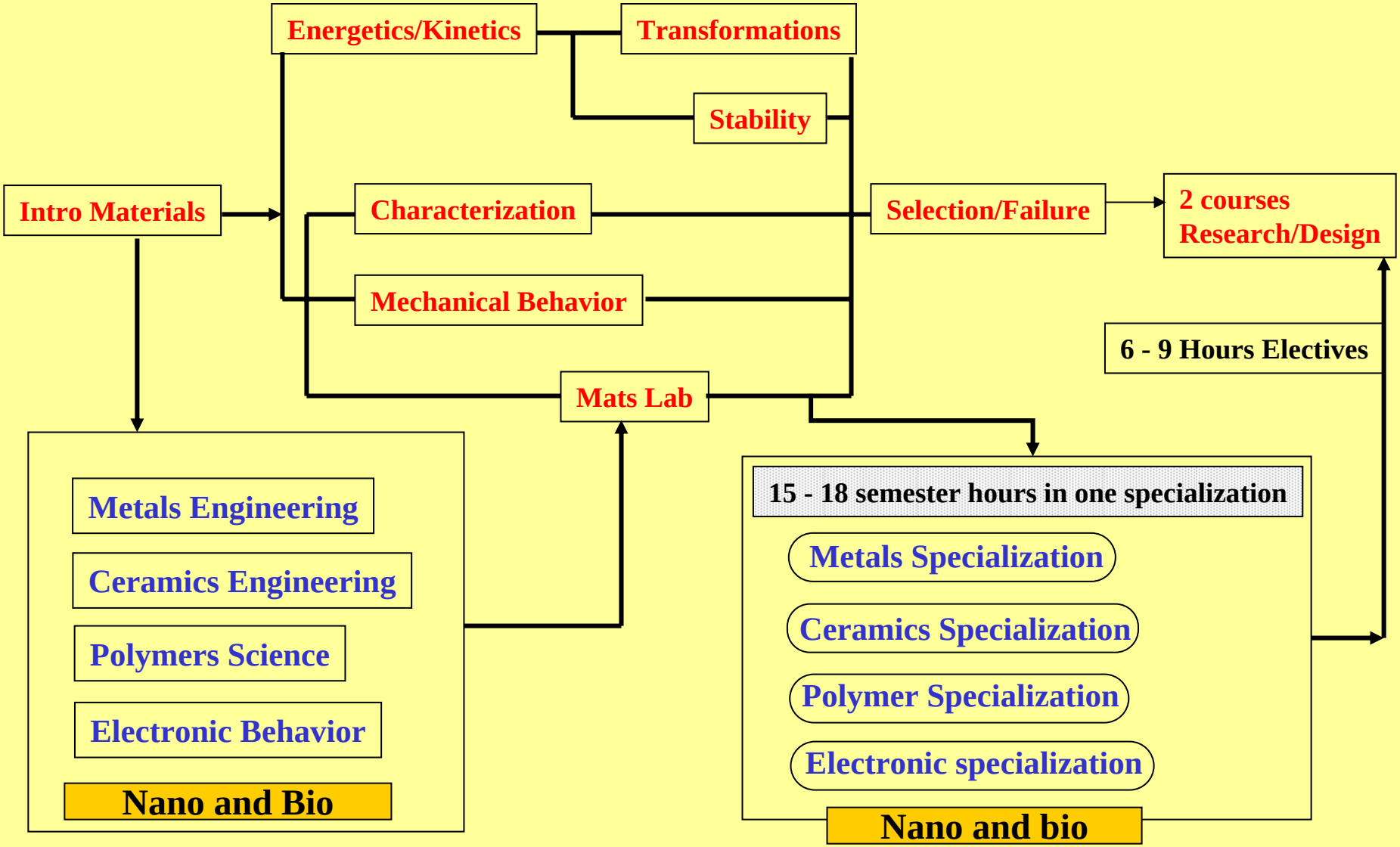
Fundamental courses "lost"

- **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



R. Abbaschian

Core Topics for MSE Graduate Curriculum

Typically at least three courses are required

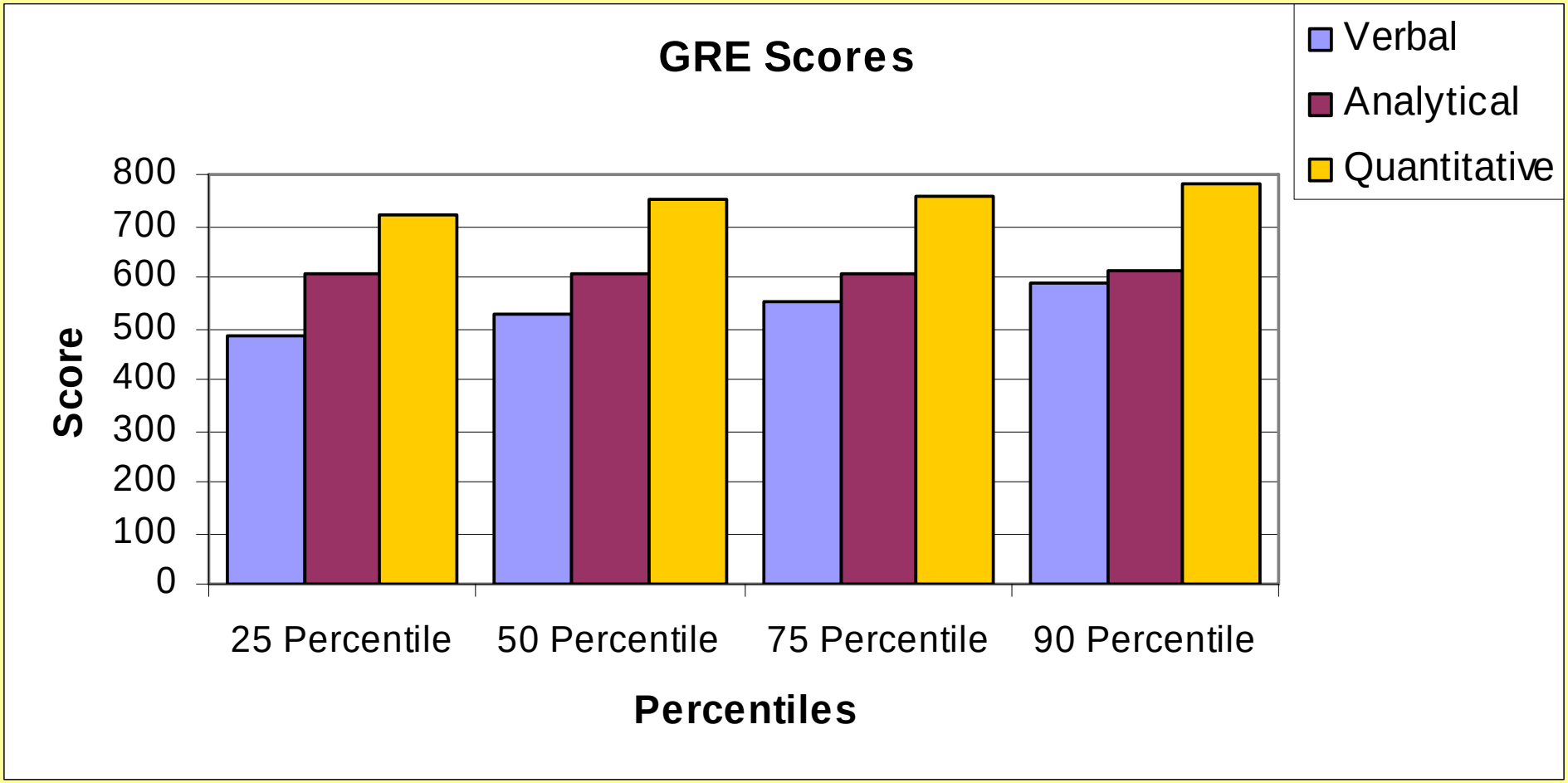
- **Material Structure/Defects**
- **Diffusion, Kinetics and Transport**
- **Materials Thermodynamics**

Some require more such as ….

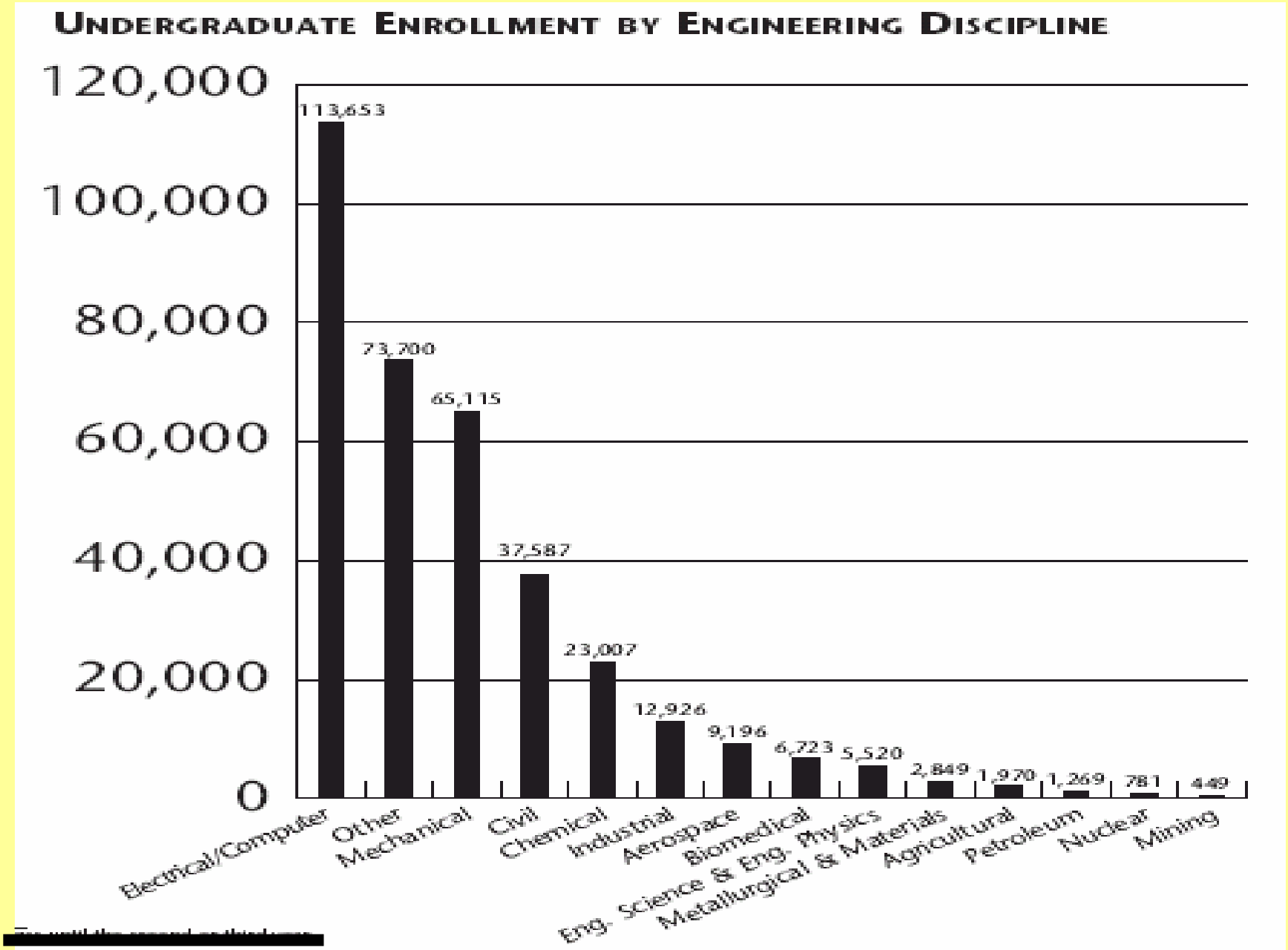
- **Materials Characterization**
- **Solid State Physics**
- **Mechanical Behavior of Materials.**
- **Mathematical Foundations in Materials Science**

Graduate students from non-MatSE backgrounds do not take ugrad material-specific courses.

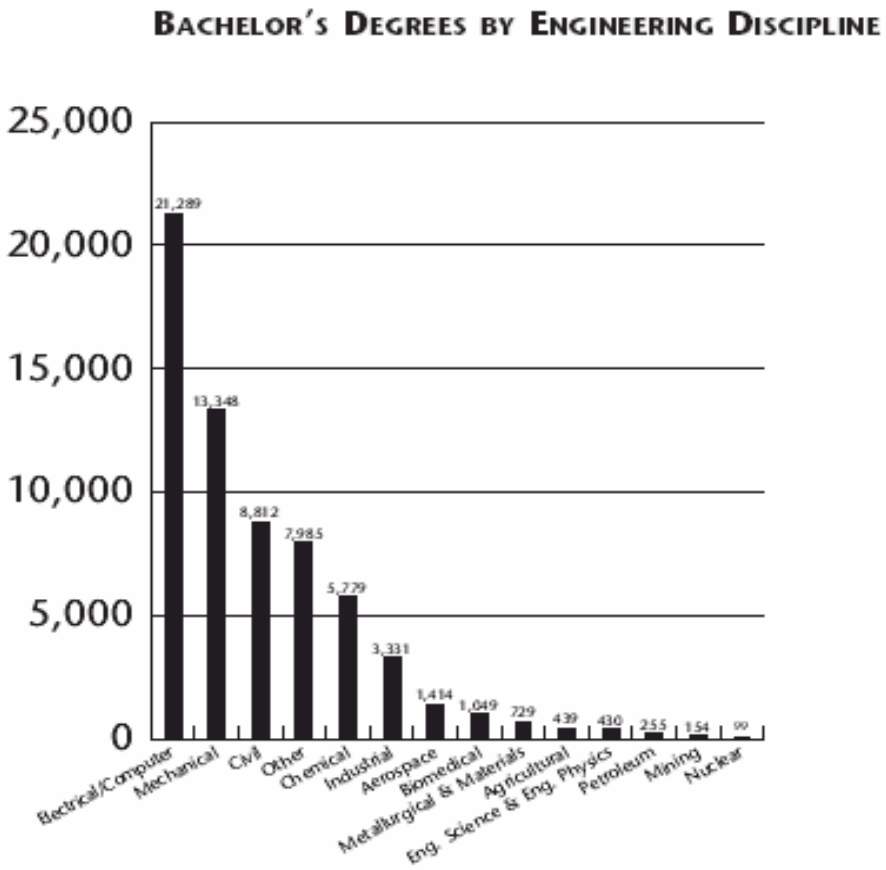
Graduate Student GRE Scores

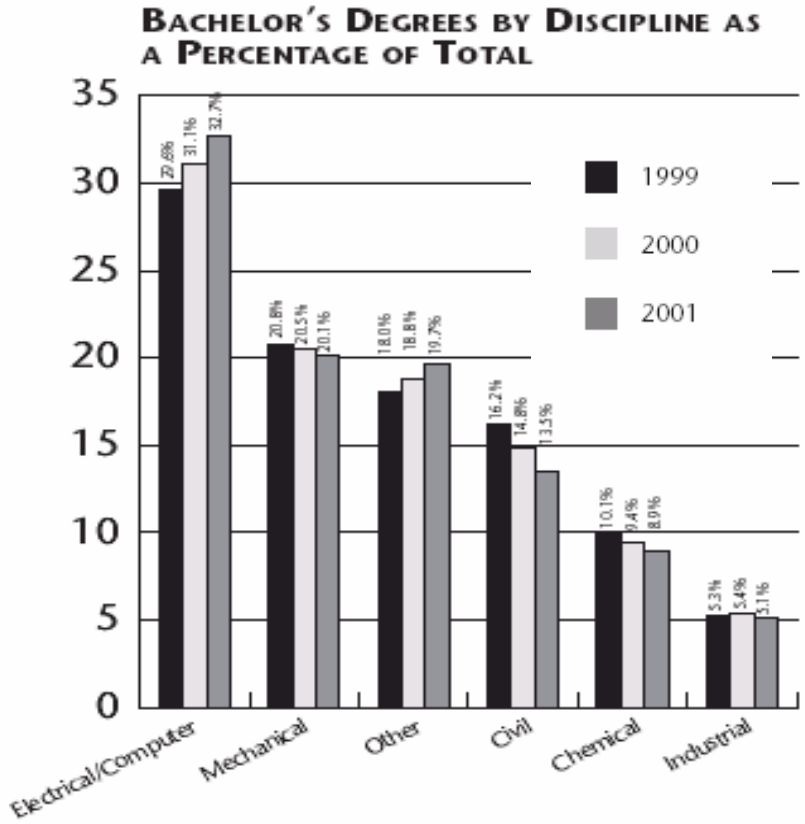


UMC 2004 survey



Source: ASEE Engineering Statistics 2001





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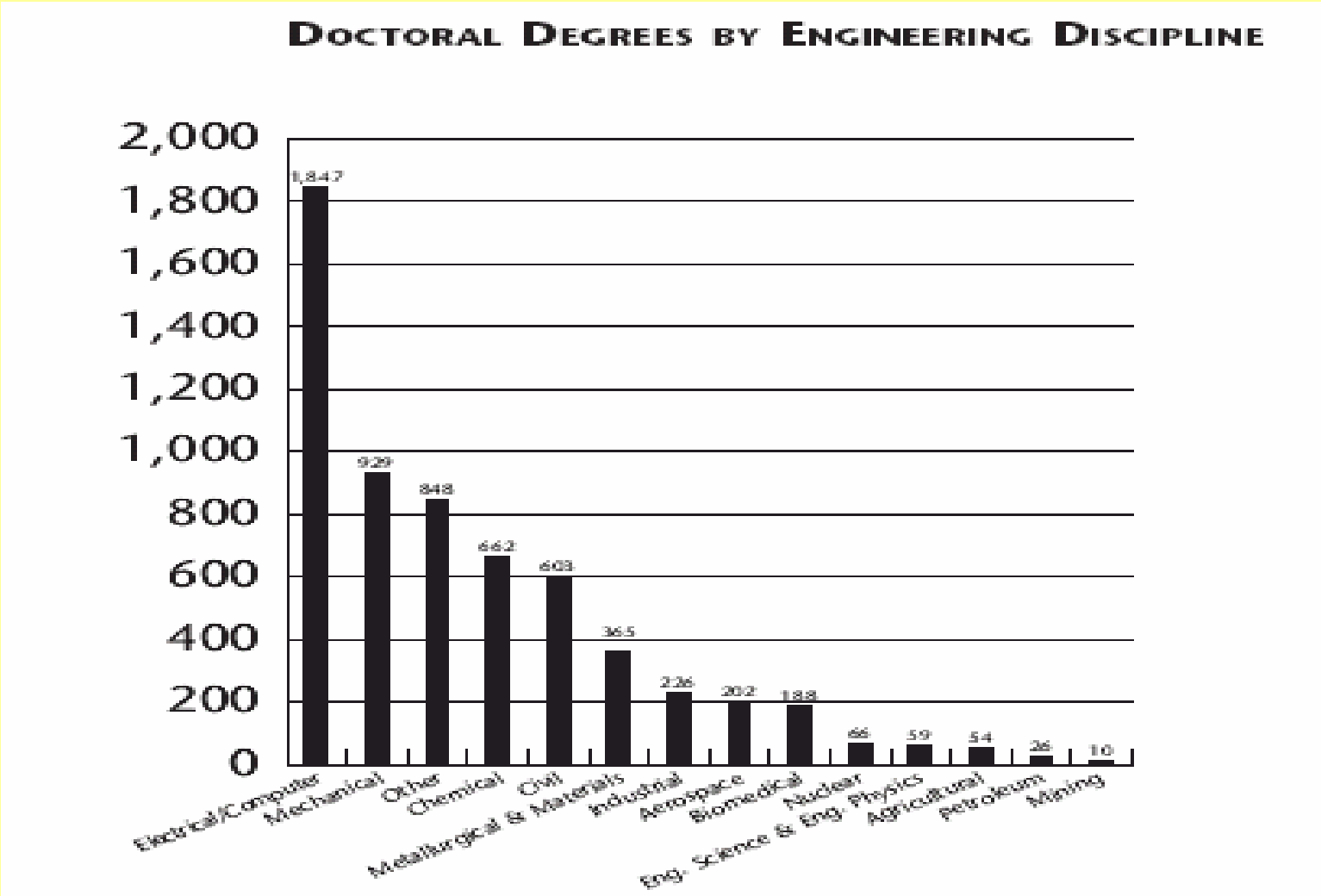

Source: ASEE Engineering Statistics 2001

Ratio of PhD to BS Graduates in Engineering (ASEE 2001)

- BioMed 1:6
- Chem Eng 1:9
- EE 1:11
- Industrial 1:14
- Mech Eng 1:15
- MSE 1:2-2.5 (~const since 1990)

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?

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