

Some Challenges and Suggestions for Educating and Recruiting Metallurgical Engineers

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SFSA

SFSA Fall Leadership Meeting
Vail, Colorado



LEHIGH
UNIVERSITY

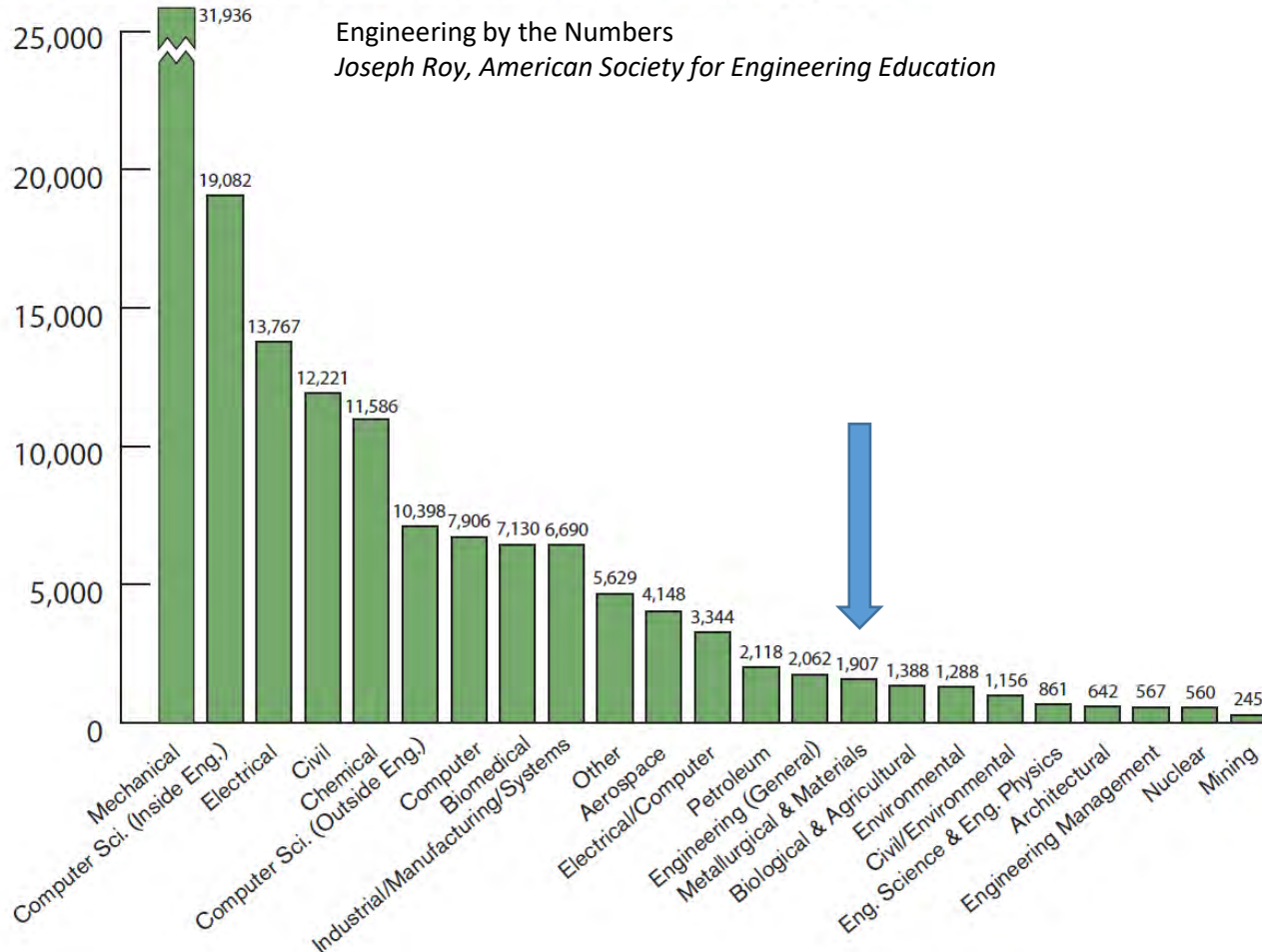
SOME OF THE CHALLENGES.....

- Recruiting Engineers into the Materials Engineering Discipline

BACHELOR'S DEGREES, 2017-2018

By

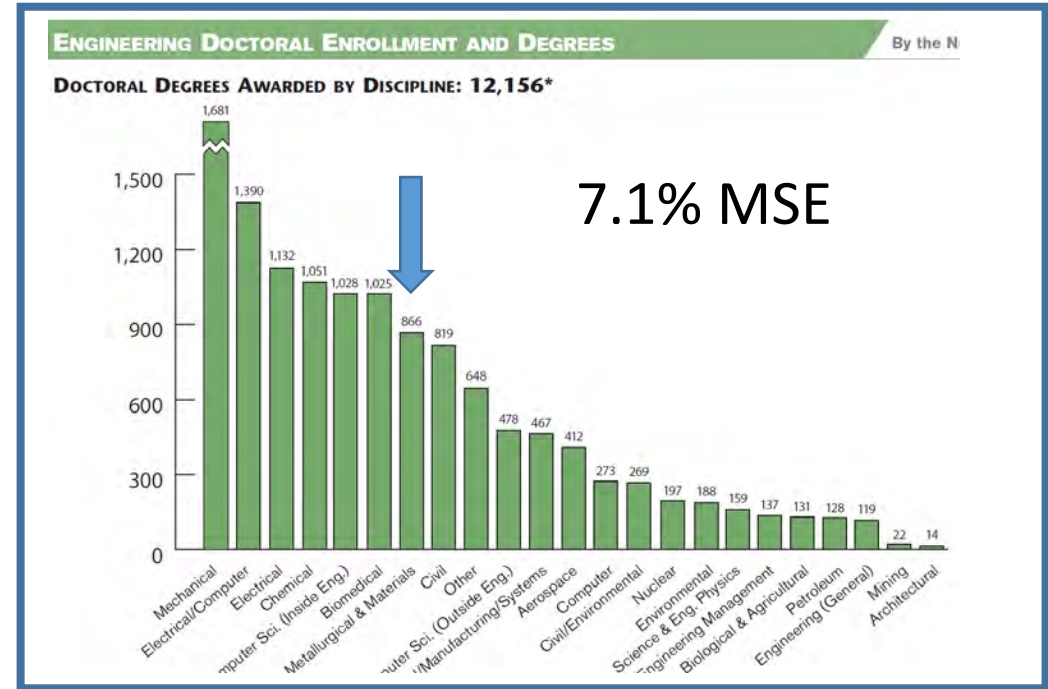
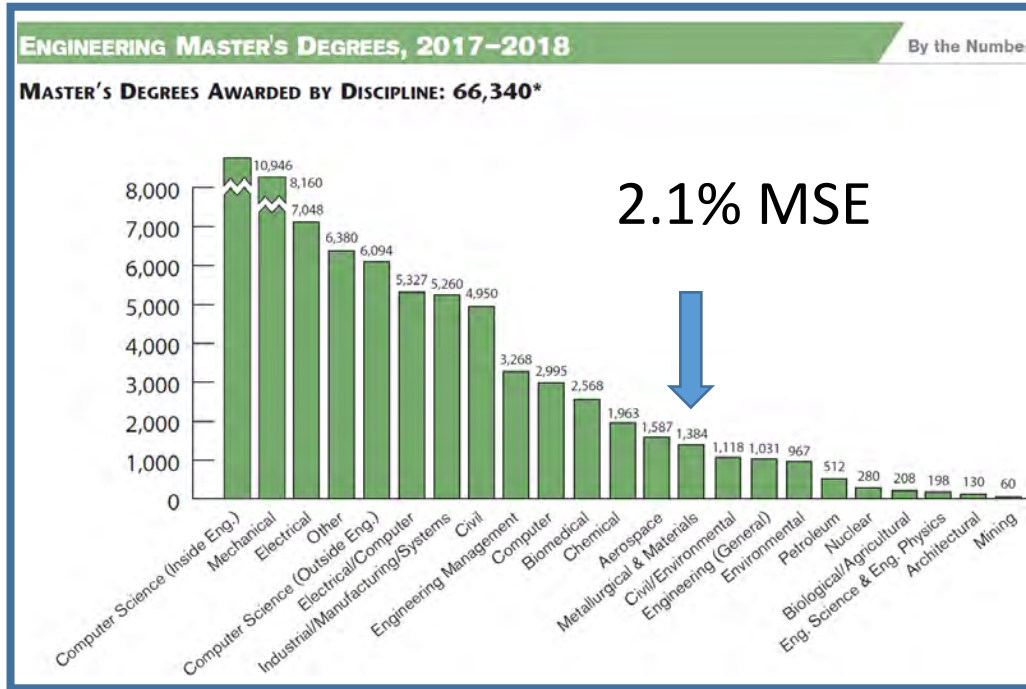
BACHELOR'S DEGREES AWARDED BY ENGINEERING DISCIPLINE: 136,233*



- Number of degrees awarded in **Metallurgical and Materials Engineering** in 2017-2018: 1,907 (1.3 %)
- At Lehigh in 2022: 300 admitted to Engineering, 3 initial interest in Materials Science and Engineering (1%)
- Number of degrees awarded in **Metallurgical Engineering** in 2017-2018: 220 (0.16%)

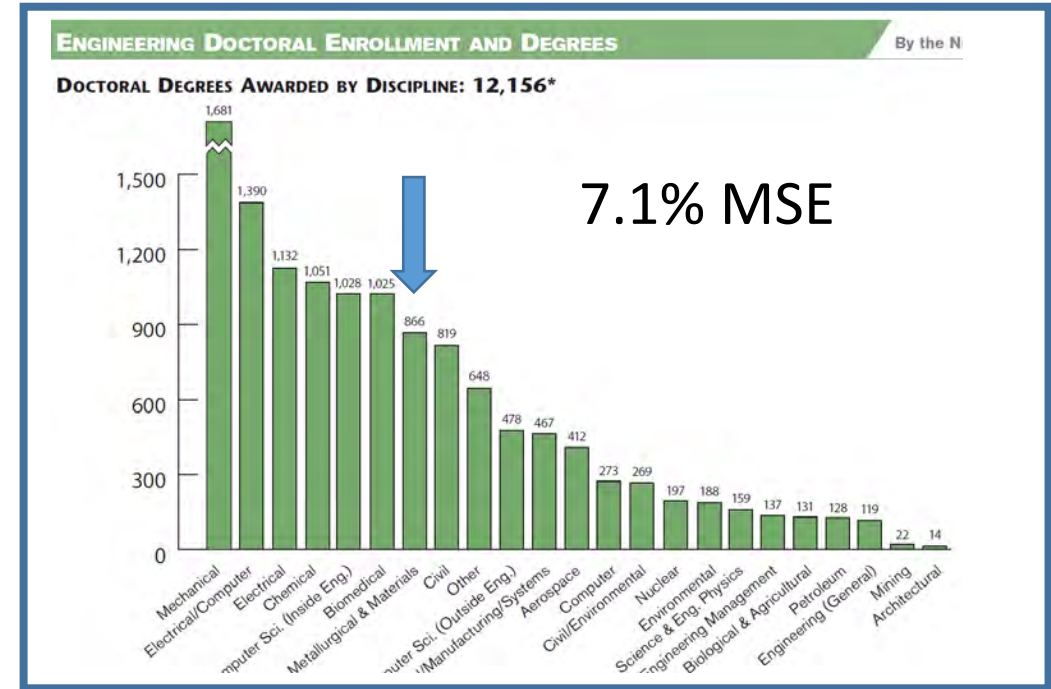
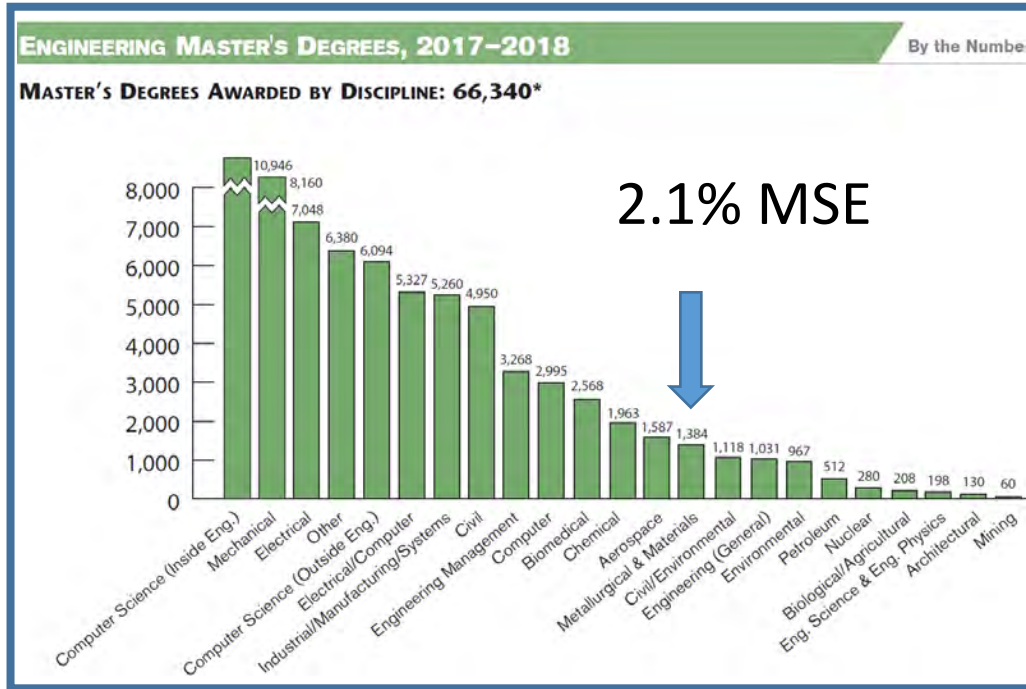
SOME OF THE CHALLENGES.....

- Numbers are a bit better for graduate enrollment.....

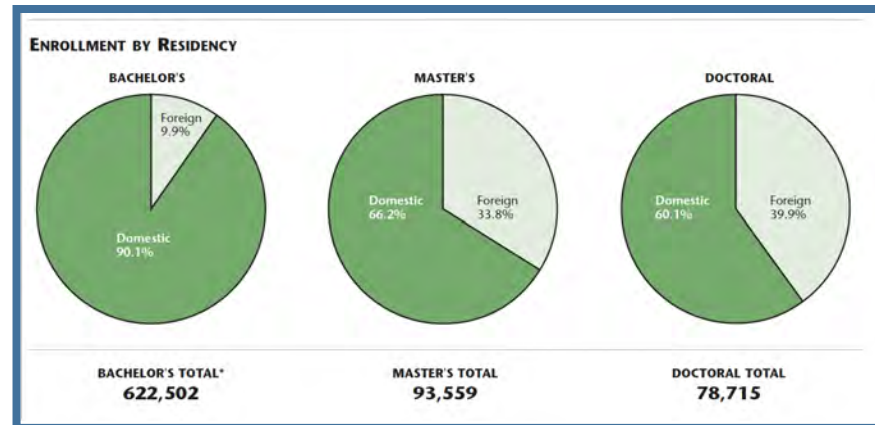


SOME OF THE CHALLENGES.....

- Numbers are a bit better for graduate enrollment.....



- But is retention of these graduate engineers a problem ?...

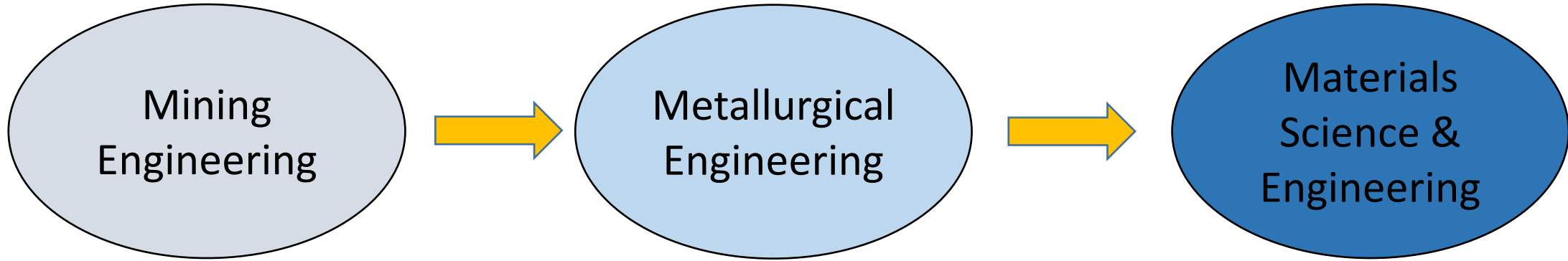


Distribution of domestic and foreign students (all engineering fields)

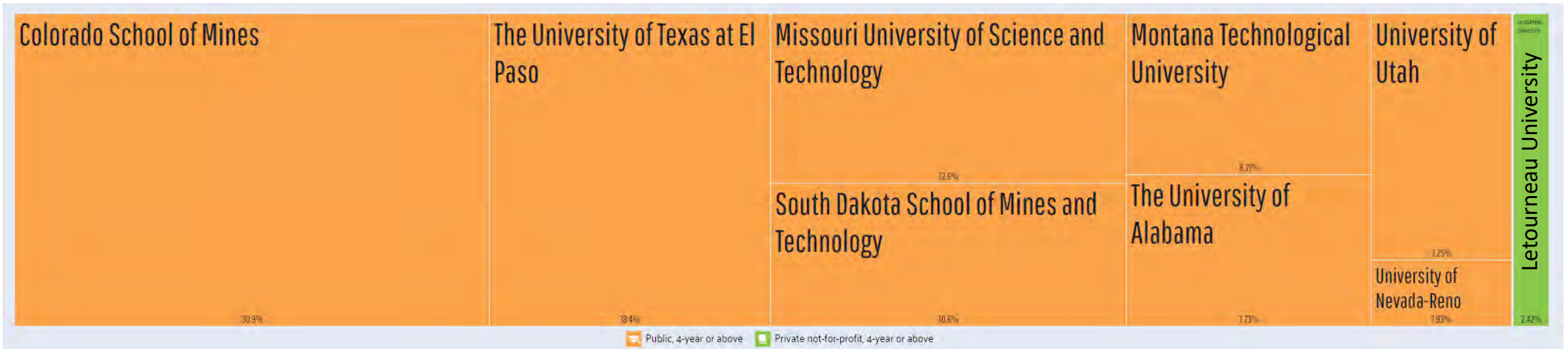
SOME OF THE CHALLENGES.....

- Shrinking Metallurgical Engineering Departments

The evolution of current MSE Departments



Universities still offering undergraduate degrees in Metallurgical Engineering (9 out of ~ 120 MSE Departments)



Some of the Challenges.....

- A shrinking curriculum in Metallurgical Engineering

Common courses/themes in
Materials Engineering

Common courses/themes in
Metallurgical Engineering

Fundamentals

Thermodynamics

Kinetics

Deformation Processing

Mechanical Behavior

Metallurgy-Based Theme Courses

Solidification Processing

Corrosion

Welding Metallurgy

Failure Analysis

Ferrous Metallurgy

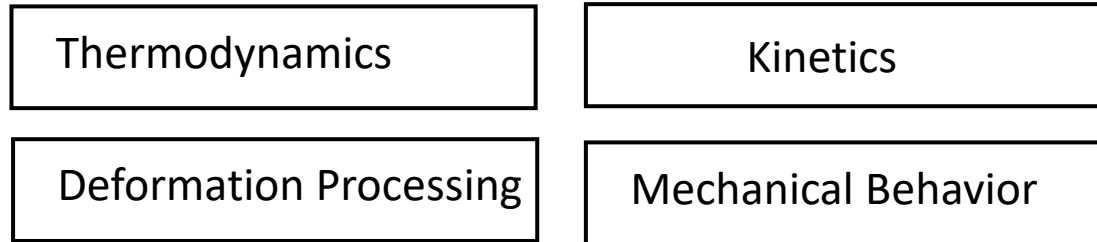
Foundry Practices

Some of the Challenges.....

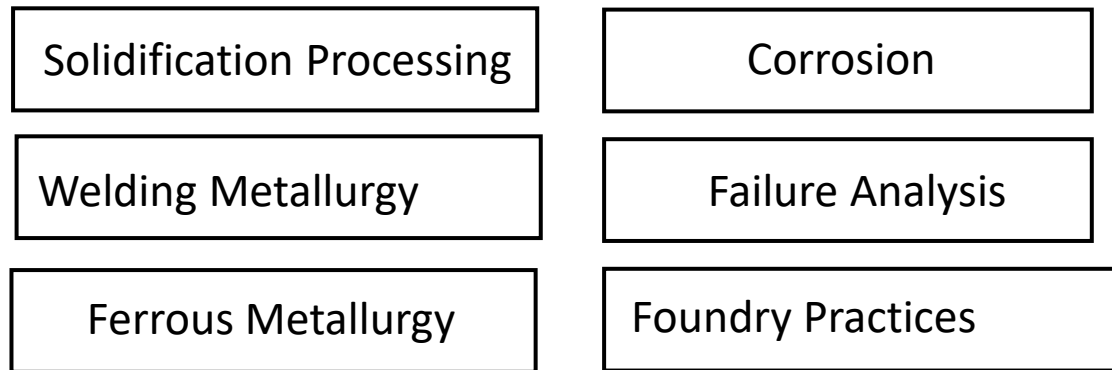
- A shrinking curriculum in Metallurgical Engineering

Common courses/themes in Metallurgical Engineering

Fundamentals



Metallurgy-Based Theme Courses



Common courses/themes in Materials Engineering

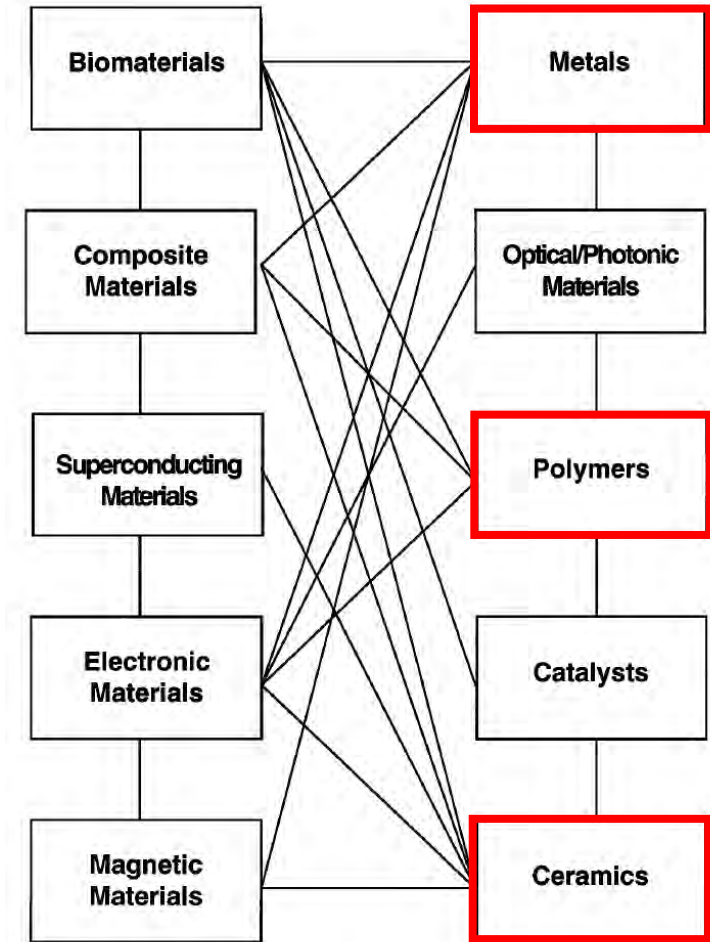


Figure 2 Interrelationships among materials categories (from Reference 2).

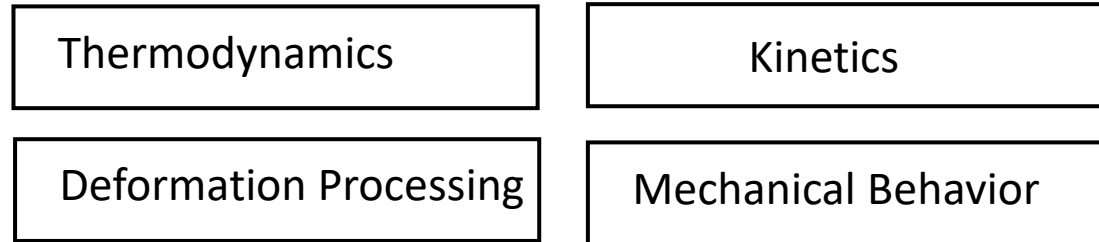
- The Committee on Science, Engineering, and Public Policy (COSEPUP)
- Connecting lines illustrate the overlapping nature of material subdivisions.

Some of the Challenges.....

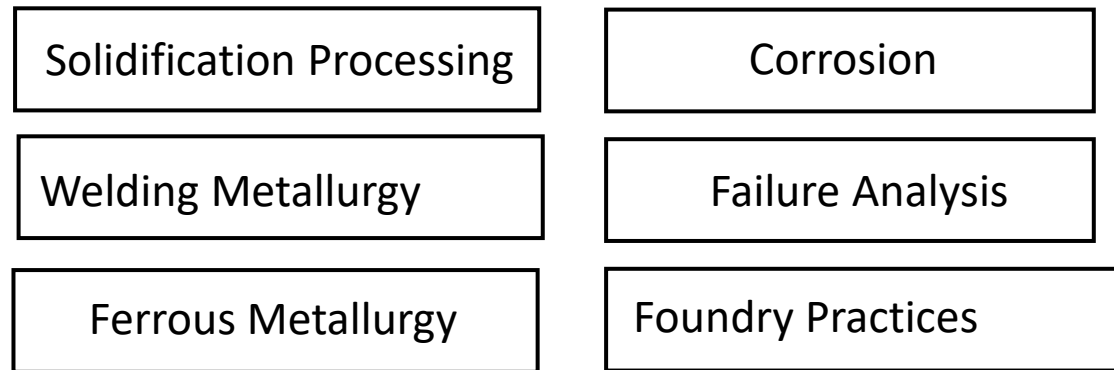
- A shrinking curriculum in Metallurgical Engineering

Common courses/themes in Metallurgical Engineering

Fundamentals



Metallurgy-Based Theme Courses



This is not a big problem....if the fundamentals are properly covered

Common courses/themes in Materials Engineering

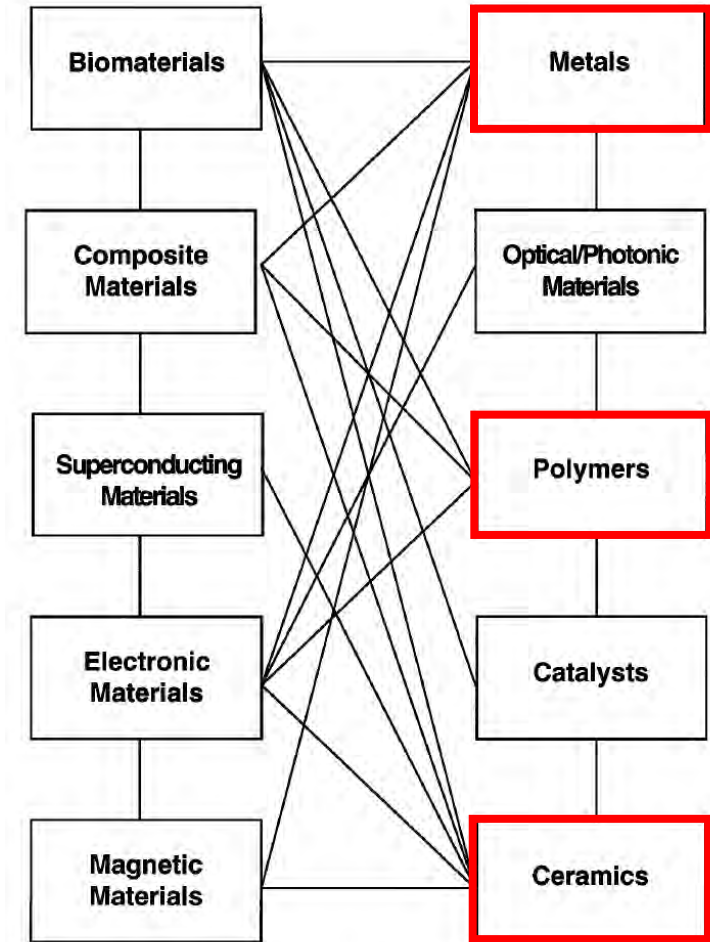


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SOME OF THE CHALLENGES.....SUMMARY

- **Difficult to attract students into Materials Science and Engineering (MSE)**
- **The “Metallurgy” curriculum is significantly reduced because it now competes with the boarder MSE curriculum**
- **Graduating materials engineers now have many more industries to choose from (polymers, ceramics, optical materials, etc.)**
- **Many university administrators have a perception that education and research in metallurgical engineering will not be as important in the future (i.e., that funding for metallurgy research is low)**

How to address this: Universities need to collaborate with all their stakeholders

- **Industry and National Labs**
- **Government Funding Agencies**
- **Professional organizations**



SOME SUGGESTIONS.....

**What can universities
and MSE departments do.....**

Marketing strategies

- **Open houses (and invite the parents)**
- **Survey classes – make them exciting**
- **Freshman seminars**
- **Interesting introductory MSE class with lots of demos (emphasizing the hands-on nature of the field)**
- **Work with admissions office to educate students early about MSE**
- **We have to do ALL of these !**



SOME SUGGESTIONS.....

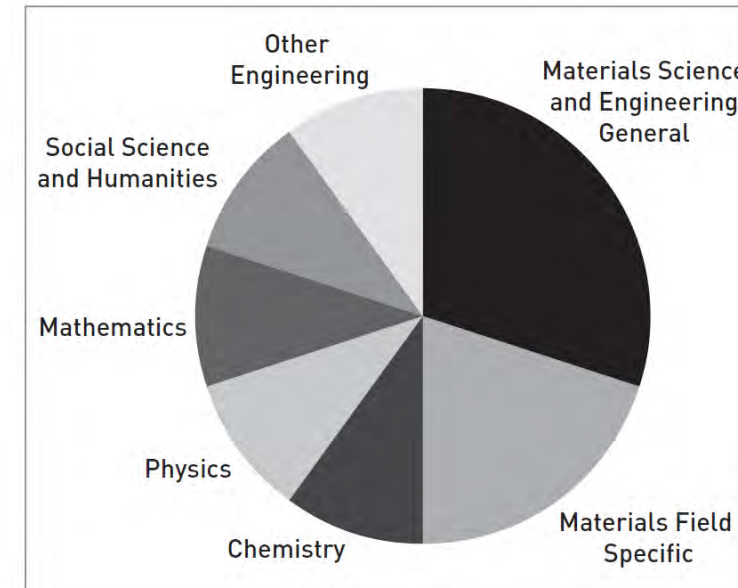
What MSE Departments can do:

Teach Materials Engineers the fundamentals so they can work on any material system....

The Technical Stuff (Fundamental classes):

- Structures
- Kinetics and Phase Transformations
- Properties
- Thermodynamics and Phase Diagrams
- Processing

Distribution of MSE Coursework



NSF Report: The Future of Materials Science and Materials Engineering Education

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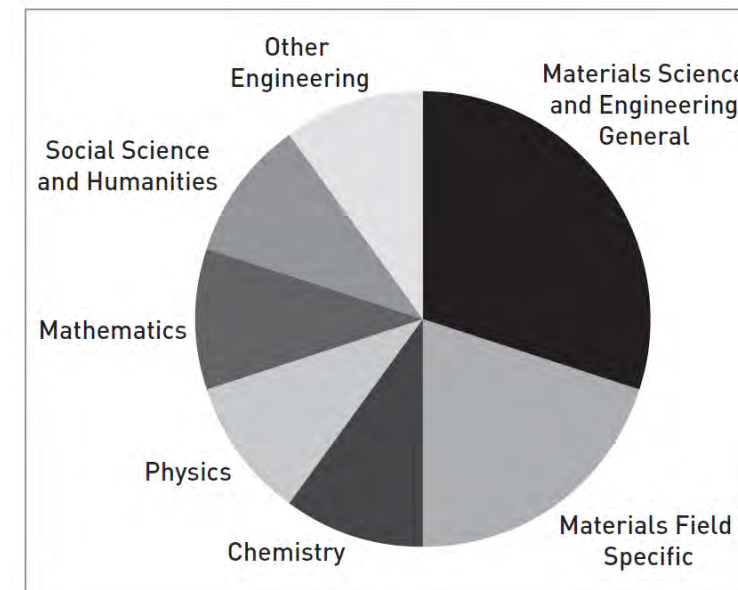
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And equally important:

- Ability to solve open ended problems
 - Communication skills !
 - Life-long learning
- > CAPSTONE COURSES

Distribution of MSE Coursework



NSF Report: The Future of Materials Science and Materials Engineering Education

You don't need (or you may not find) students who "know steels". You need students who have an excellent grasp of fundamentals that can think critically, communicate effectively, and solve open-ended problems

SOME SUGGESTIONS.....

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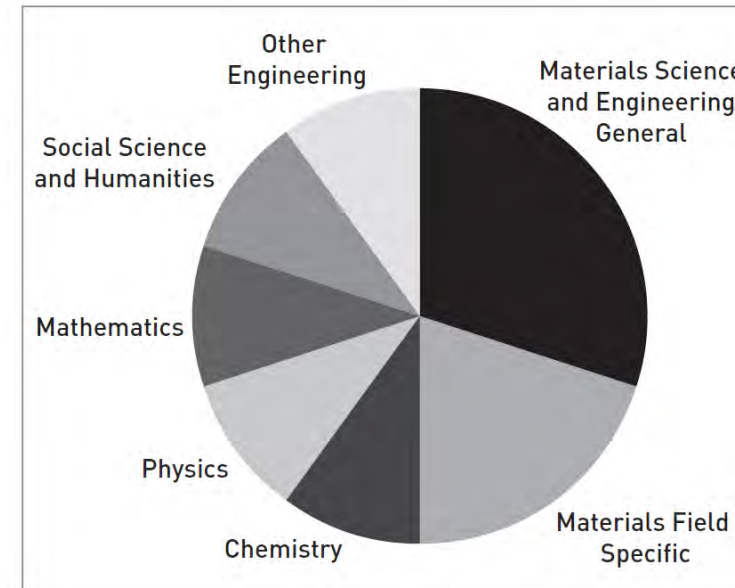
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Books by Ron Lieber

- The Price You Pay for College
- The Opposite of Spoiled: Raising Kids Who Are Grounded, Generous, and Smart With Money



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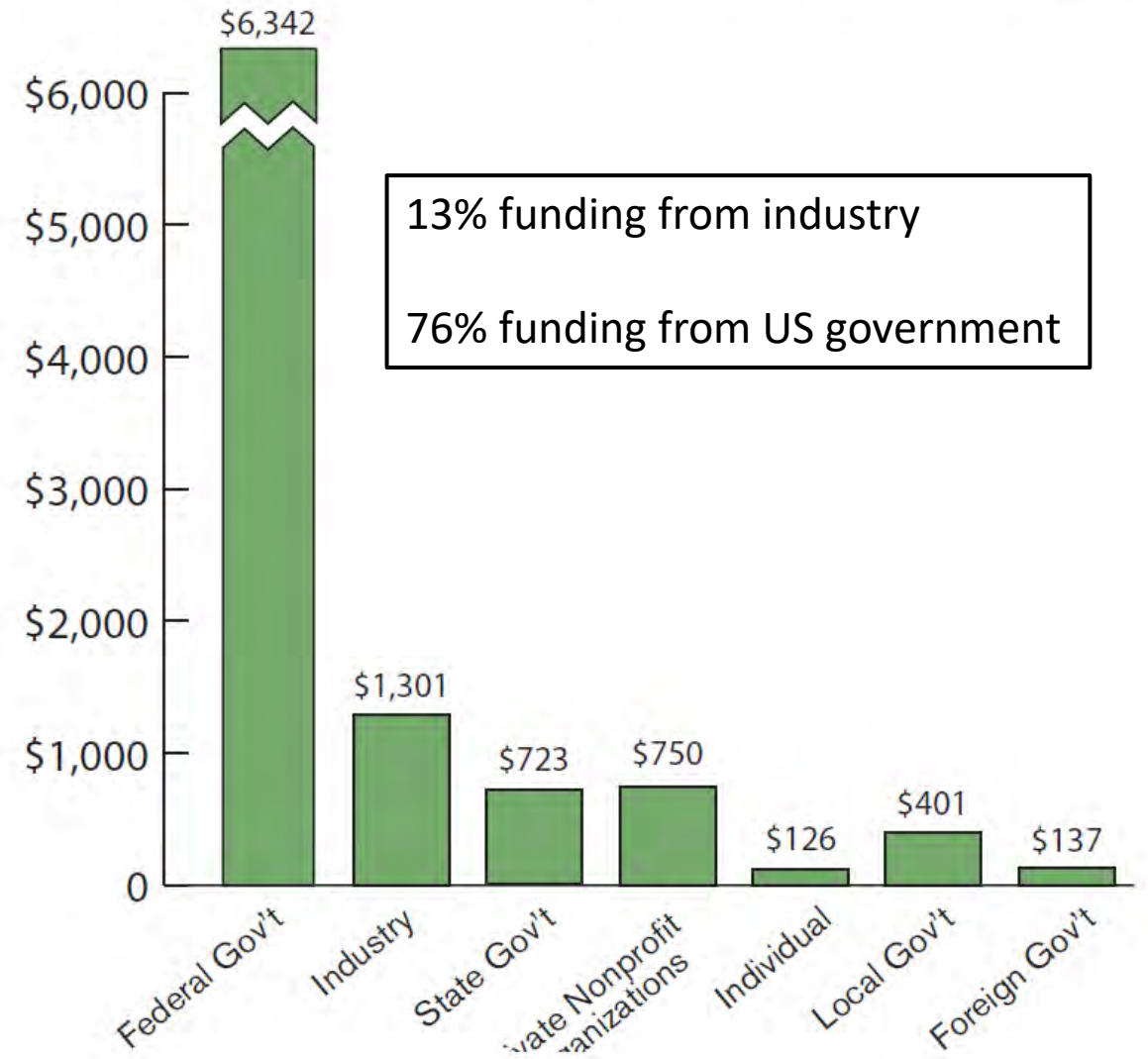
SOME SUGGESTIONS.....

What Industry and National Labs can do:

University/Industry/Lab Collaboration

- Sponsor internships
- Support undergraduate capstone courses
- Sponsor graduate research
- Communicate (preferable with \$\$) with University administrators !

RESEARCH EXPENDITURES BY SOURCE IN MILLIONS OF DOLLARS: \$9,780



Example: Lehigh's Capstone Course - Integrated Product Development

- Two semester undergraduate capstone course
- Industry provides a real problem for students to solve (or a product to develop)
- Industry provides some funding to cover lab/equipment usage costs
- University assembles a team of undergraduate engineers and business majors
- Provides an open-ended problem for the students to solve, along with all the challenges



EXAMPLE - A Government-Industry-University Collaboration Support Graduate Research

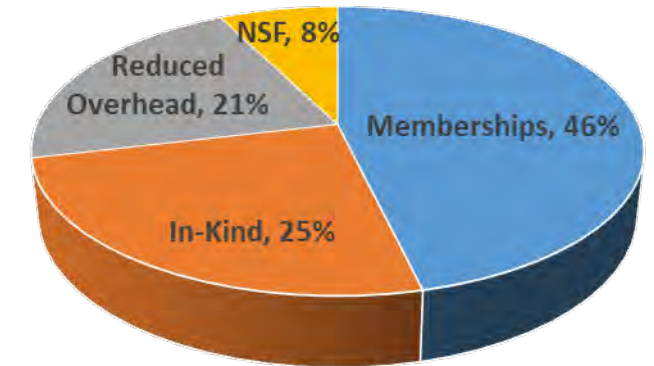
Manufacturing and Materials Joining Innovation Center - Ma²JIC



Over 40 Industry and National Lab Members



\$48,000,000 in funding to date for graduate education in Metallurgical Engineering



GRADUATES

- 99 M.Sc. and Ph.D. (2012-2022)
- Many hired by industrial sponsors

Another Example – The SFSA Steels Performance Initiative

SPI organizes collaboration between steel industry leaders and university researchers

Development and deployment of new steel technologies has been under-supported for decades

Addresses the need for higher performance capability of steel components in weapon systems

Investing in the industrial base positions the US as commercial leaders while improving DOD support

Helps train the next generation of metallurgical engineers



The real payback when graduate research is funded...

Manufacturing and Materials Joining Innovation Center - Ma²JIC

- **99 M.Sc. and Ph.D.**

**Metallurgical Engineers
between 2012-2022**

- **Many hired by industrial
sponsors**

DoD Supported Students at Lehigh and Their Current Positions (All through SFSA-Directed funding)

Jeff Farren – Carderock Naval Surface Warfare Center

Dan Bechetti – Carderock Naval Surface Warfare Center

Brett Leister – Carderock Naval Surface Warfare Center

Andrew Stockdale – Bettis (Navy Nuclear Propulsion Laboratory)

Erin Barrack – Sandia National Laboratory

Robert Hamlin – KAPL (Navy Nuclear Propulsion Laboratory)

Sean Orzolek – Carderock Naval Surface Warfare Center

SOME FINAL SUGGESTIONS.....

Industry, National Labs, Government Funding Agencies, and Professional Organizations

- Communicate the importance of metallurgical engineering to University Administrators
- Let them know you still need metallurgical engineers
- Inform them there is still plenty of funding for research, and there is still plenty of exciting science/engineering that needs to be done

Retaining and Training Metallurgical Engineers – Short Courses

ASM Short Courses

- Heat Treating, Microstructures and Performance of Steels
- Steel Metallography
- Metallurgy of Steel for the Non-Metallurgist
- Stainless Steels
- Metallurgy of Welding and Joining
- Practical Fractography
- Principles of Failure Analysis
- Introduction to Metallurgical Lab Practices

ThermoCalc Courses

- Thermocalc Software
- DICTRA Phase Transformation Modeling
- TC-PRISMA
- TC-PYTHON

Magma Courses

- Level I Software Training
- Level II Software Training
- Level III Software Training
- Sand Casters – Iron Level I Software Training
- Permanent Mold – Level I Software Training