Trends and Challenges in Chemical Engineering Education

US Perspective

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WCCE
Barcelona, Spain
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165 Chemical Engineering Departments

Ten Year US View
Chemical Engineering Graduates

ChemEs are also among the highest paid engineers!
2016 Salary Survey - BS Level (Mean Salaries)

<table>
<thead>
<tr>
<th>Major</th>
<th>Natl.</th>
<th>CMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Engineering</td>
<td>$69,196</td>
<td>$74,256 (17)</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>$66,269</td>
<td>$98,062 (77-ECE)</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>$65,593</td>
<td>$75,741 (49)</td>
</tr>
<tr>
<td>Materials Science</td>
<td>$63,478</td>
<td>$74,650 (16)</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>$61,288</td>
<td>$71,100 (11)</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>$59,995</td>
<td>$63,396 (14)</td>
</tr>
<tr>
<td>Computer Science</td>
<td>$69,100</td>
<td>$108,955</td>
</tr>
<tr>
<td>Business Admin/Mgmt</td>
<td>$53,901</td>
<td>$75,696</td>
</tr>
<tr>
<td>Petroleum Engineering</td>
<td>$89,563</td>
<td></td>
</tr>
</tbody>
</table>

B.S. Job placement (AIChE, 2007)

Chemicals Fuels ~42%
Bioengineering area:
- Has been “hot” area: most new faculty in bio area
  Added new frontiers in chemical engineering:

- Many new Biomedical Engineering Depts
  Job market biomedical engineers?

Many U.S. departments (~50%) were renamed as:
Chemical and Biomolecular Engineering
(e.g. Cornell, U. Penn., Illinois, Georgia Tech)
Chemical and Biological Engineering
(e.g. Colorado, Northwestern, Notre Dame, Wisconsin)

- Nanotechnology is other “hot” area
Many faculty members in US do not publish anymore in chemical engineering journals.

Move from Engineering to Science

Impact factors ~2.2

25% US

Impact factors ~30

15% US

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Trends in Chemical Engineering

- Increasing emphasis on **Science** in Chemical Eng. Departments
  - Many professors are not chemical engineers
  - Has increased multidisciplinary approach

- Decreased emphasis on chemical engineering fundamentals (fewer transport courses, one semester Thermo: 1\textsuperscript{st} & 2\textsuperscript{nd} Law, Phase & Chemical Equilibria)

- Process Design courses largely outsourced to retired industry people
- Process Control no longer required at many U.S. universities
## Industrial Survey on Importance of Skills

*John Chen (2013)*

<table>
<thead>
<tr>
<th>Skill</th>
<th>Average Relative Importance 1-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UO</strong>: unit operations, transport phenomena, thermodynamics, separation processes *</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>RE</strong>: reaction engineering, catalysis, kinetics</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>AM</strong>: analysis, modeling, simulation, process control *</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>MAT</strong>: materials, surface science, polymers *</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>BIO</strong>: biotechnology, medical and life sciences</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>NANO</strong>: nanotechnology and its applications</td>
<td>1.8</td>
</tr>
</tbody>
</table>

*main perceived gaps between importance and proficiency by new hires*
Academic Disconnect: Trends Faculty Composition

Unit Operations
Faculty Strength in UO

Evolution over Time

Emeritus | Professor | Associate Prof. | Assistant Prof.

Emeritus | Professor | Associate Prof. | Assistant Prof.

Bioengineering
Faculty Strength in Bio

Evolution over Time
Dow concerned about big-push to Bio

Dow requires critical scientific & engineering skills → 75-100 PhD/year

- Chemistry, Materials Science, Chemical Engineering, Mechanical Engineering

US Chemical Engineering & Chemistry Departments are chasing biotechnologies

- 31% of the Chemical Engineering Departments in the US added “bio” to their names in 20yrs
- “Bio-Tsuname”: Funding → New Faculty → Research → Teaching → Students → Workforce

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**Number of Published Articles**

- Biodiesel + Cellulosic Ethanol + Bioengineering
- Reactor Design + Transp. Phenomena + Fluid Dynamics

**Percentage of Faculty with “bio” Related Research Interests:**

- Caltech: 23%
- UC Santa Barbara: 28%
- Northwestern: 35%
- Georgia Tech: 42%
- Berkeley: 44%
- UT Austin: 45%
- U Illinois: 58%
Remarks on Education

1. Need **closer interaction with industry**; otherwise risk being irrelevant!

2. Need to **keep core Chemical Engineering Knowledge**
   Need to emphasize fundamentals: basis life-long learning

3. Need to modernize curriculum and add flexibility
   - Increase exposure molecular level
   - Increase exposure to energy *(alternative/renewable)* and sustainability issues
   - Expose students to new process technology
   - Introduce product design as complement of process design
   - Emphasize process operations, enterprise planning
   - Increase link to other industrial sectors *(pharma, electronics)*

4. Need to recognize that **“bio-area”** will be important but not dominant force in Chemical Engineering; similarly **“nano area”**

5. Environmental Engineering increasingly important and requires chemical engineering *(water use efficiency, pollution control.)* Civil Eng. ownership?

6. Need to **provide excitement to recruit the very best young people** to join Chemical Engineering

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