Trends and Challenges in Chemical Engineering Education
US Perspective

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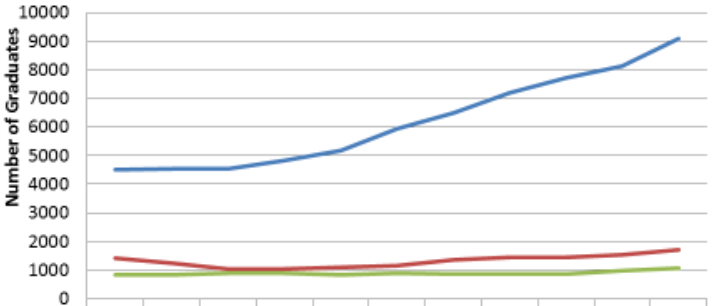
Carnegie Mellon

165 Chemical Engineering Departments

Ten Year US View Chemical Engineering Graduates



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bachelors	4521	4533	4551	4829	5167	5948	6487	7205	7717	8126	9090
Masters	1405	1231	1036	1051	1084	1162	1354	1440	1456	1544	1716
Doctorate	822	844	898	888	836	905	863	849	866	993	1062

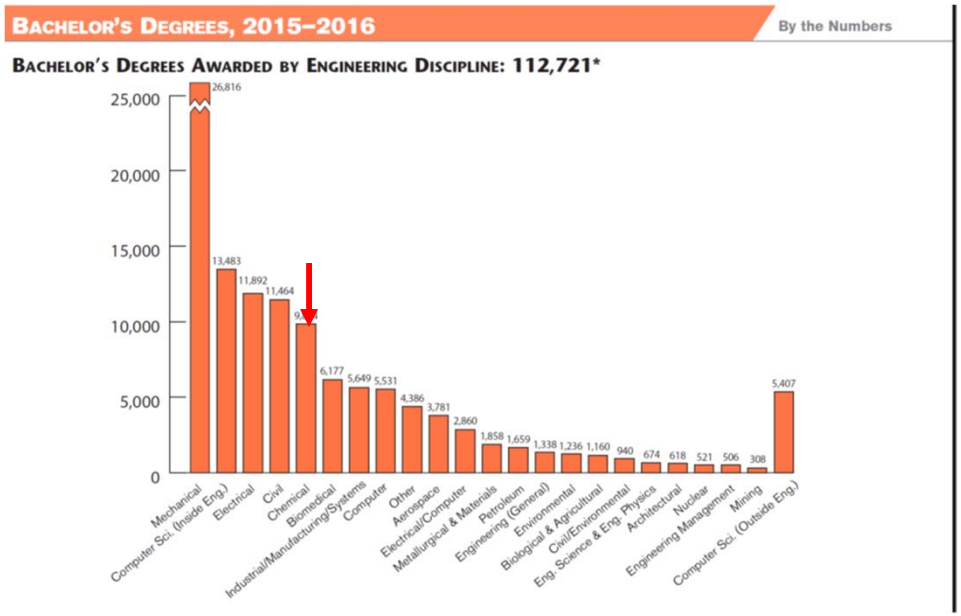
Source : ASEE (American Society of Engineering Educators)

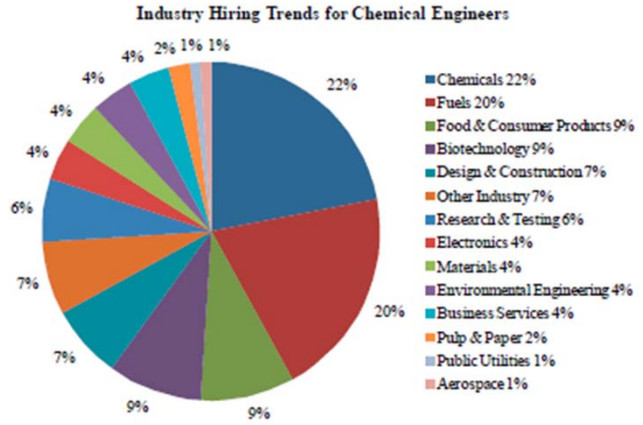
ChemEs are also among highest paid engineers !

2016 Salary Survey - BS Level (Mean Salaries)

Major	Natl.	CMU
Chemical Engineering	$69,196	$74,256 (17)
Electrical Engineering	$66,269	$98,062 (77-ECE)
Mechanical Engineering	$65,593	$75,741 (49)
Materials Science	$63,478	$74,650 (16)
Biomedical Engineering	$61,288	$71,100 (11)
Civil Engineering	$55,995	$63,396 (14)
Computer Science	*$69,100*	*$108,955*
Business Admin/Mgmt	*$53,901*	*$75,696*
Petroleum Engineering	$89,563	

B.S. Job placement (AIChE, 2007)





Chemicals Fuels ~42%

Trends in Chemical Engineering
(Last decade)

Varma, A. and I.E. Grossmann, ""Evolving Trends in Chemical Engineering Education," AIChE J., **60**, 3692-3700 (2014).

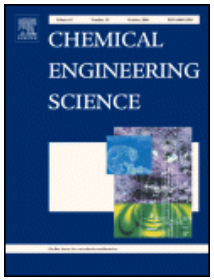
- **Bioengineering area :**
  - ***Has been "hot" area: most new faculty in bio area***
    Added new frontiers in chemical engineering:
  - ***Many new Biomedical Engineering Depts***
    Job market biomedical engineers?

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*

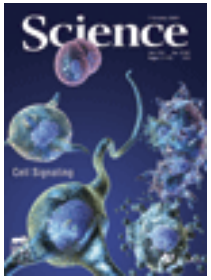
Move from Engineering to Science



Impact factors ~2.2

25% US

15% US



Impact factors ~30

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: 1st&2nd Law, Phase & Chemical Equilibria)***

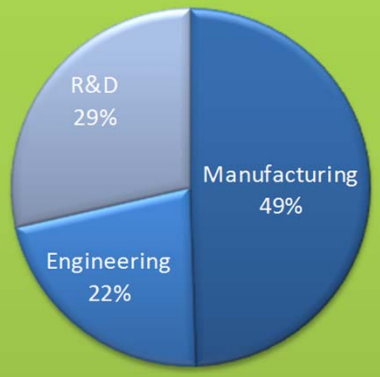
  - ***Process Design courses largely outsourced to retired industry people***
  - ***Process Control no longer required at many U.S. universities***

Industrial Survey on Importance of Skills

13AIChE
Annual Meeting, San Francisco, CA

John Chen (2013)

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

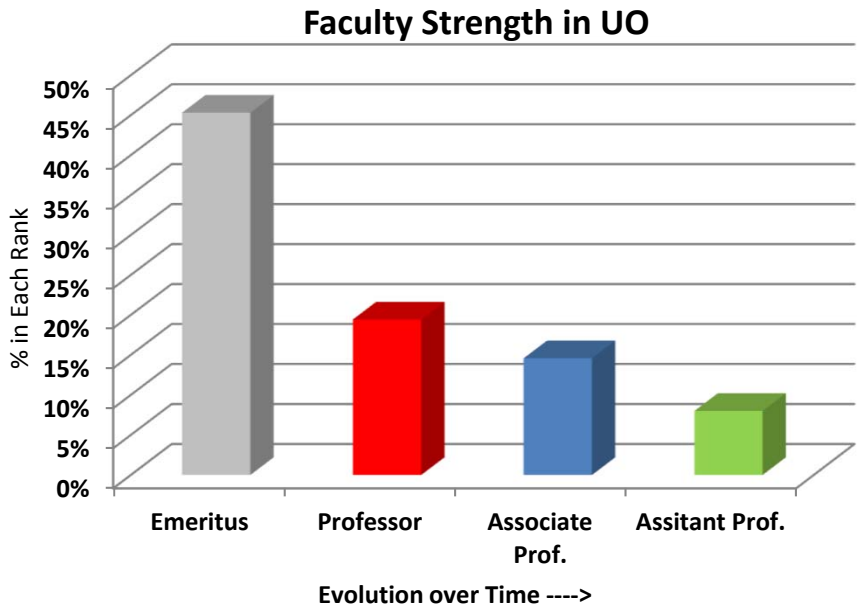


93 respondents (ChemE recruiters and leaders)

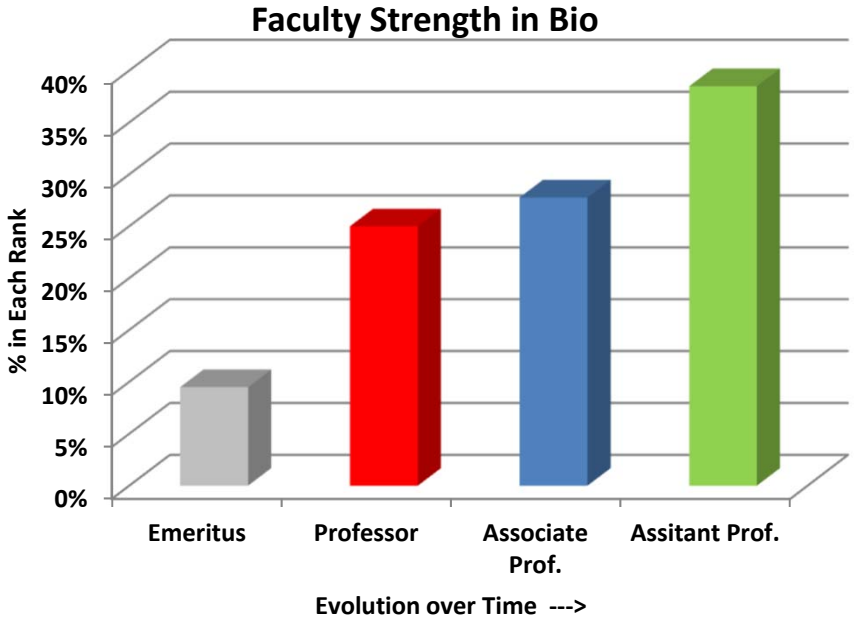
* *main perceived gaps between importance and proficiency by new hires*

Academic Disconnect: Trends Faculty Composition

Unit Operations



Bioengineering



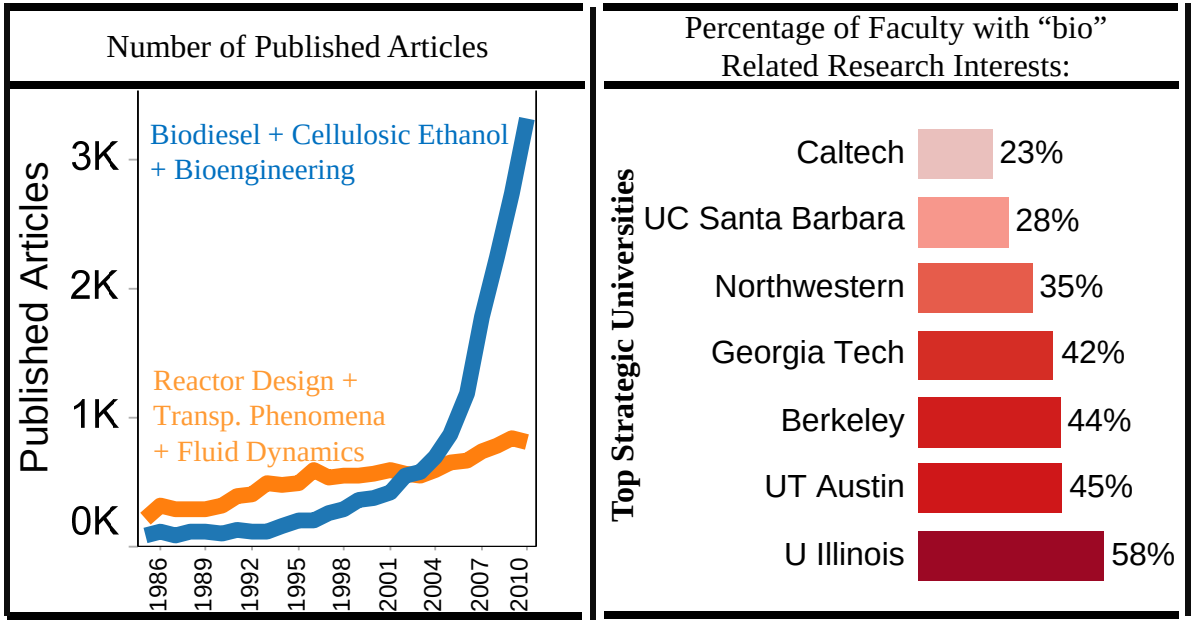
Dow concerned about big-push to Bio

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

- Chemistry, Materials Science, Chemical Engineering, Mechanical Engineering
- Dow Solar, Energy Storage Materials, Lightweight Materials, Electronic Materials

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



R&D
Dow Research & Development

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**

Carnegie Mellon Chemical Engineering Curriculum