Session 2 - Advice from Industry to Academics

Industry breakout groups prepared advice for academics engaged in curriculum development.

Group A

What key content knowledge will a new BS ChE need on arrival in industry in 2015 and beyond? How will the needs be different from now? What content might you add to or subtract from the curriculum concept proposed in the introduction?

Important Skills and Technical Content Topics for the BS ChE

(the ranking, where present, is 1 = most important)

- Problem solving 2
- Conversant (not expert at all) across broad range of science 2
- Graduates are presently weak in chemistry (biochemistry)
    - Need understanding molecular chemistry
- Science integrator 1.5
    - Bridge research to product development
    - R&D, applied math
    - Broad range of problems
    - Math-based
    - Internal consultant for product development
- Deep in Engineering Sciences 2
    - Quantitative understanding of "stuff"
    - A true understanding
- Empiricism 3
- Efficiency/Optimization (real world) 1
- Concepts of equilibrium vs. rate 3
- Concept of conservation (mass balance, etc.) 3
- Properties of materials
- Continuum mechanics 2
- Fundamental understanding 1
- Systematic approach 3
- How to frame problem 2
    - Can you teach abstract thinking (out of the box)
- Economics 2
- Figure out how to make "stuff" in the real world 2
- Dealing with uncertainty 1
    - Statistics
    - Decision analysis

    - Probabilistic
- Risk-based approach 1
- Synthesize a simplified description of a complex system 3
- Technical writing/oral communication skills*
- Teamwork/Leadership
- Upgrade problems
- What to do with it 1
- Mathematics 3
- Bridge gaps
- Industry experience (intern, summer jobs, coops) valued highly
- Focus on principles

Chemical Engineers are not to be/do:

- Deep in science (bio, chem., phys.)
- Mechanical manipulations (but need some mechanical aptitude)
- Electrical engineers (implications for process control??)

Recommendations for Curriculum

Chemistry - add one semester of organic chemistry/biochemistry

English

- Good to have some technical writing emphasis
- Integrate technical writing with communications class
- Integrate technical writing with lab course

Material Sciences – could go

Management/Business - Engineering Economics, NPV → should it be later??

Molecular Trans - yes

Multi-scale Analysis

- make sure appropriate math background
- Balance research applications vs. practical
- Batch processes

Systems

- Need process control (could be taught differently)
- Built in stats, Dec. Anal., Probability risk based approach

Cross-disciplinary science integration: the depth of skill required in various technical areas for BS ChEs:

Chem	Phys	Bio	Math	Eng Sci.

Questions that Bear on BSChE Curriculum Development

- Need for advanced degrees in ChemE
  - Similar transformation as in science fields?
- BS degrees often move up only in sales, management
- Our opinion; may or may not be niche
- Biology vs. biochemistry as the "quantitative base science"
- What is unique role for ChE?
- One curriculum for all ChEs?
- Are there useful academic department performance metrics, based on their graduates? (Jobs? Grad school admissions? Salary?)

Basic research	Product research	Development	Manufacturing	Marketing/Sales

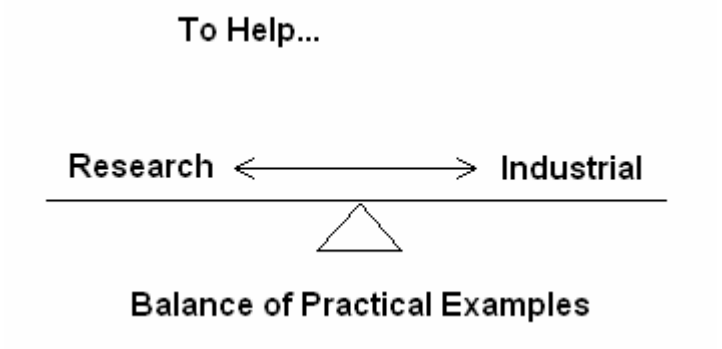
- 4-yr ChemE vs. General Engineering year + 3 years of ChE
- Part of a year course with other schools

Group B

What skills (lab skills, computing skills, etc.) and attributes (character, etc.) will ChEs need in 2015? What business processes and approaches (e.g., six-sigma, lean manufacturing) may be needed in 2015?

Skills

- Organic chemistry lab skills (equipment setup, etc.)
  - Challenging! & drives understanding
- Analytical skills
- Statistical design (Design of Experiments)
- Computing skills (minimum MS Office + !)
- Process design tools – Aspen Plus
- Presentation skills
  - Concise
  - Selling
  - Convincing
- Critical thinking
- Ability to research independently
- Organize information & formulate issues (understand)
- Self-motivated & independent work
- Work/life balance
- Drawing interpretation or CAD?
  - (Process and Instrumentation Diagrams)
- Process control! (lab with statistics and tuning)
- Interconnect courseware early! & often!
- Engineering judgment & sense of practical knowledge (rules of thumb; order of magnitude)
- Industrial experience for academics
  - At least 5 yrs (balanced variety)



- Incorporate emerging technologies into lab examples

    - "intensived processes" vs. "old" processes
- Scale up
- Instrumentation, calibration: Gage, R+R

Attributes desired in a graduate

- Tolerance & diversity appreciation
- Peer management & managing up (respectively)
- Receptive to feedback
- Able to admit it when wrong
- Big picture
- Gets dirty! Hands-on.
- Works (&plays) well with others
- Mentoring!
- Social skills!
- Professionalism & ethics
- Summer internships required, or forced co-op, to learn professionalism

Business processes

- Teambuilding
    - ← Leadership
    - Consensus
    - Mtg. Management
- Project management – stage gate
- Problem solving
- Safety! (OSHA, environmental, lockout, fall projection, lab safety)
- Financial budgets & forecasts (total cost/life cycle)
    - NPV
    - ROI
    - Balance sheet
- Balancing constraints
- Six sigma
- Lean Manufacturing
- Value Stream Management
- Value Engineering
- Intellectual property (patent review/search)
- Benchmarking
- Decision analysis

No specific curriculum required for these ideas. Just incorporation into courseware, labs, mentoring, thought processes!

Group C - Globalization

By 2015, how will globalization affect how industry uses US-educated BS ChEs? In light of the effects of globalization, what are your suggestions for the US undergraduate curriculum of 2015?

The Impact of Globalization on Engineering Work and Business

- A 24-h day - teleconferences with Asia
- Outsourcing high labor
- Many cultures and business practices
- Global supply chains and options
    - make equipment anywhere
    - sell stuff anywhere
- Global standards for equipment, specifications, performance
- Support global standards with SWIFT teams
- Non-US Research & Development and Engineering
- Learning to work globally
- Need to be able to split projects/goals for geographically diverse workforce
- All this is forcing us to clearly define core competencies
    - e.g., outsource detailed engineering
- "Commoditization" of products
    - specialties are no longer special
    - greater efforts on new products
- Less specialized, detailed engineering skills in big companies -> outsource
    - still need to be able to shop smart and evaluate
- Differing expectations for career versus local economy
    - "global caste system"
    - our "non core"
- It changes our assumptions! What makes sense for the US is not the global answer
- A lot of good engineers are being trained outside of the US (China and India)
- Engineering gets the best and brightest students in "BRIC"

Roles for US BS Chemical Engineers

- More demand for technical breadth
- Soft skills are critical - working with, and through, cultures
- Team management, remote teams
- Recognize that mathematics, like English, is a glabal language for technical communications
- Be ready for change
    - the answer "depends" - no "right" answer
    - contextual flexibility

- Be aware of how answers depend on local conditions
- Skills must be beyond "turn the crank" - but still need to know how to do so (to justify salary!)
- There is a role for traditional engineering so that we can revitalize US manufacturing
    - there are a lot of people and opportunity here

What the Curriculum Needs

- Exposure to "value proposition" concept
- "Lean manufacturing" concepts
- Open-ended problems
- Awareness of local differences (different countries)
- Diverse student body (cultures)
- Content is not the issue - we need teaching tools and techniques that can instill and foster the "soft skills"
- Professors bring research issues and problems into courses
- Team operations, experience - awareness
- Experience with remote teams via inter-university projects

In summary:

1. A renewed curriculum gives us a new opportunity to build integrations, experiences, problem skills, soft skills
    - technical content is still there, but after decades of use is rigid and a barrier to change
2. A lot of the benefit of a new curriculum can be achieved by incorporating relevant open-ended problems, more project work, teams, soft skills
    - otherwise not changing content and structure
3. Reason to change curriculum is to attract the best and brightest students into ChE