Utah Chemical Engineering Spring Teaching Retreat

Thinking about Curriculum

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Drivers for Curriculum Change

• Breadth of employment opportunities for ChE graduates
• Importance of biology as a foundation science for ChE
• The web, and other opportunities for delivery of subject matter

CCR/NSF Curriculum Workshops

• January 2003 – Orlando (49, incl. 4 companies)
  – Day 1: assess curriculum – keep, discard, add
  – Day 2: describe curriculum, without present categories

• Result was a new classification of the chemical engineering subject matter

• Details at web.mit.edu/che-curriculum
Workshops – Next Steps

- Refine classification and outline curriculum in April and June 2003 workshops
- Presently seeking to fund development of pilot modules
- Must have the broad participation of the chemical engineering community!
Curriculum Examination

• But do we really need to change the curriculum????

• “Just add a biology course and some new example problems”

• *Internal* drivers – the mission of the university to conserve, refine, extend, teach
Four Questions

• For the profession:
  – Attributes and skills of BS graduates?
  – Organization of ChE subject matter?
  – Arrangement of subject matter into a curriculum?

• For particular departments:
  – Apply to University of Utah?
Method

• Divide into groups
• Introduce the question (3 minutes)
• Silent reflection (3 minutes)
• Collect ideas and organize
• Discuss and formulate response
• Summarize and prepare report
• Report to full audience (3 minutes)
• Take a break (10 minutes)
Attributes and Skills

• Attributes: the tendency to “think like an engineer”
  – Practical and creative
  – Not demoralized by messy data
• Skills: the ability to “think like an engineer”
  – Analyzes problems
  – Estimates magnitudes
• We teach ChE subject matter, but a very real purpose is to cultivate attributes and skills
Transferable Skills

- *Exclude* curriculum-specific skills: e.g., “skill in PFR design”
- *Include* skills useful to most engineers, irrespective of field
- What is necessary for career-long versatility in rapidly changing technology over a wide variety of application areas?
Question 1 (1:30 – 2:20)

- Silent reflection (3 minutes)
- Collect ideas and organize
- Discuss and formulate
- Summarize and prepare report
- Report to full audience (3 minutes)

What attributes and skills should characterize the B.S.ChE?
The Subject Matter of ChE

• “Subject matter” is the body of knowledge that ChEs use
• We first organized our subject matter as industrial chemistry
• Then material reorganized as unit operations
• Then these operations were described by thermo, transport, reaction engineering, etc.
• Older categories can remain useful!
On Classification

• Present categories are economical and useful
• But there may exist other economical and useful arrangements
• Already we select and emphasize – consider ME versus ChE thermodynamics
• Possible organizing principles: themes that run through several courses
  – rate vs. equilibrium
  – transient vs. steady
Rearranging the File Cabinet

- **Forbidden words**: thermodynamics, transport, reaction engineering
How should we organize/classify the subject matter of chemical engineering?

• Silent reflection (3 minutes)
• Collect ideas and organize
• Discuss and formulate
• Summarize and prepare report
• Report to full audience (3 minutes)
Curriculum – Order of Presentation

• c.1974 (UA)
  – M&E balances
  – Fluid mechanics
  – Staged separations
  – Heat transfer
  – Diffusional separations
  – Reactor engineering
  – Lab
  – Thermodynamics
  – Process control
  – Design

• c.2004 (MIT)
  – Introduction to ChE
  – Thermodynamics
  – Fluid mechanics
  – Heat and mass transfer
  – Reactor engineering
  – Separations
  – Lab
  – Design
The Task of Curriculum

- Day-by-day presentation must result in an integrated understanding
- Courses organized by subject areas may not be best approach
- Could the curriculum be designed so that
  - Full structure is apparent more early?
  - At each level the student is capable of doing some engineering job?
Question 3 (3:40 – 4:30)

How should we arrange the subject matter for presentation over four years?

• Silent reflection (3 minutes)
• Collect ideas and organize
• Discuss and formulate
• Summarize and prepare report
• Report to full audience (3 minutes)
Question 4 (4:30 – 5:00)

How does this apply to the University of Utah?
On Building a Curriculum

• CONSTRAINT: a new BSChE curriculum should produce a graduate fully capable of understanding and using the tools of the traditional chemical engineer.

• VISION: that graduate will have a superbly integrated skill set, honed by examples from the breadth of chemical engineering applications.
In Conclusion

• Walker and colleagues - summer in Maine
  – *Principles of Unit Operations*

• The McGraw-Hill series
  – “building the literature of a profession”

• Thank you
Desired Attributes of the Graduate

• Versatile/creative
• Willing to make assumptions and estimate
• Life-long professional growth
  – Knows how to learn
  – Desires life-long learning
  – Thinks critically
  – Receptive to new ideas
  – Seeks appropriate connections with other fields
• Broader context
  – Knows where ChE fits in
  – Has social responsibility
  – Has personal initiative
  – Is driven to add value
  – Leader/team member
  – Member of society/good citizen

• The engineer as problem-solver (both analysis and synthesis activities):
  – Keeps it simple
  – Makes rational assumptions
  – Communicates qualitative concepts
  – Determines important parameters
  – Applies skill set to open-ended and novel problems
  – Can cope with
    • Incomplete information
    • Multiple (often conflicting) objectives
    • Multiple solutions (multiple paths to solution)
    • Iterative problem solving
    • Uncertainty/messy data
    • Managing complexity
    • Risk taking
    • Rapid generation and pruning of alternatives
  – Understands and works with uncertainty and sensitivity
  – Thinks like a molecule
Teaching by Example

- Water Desalination
- Design for Self Assembly
  - Polymer coating
  - Nanotechnology
  - Hybrid systems
- Design of Membranes
  - Next generation beer bottles
  - Fuel cells
- CO₂ Emissions from vehicles
- Stationary Source Emission Abatement
- Bioartificial Pancreas
- Protein Expression
- Make Polystyrene Peanuts from Raw Materials
- Drug Delivery/drug patch
- Blood flow in body
- Mass and energy balance of CSTR
- Arrhenius plot from experimental data
- Trouble-shooting
- Quality control
- Economic & market analysis
- Design of Distillation Column → Molecular modeling of Non-ideal phase equilibria
- Chromatographic Separation of Proteins – all scales
- Catalytic and/or multiphase reactor design
- Hydrogen from biomass
- Climate change
- Viral infections
- Atomic Layer Deposition
- Controlled particle formation

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An Example Curriculum

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<td>SYSTEMS 2 simple processes</td>
<td>SYSTEMS 3 advanced processes</td>
<td>SYSTEMS 4 design</td>
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<td>HUMANITIES electives</td>
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MULTISCALE 1 conserv eqns/phys props | MULTISCALE 2 multiphase/reaction | MULTISCALE 3 equipment |
| MOLEC PROC 1 intro transport/reaction | MOLEC PROC 2 advanced transport/reaction | MOLEC PROC 3 surfaces and structures |
| LABORATORY instruments/statistics | LABORATORY unit ops demonstrations | LABORATORY research |

LABORATORY demonstrations | LABORATORY research | LABORATORY research | LABORATORY research |

SYSTEMS 3 advanced processes | SYSTEMS 4 design | SYSTEMS 4 design | SYSTEMS 4 design |

TECHNICAL electives | TECHNICAL electives | TECHNICAL electives | TECHNICAL electives |