Utah Chemical Engineering Spring Teaching Retreat

Thinking about Curriculum

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2004 April 29

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

R.C. Armstrong, "Curriculum Revitalization in Chemical Engineering", proposal to NSF, following July 2002 CCR meetings.

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)

What attributes and skills should characterize the B.S.ChE?

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

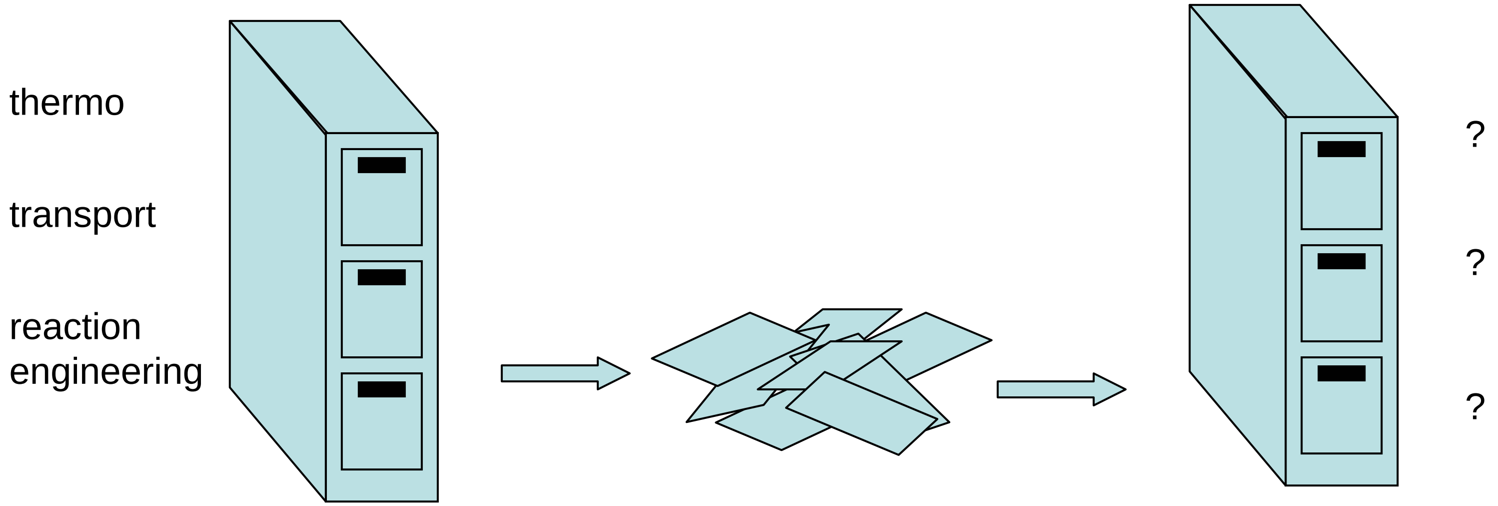
The Subject Matter of ChE

- "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

Question 2 (2:30 – 3:30)

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

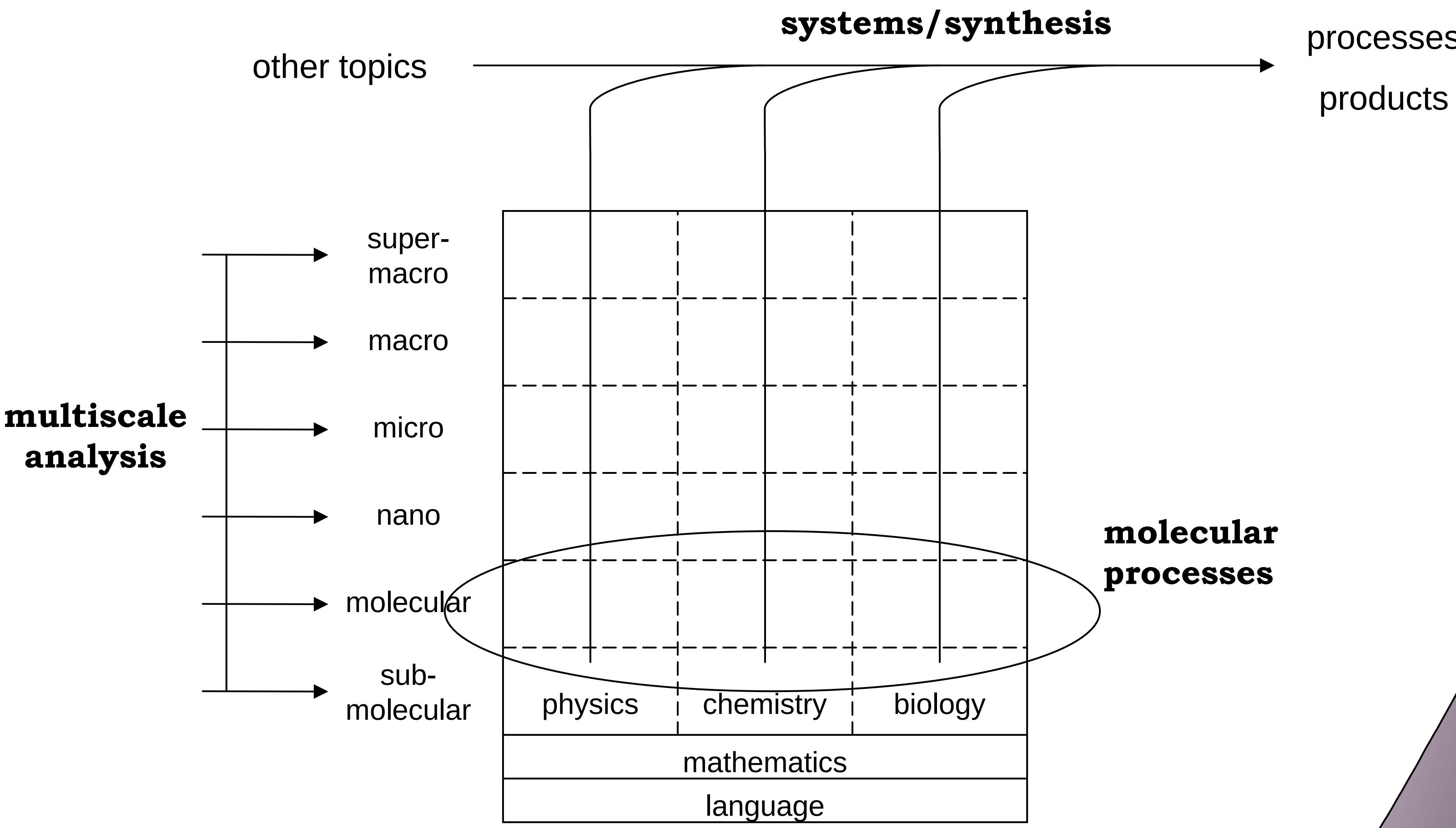
Desired Attributes of the Graduate

- 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
- CO_2 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

Map of the Subject Matter



An Example Curriculum

FRESHMAN	SOPHOMORE	JUNIOR	SENIOR
SYSTEMS 1 introduction	SYSTEMS 2 simple processes	SYSTEMS 3 advanced processes	SYSTEMS 4 design
MATH through ODEs PHYSICS mech/electrical	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
BIOLOGY general	BIOLOGY cell	BIOLOGY molecular	TECHNICAL electives
CHEMISTRY general	CHEMISTRY organic	CHEMISTRY physical	
HUMANITIES read/write	HUMANITIES read/write	HUMANITIES econ/electives	HUMANITIES electives