Summary Report on Curriculum Ideas

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Conclusions Regarding The Chemical Engineering Profession...

- The Chemical Engineering Profession is very successful
  - has moved in many new directions, pushing the understanding and use of new technologies
  - students are highly sought after by industry
  - this has been made possible by the effective teaching of the fundamentals of chemical engineering
... however...

• Chemical Engineering is facing significant pressure from other disciplines

and

• The Current Curriculum is not well integrated:
  – it is compartmentalized in the subjects presented
  – “tired”

• The Current Curriculum is largely **not:**
  – exploring transformations at the molecular level
  – embracing complexity and uncertainty
    • closed problems with one answer
  – demonstrating the applicability of multiple scales
  – demonstrating/effectively using systems approaches
  – employing relevant, interesting and topical examples to illustrate principles
Integration of the Curriculum: New Core Organizing Principles

• Molecular Scale Transformations
  – chemical & biological
  – physical: phase change, adsorption, etc

• Multi-Scale Descriptions
  – from sub-molecular through “super-macro”
  – for physical, chemical and biological processes

• Systems Analysis & Synthesis
  – at all scales
  – tools to address dynamics, complexity, uncertainty, external factors

Old core did not integrate molecular concepts

Old core covered only macro to continuum, physical and chemical

Old core primarily tied to large scale chemical processes
Creation of the New Curriculum: Essential Elements

• Case Studies and Examples
  – Diverse
  – Relevant and Topical
  – Integrated into Curriculum
    • horizontal integration (over time)
    • vertical integration (between classes at same time)
  – Provide real world context
    • safety, economics, ethics, regulation, IP, market/social needs
  – Provide real world challenge
    • open-ended, complex, incomplete data, rapid generation and pruning alternatives
...Essential Elements... (cont.)

- Integrated Curriculum

- Junior
  - Enabling Sciences
    - Physics
    - Chemistry
    - Biology
    - Math
  - Molecular-Scale Transformations
  - Multi-Scale Descriptions
  - Systems Analysis & Synthesis

- Soph

Topics in one area feed into the next area
...Essential Elements… (cont.)

- Integrated Curriculum: Incorporating the fundamentals

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- Physical
- Molecular-Scale Transformations
- biol/chem
- macro balances
- Multi-Scale Descriptions
- continuum
- molecular & micro
- small systems
- Systems
- Analysis & Synthesis
- any scale with complexity
- simple macro systems
- any scale with complexity
...Essential Elements… (cont.)

- Integrated Curriculum: incorporating modules

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...Essential Elements...  (cont.)

- Integrated Curriculum: Incorporating Examples

- Enabling Sciences
  - Physics
  - Chemistry
  - Biology
  - Math

- Molecular-Scale Transformations

- Multi-Scale Descriptions

- Systems Analysis & Synthesis
The Spectrum of Curriculum Change: from “tweaks” to “complete overhaul”

• The consensus is that we seek large change
  – the science base has dramatically increased
  – this creates new economic opportunity
  – some discipline will emerge to address these new opportunities
  – chemical engineering is well-positioned to be this new discipline...
  – …but it will require a large change to the undergraduate curriculum

• This change may require a 10 year investment
• We must accommodate a diversity of universities
Discussion following Summary Report – Thursday 2003 April 10

**Needs**
- Pool of case studies to draw from
- A course must include content, organization, and delivery
  - ChEs qualified to prepare content
  - Need input from others for organization and delivery
- Materials that work at the heart of curriculum
- Remaining effort must depend on this group – not handed off to the professional organizations
- Tap into industrial resources
- What to call old Organizing Principles to make the conversion to the new?
  - Perhaps call the new modules by the old names?
- “Radical surgery” to make core vital, connecting research → core ← new industry
- Ensure graduates KNOW what their core is, in a new delivery scheme

**Opportunities**
- Web interaction between universities
- Teaching how to learn
  - Isaiah Warner (Chem LSU) et. al
  - This is our opportunity to do so!
  - It must work at the heart of the curriculum
- Outreach to HS students and industry boards
  - CACHÉ Corp. could be model for distribution
  - Also competitions sponsored by XE
  - Other professional groups, such as the divisions within AIChE
- We can use this to reactivate continual change
- New approach to stimulate invention
- Start new Organizing Principles at grad level as testing ground?
  - This is happening already
- Could we restart the pipeline from research to UG curriculum? (last used ~1970)
- Computations will allow us to make research accessible to UG (bypass advanced math)
- This is opportunity to connect research to UG
- Problems will change, so we focus on strong, versatile skills
- Students must know how to find out information and tools
- Value of our core is that we are able to branch out in many directions
- Core is way of thinking – bio is “just” another application of what we do
- We learn (tools) while we do problems (vehicles)
- ChE is attractive to industry because the ChE core is a foundation for diverse activity
- Integrated modules can also cultivate the attributes, while teaching the skills
  - Teach students how to think about problems
- ChE, with a core, will be able to embrace bio applications
Discussion following Summary Report, continued – Thursday 2003 April 10

**Concerns**

- If student fails a single module, how to handle in an integrated curriculum?
  - How to handle transfer students?
  - Web interaction may offer new methods for scheduling
- How to test curriculum modules?
  - Find a way to offer, e.g., 1-credit courses in a university
- ABET – how to get on board?
- Are our new Organizing Principle names too abstract/obscure for HS students?
- We (as developers of the curriculum) shouldn’t go too deeply into marketing (and thus dilute our effort)
- AIChE can’t do engineering education and marketing as a handoff from us
- Connectedness of curriculum could make it difficult for a given university to phase it in.
- Some departments can be radical, some will not
- Different universities presently teach fundamentals at different levels
- “Small scale systems” is still a research problem
- **Heavy research funding** probably distracts from teaching effort
- The ChE core has served well, but more at earlier times when connected to the active research. Less so recently. It has become a **FIXED CORE**
- In 60s, faculty covered all fields; in 70s, specialization and increased funding widened field and made it difficult for the individual to cope with it - in reaction, we left core alone
- Now, research is at the periphery, not the core
- Bring the “research halo” back to center as support for core
- In teaching, bring examples from research (how to explain?) but not necessarily the direct topics/developments of research
- Broader science foundations require more support/interaction with service departments
- How to develop in the ChE faculty the broad foundation (especially bio)?
- Will continued faculty specialization limit us from attaining a core at all?
- This group wants to avoid tracks, to identify/maintain a core
  - Also true at grad level
- Civil engineering as an example of fracturing the discipline
- Volume of information is **larger** now
  - Will our grads be broad but shallow?
  - Is it a problem?
- **Paul Penfield**: “ChE is a laughingstock” (for the constraints we impose on our curriculum)
  - Some think ChE is “quaint” for attempting to hold all together
  - We claim wide territory and yet we seek a core; outsiders think we’re crazy, that it’s unworkable