Frontiers in Chemical Engineering Education

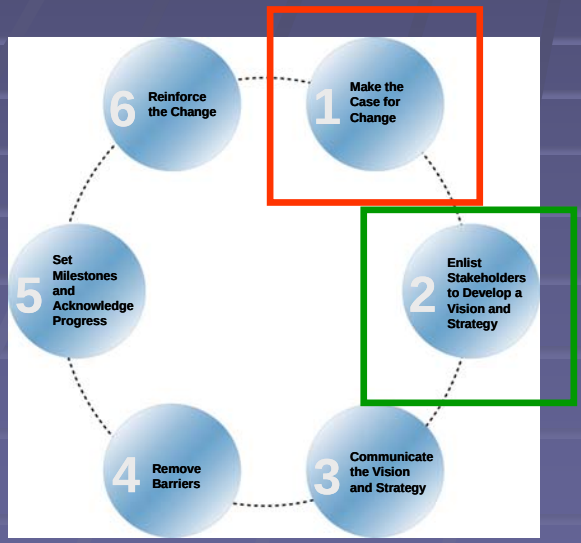
Where We Landed

Review of Events to Date

- Transformation: An Introductory Discussion
- What's been determined to date:
  - The Process
  - The Principles
  - The Attributes
  - The Curriculum
    - Organizing Principles
    - Learning Strategy
    - Specific Content

Transformation: typical approaches

HCA Change Model



Kotter Transformation Model

EXHIBIT 2
The Eight-Stage Process of Creating Major Change

1 ESTABLISHING A SENSE OF URGENCY
- Examining the market and competitive realities
- Identifying and discussing crises, potential crises, or major opportunities

2 CREATING THE GUIDING COALITION
- Putting together a group with enough power to lead the change
- Getting the group to work together like a team

3 DEVELOPING A VISION AND STRATEGY
- Creating a vision to help direct the change effort
- Developing strategies for achieving that vision

4 COMMUNICATING THE CHANGE VISION
- Using every vehicle possible to constantly communicate the new vision and strategies
- Having the guiding coalition role model the behavior expected of employees

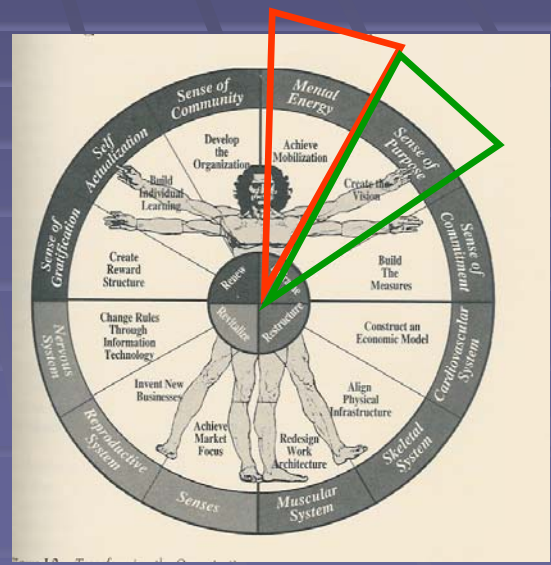
5 EMPOWERING BROAD-BASED ACTION
- Getting rid of obstacles
- Changing systems or structures that undermine the change vision
- Encouraging risk taking and nontraditional ideas, activities, and actions

6 GENERATING SHORT-TERM WINS
- Planning for visible improvements in performance, or "wins"
- Creating those wins
- Visibly recognizing and rewarding people who made the wins possible

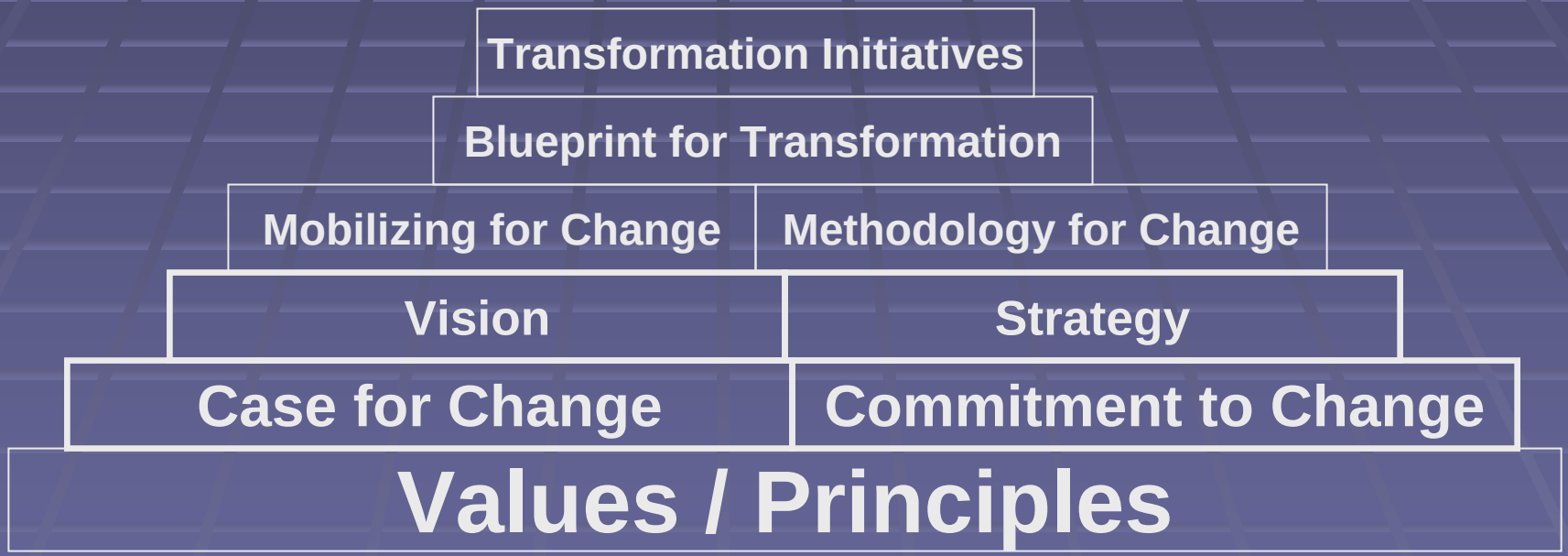
7 CONSOLIDATING GAINS AND PRODUCING MORE CHANGE
- Using increased credibility to change all systems, structures, and policies that don't fit together and don't fit the transformation vision
- Hiring, promoting, and developing people who can implement the change vision
- Reinvigorating the process with new projects, themes, and change agents

8 ANCHORING NEW APPROACHES IN THE CULTURE
- Creating better performance through customer- and productivity-oriented behavior, more and better leadership, and more effective management
- Articulating the connections between new behaviors and organizational success
- Developing means to ensure leadership development and succession

CAP Gemini Transformation Model



Building Transformation

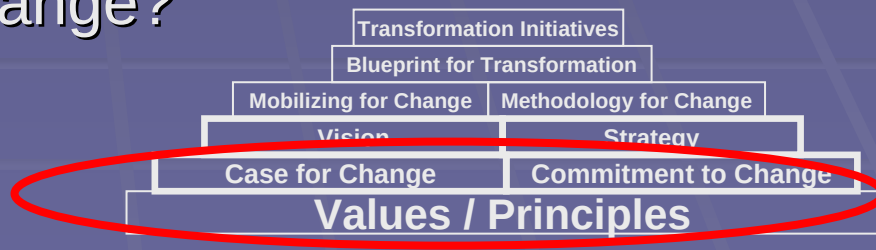


The Medium for Change: Workshops

- 3 Workshops held at various locations
- Mostly academic (< 5% industry)
- Work output via:
  - Presentation
  - General large discussion
  - Break out groups with reports back
  - Summary sessions

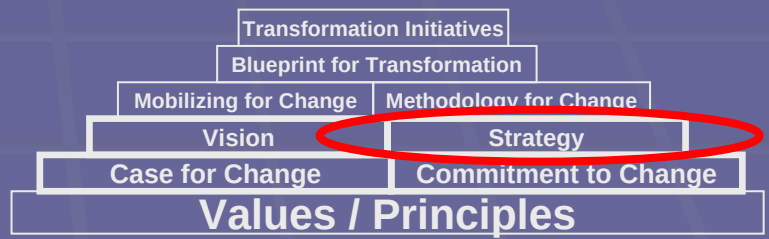
The Process:
Episode 1: A New Hope

- Workshop 1: Orlando, January, 2003
  - "Hey, this curriculum work isn't Mickey Mouse stuff…"
  - Workshop focused on "foundation"
    - Values/Principles
      - What are our values?
    - What is the Case for Change
    - Start of commitment to change
    - What's our vision of this change?



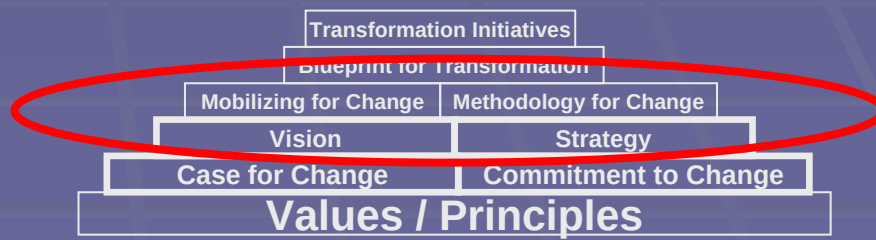
The Process:
Episode 2: The Faculty Strike Back

- Workshop 2: Austin, April, 2003
  - "Even the Curriculum looks bigger in Texas…"
  - Workshop focused on:
    - Curriculum Strategy: Organizing principles for curriculum
    - Deliverable from Strategy : students and their attributes
    - Learning Strategy: Principles for how this curriculum could be taught
    - Confirmation that the change is transformational



The Process: Episode 3: Return of the Educators

- Workshop 3: Cape Cod, June, 2003
  - "Life's a beach when you are doing curriculum work…"
  - Workshop focused on:
    - Learning Strategy: More detailed thoughts on how to utilize the organizational principles
    - Curriculum Blueprint
    - Outline of mobilization and methodology for change



Principles and Values

- Chemical Engineering is built on certain foundation studies
  - Physics, chemistry, ***biology*** and mathematics
- There is a core set of understandings (fundamentals or principles) that form the foundation of chemical engineering work
- Chemical engineering:
  - Is quantitative, involving analysis, design and synthesis
  - Addresses materials and phenomena at all scales from molecular to “super-macro”
  - Solves problems related to both ***product*** and process
  - Handles problems across all of its foundation sciences: ***biology***, chemistry and physics

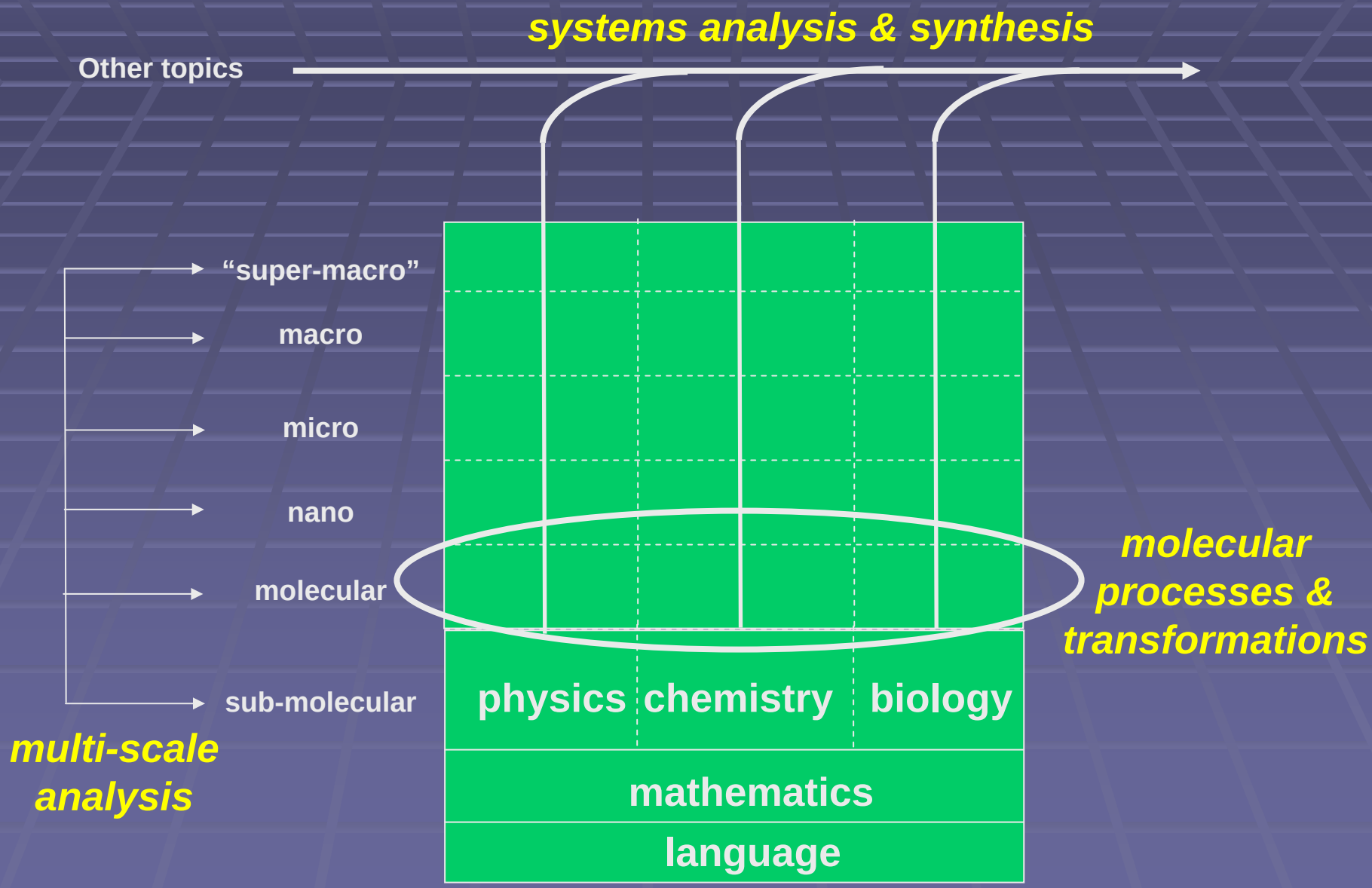
Attributes of the “product”: the BS Chemical Engineer

- Chemical engineers are adroit problem-solvers
  - They keep it simple, making rational assumptions and estimates
  - They determine which parameters are important
  - Understand and work with uncertainty and sensitivity
- Chemical engineers can apply their skills to open-ended and novel problems, coping with:
  - Incomplete information
  - Multiple (often conflicting) objectives
  - Iterative solution methods
  - Uncertain and “messy” data
  - Complexity
  - Risk and risk-taking
  - Rapid generation and pruning of alternatives
- Chemical Engineers “think like the molecule”
- Chemical engineers seek life-long professional growth by
  - Knowing how to learn
  - Desiring life-long learning
  - Thinking critically
  - Being receptive to new ideas
  - Seeking appropriate connections to other fields
- Chemical engineers understand the broader context
  - They know where chemical engineering fits in
  - They understand and accept the social responsibilities that accompany their discipline
  - They are driven to add value

The new curriculum

- Core set of organizing principles
- Learning Strategy
- Timecourse for Curriculum

Organizing Principles



Learning Strategy

- Curriculum should integrate all organizing principles and basic supportive sciences throughout the educational sequence
- All organizing principles should be operative throughout the sequence and should move from simple to complex (“spiral learning”)
- Curriculum should be consistently infused with relevant and demonstrative:
  - Laboratory experiences
  - Examples
    - Open-ended problems an d case studies
    - Challenges of engineering practice: safety, economics, ethics, regulation, IP, market/social needs
- Curriculum should include a first year chemical engineering experience
- Opportunities for teaming experiences and use of communication skills (oral and written) should be included throughout the curriculum
- Curriculum should address different learning styles

Sample of Integrated Curriculum

Freshman Sophomore Junior Senior

Enabling Courses:
-Physics
-Chemistry
-Biology
-Math
-Mat'ls Sci
-Eng/Comm
-Bus/Mgt

Chem Eng
-The Frosh Experience

Molecular-Scale Transformations

- Molecular Basis of Thermo
- Classification of Molecules
- Molecular Basis of -Reactions
-Props & Constitutive Eqns
- Special Topics

Multi-Scale Analysis

- Interfaces & Assemblies
- Homogeneous Reactor Eng
- Multi-scale Descriptions of Reactive Systems
- Beaker to Plant: Principles of Product & Process Design

Systems

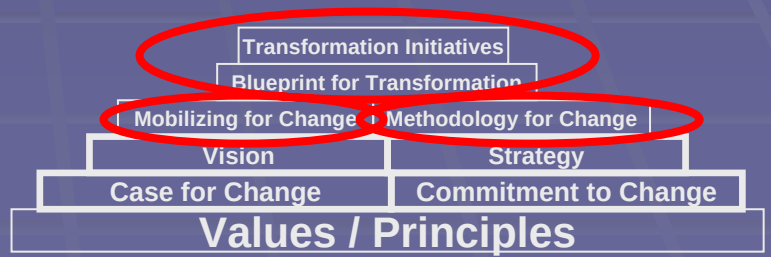
- Intro to Systems
- Intro to Molecular Systems
- Systems & the Marketplace

Concerns

- Will student outcomes be demonstrably improved?
- Can we build a consensus in the profession for this large change?
  - “But we already have a great core – thermodynamics, transport, and kinetics – which provide a versatile education for our students.”
- How do we implement this is a timely and uniformly high quality way over a widely disparate distribution of schools and resources and for such a wide and changing distribution of industries?

The path forward

- Build consensus and obtain critical feedback from both academia and industry
- Prepare the new educational materials
  - Marshal the necessary resources
    - people and $$$
  - Develop oversight and management plan
- Plan for deployment and assessment



Setting Expectations amid Imperfect Diversity

- The group, both academic and industrial representatives, is not wholly representative of their larger constituencies
  - Group opinions are guiding, not definitive
  - Not all opinions will be acted on

How to make this time work

- Be here when you are here
- Be open and honest
- Be respectful of others
- As much as possible, “shed light, not heat”
- Have fun

What do we need to do here?

- It is critical that industrial participants
  - Outline what the future will look like: What will the future undergraduate experience need to deliver?
  - Understand the current direction and give strong and actionable feedback on the directions into which this curriculum initiative is going
  - Participate, including be clear and committed as to how industry can stay engaged in this endeavor

What do we need to do here?

- It is critical that academic participants
  - Listen to, understand and engage industrial participants: get the most out of this interaction
  - Outline what the future undergraduate experience will look like: add specificity as to what is needed when
  - Understand the interactions between the different curriculum workstreams
  - Co-develop with industrial participants how to keep industry engaged in this effort