Capstone Design Sequence in the Chemical Engineering Department at École Polytechnique

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presented by

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Presentation Overview

- Design Competencies and Chemical Engineering Design Competencies
- Survey of Capstone Design Sequences
- Capstone Design Sequence at École Polytechnique
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The central focus of Engineering is design, an art entailing the exercise of ingenuity, imagination, knowledge, skill, discipline, and judgement based on experience.
Establishing Engineering Design Competencies…

- Taken from Crain et al, Washington State University, 1995

- Set of 7 Engineering Design competencies:
  - Teamwork: roles & responsibilities
  - Information gathering: literature, survey techniques
  - Problem definition: understand open-ended nature of design problems, goal statements, problem definitions
  - Ideas generation: teams brainstorm, individuals generate ideas, synthesis
  - Evaluation & decision-making: iterative approach that employs evaluation repeatedly
  - Implementation: time management
  - Communication: listening, giving/receiving constructive criticism, communications protocols
One Strategy for Chemical Engineering Design Training

• In early design courses, students should learn “soft” design competencies (Crain et al).

• Process design should be taught throughout the Chemical Engineering curriculum.

• In the Process Design course, students should learn “harder” design competencies related primarily to the Design Process.

• In the Design Project course, students should apply all of the above.
Some Chemical Engineering Design Competencies

- Understanding of design of unit operations, the design process, and relationship with product design.
- Project planning & organization. Product Development process.
- Holistic process analysis tools and process optimization.
- Process cost estimating techniques and process economics – and using them to add business value.
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Informal Survey of the Capstone Design Sequence

8 Chemical Engineering Departments were surveyed:

- McGill University
- McMaster University
- University of Calgary
- University of Ottawa
- University of Toronto
- Georgia Institute of Technology
- Texas A&M University
- University of Pennsylvania
Survey Methodology

- Explained the context, and asked 4 questions.
- Summarized the responses, and returned them in tabular form for comment.
- Interpreted the responses, and returned this presentation for comment.
4 Survey Questions

• What number of courses and credits are involved in the Chemical Engineering capstone design sequence, today and 10 years ago?
• What are the main changes you have made to the curriculum in the capstone design sequence?
• What is the role of process simulation in the capstone design sequence – today and 10 years ago?
• What do you think about a 1st year capstone design sequence emphasizing basic design competencies?
Conclusions From Survey

- **Capstone design sequence** = **Process Design + Design Project**.
- 1 university has essentially not changed the capstone design sequence over 10 years, 7 are increasing the design content, and 1 university has actually decreased the credits for the design sequence.
- All the Canadian departments have or are in the process of increasing the credits for the capstone design sequence. **Drivers:** time to complete Project and accreditation process.
Conclusions From Survey

- Of the 4 Canadian Departments surveyed who have implemented changes, an average of 10.75 credits is given to the design sequence, compared to 6.75 credits 10 years ago.
- Of the 9 universities, 3 complete the Design Projects with a direct Industry client relationship.
Some Survey Comments re the Capstone Design Sequence

- Emphasis on Product and Process design
- Increased direct influence from the engineering consulting industry
- Reduced emphasis on covering the design of a broad range of process units
- Increased emphasis on environment and safety
- Increased emphasis on holistic process analysis tools, e.g. simulation, pinch, controllability
- HYSYS is by far the most commonly-used process simulator
- The debate rages over a first year design course!
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Canadian Design Engineering Network (C-DEN)

• An NSERC Initiative to improve design education in Canadian Engineering programs.
• A portal to be created with design-oriented learning materials, connected to CDEN “desks” at universities across Canada.
• Polytechnique is currently developing CDEN modules in undergraduate fluid mechanics, heat transfer, separations, process control, process design.
• The CDEN 3-tier structure has been adapted to involve project-based (design) learning of course material:
  – Tier I: Basic concepts
  – Tier II: Case Study learning using a computer tool
  – Tier III: Open-ended problem
Capstone Design Sequence at École Polytechnique

- Process Design + Design Project under discussion
- Considering an increase in the credits for Design Project due to level of effort required
- Design Projects done directly for industry
- Increased emphasis on costing techniques, environment and safety
- Application of project planning techniques
- HYSYS and ASPEN process simulators used
- Decreased emphasis on survey of unit operation design techniques
- Increased emphasis on holistic process analysis tools, e.g. simulation, pinch, controllability
Design Process & Process Integration

Process Design

Process Integration

Design Process