Capstone Design Sequence in the Chemical Engineering Department at École Polytechnique

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presented by

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 Design Competencies and Chemical Engineering Design Competencies

- o Survey of Capstone Design Sequences
- Capstone Design Sequence at École Polytechnique

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Canadian Academy of Engineers (1991)

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:
- <u>Teamwork</u>: roles & responsibilities
- Information gathering: literature, survey techniques
- <u>Problem definition</u>: understand open-ended nature of design problems, goal statements, problem definitions
- <u>Ideas generation</u>: teams brainstorm, individuals generate ideas, synthesis
- <u>Evaluation & decision-making</u>: iterative approach that employs evaluation repeatedly
- <u>Implementation</u>: time management
- <u>Communication</u>: 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.
- Knowledge from experience. Multidisciplinary approach. Value engineering concepts.

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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

