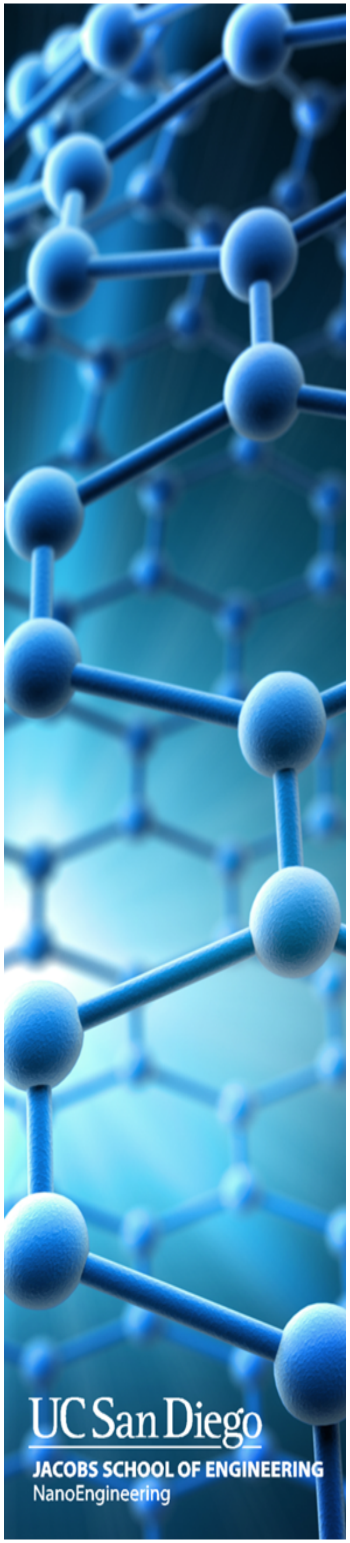


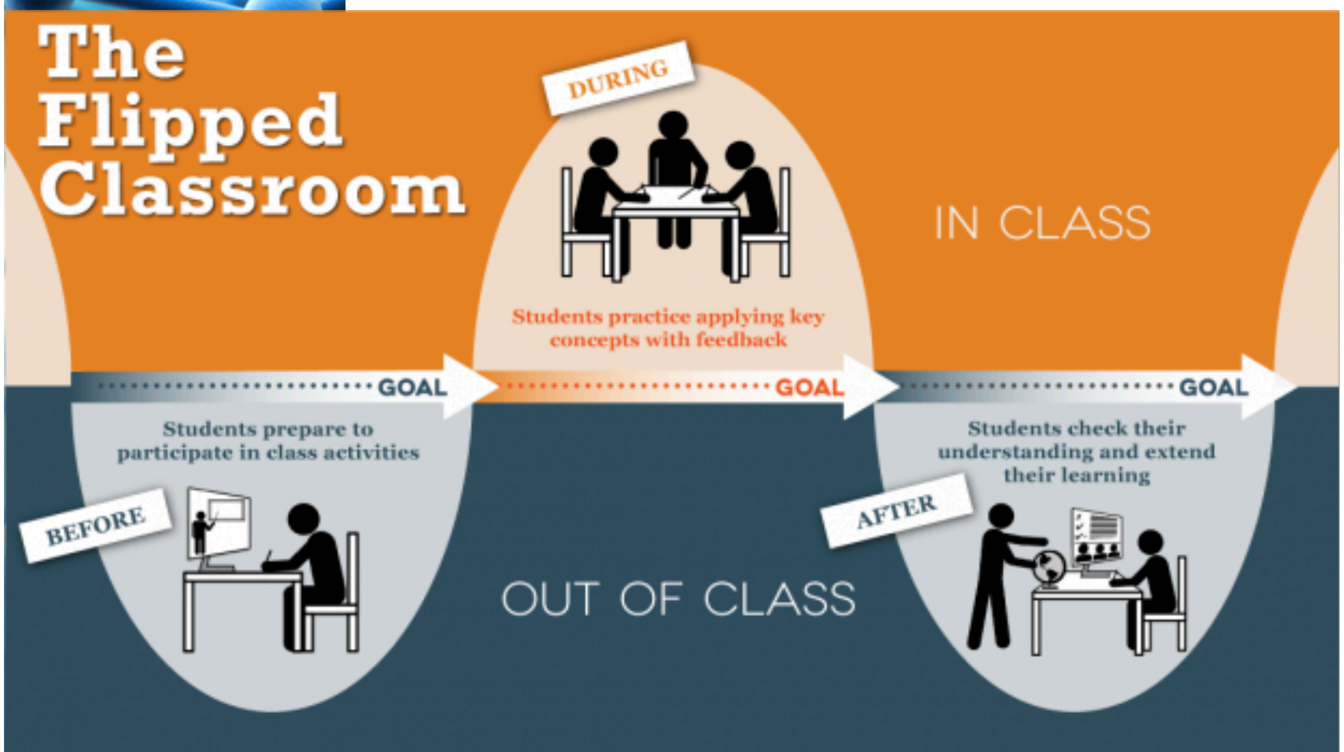
It’s All By Design: Incorporating Design Early in the Chemical Engineering Curriculum

Justin Opatkiewicz
Associate Teaching Professor of Chemical Engineering
NanoEngineering Department
UC San Diego
E-mail: jpopat@eng.ucsd.edu

Live session:
https://unewhaven.zoom.us/j/98178976533

After the Lower Division Courses- Emphasizing Collaboration

- There have been many studies on the benefits of collaborative learning, like the flipped classroom



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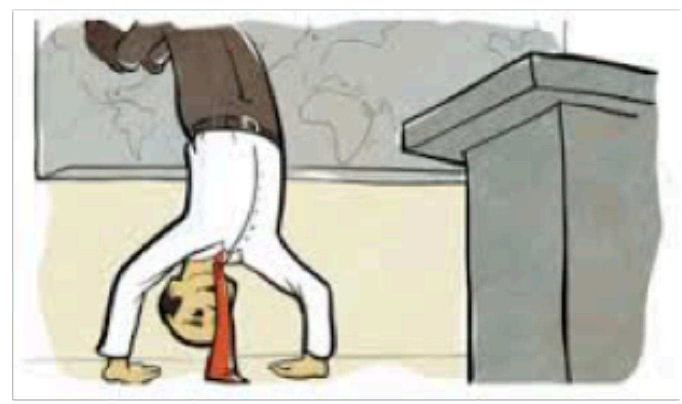

BYU CTL

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Early Exposure to the Industrial Experience: Collaborative Group Work

- Incorporation of group projects can serve as an addendum or an alternative to flipping the classroom

Peters Consultants

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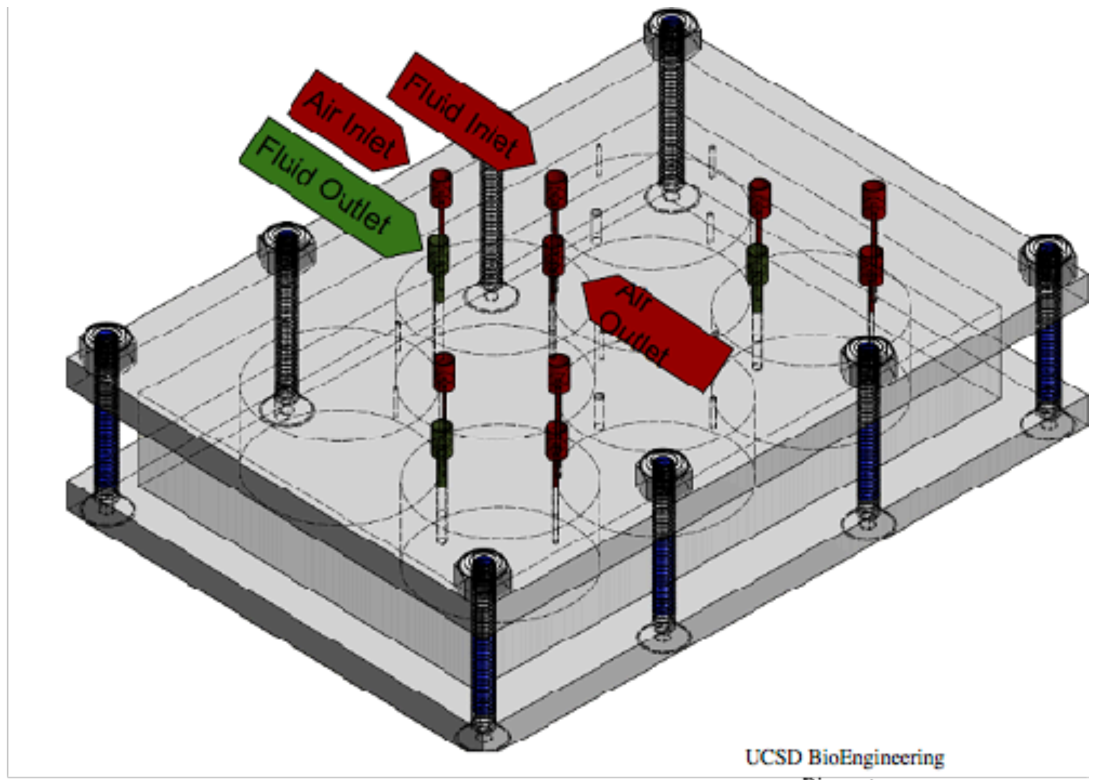
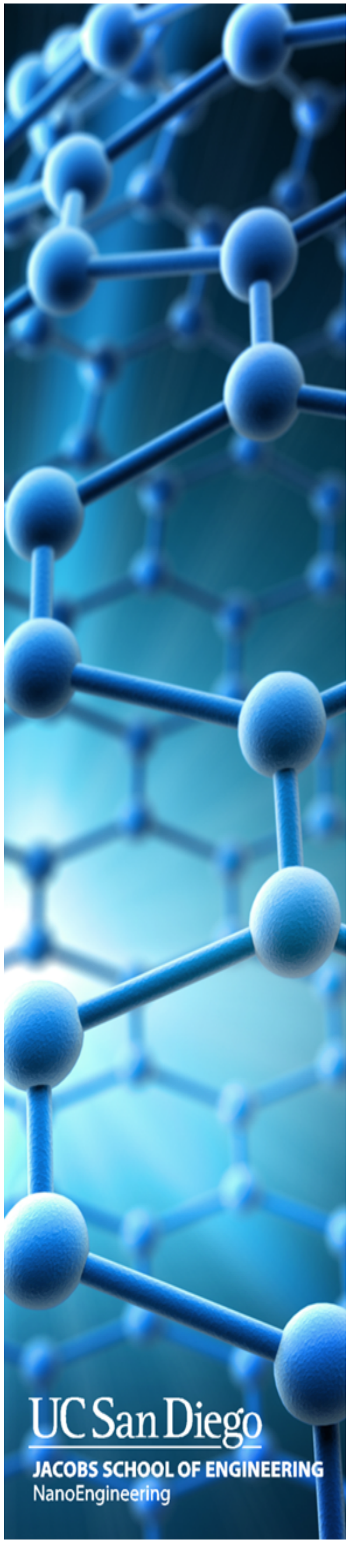
Consolidating the Course in a Single Project

- Give each course its own senior-level design project

UCSD Mechanical Engineering
-Ocean Wave Energy Converter



UCSD BioEngineering
-Bioreactor



Problem:
Discrete or Accumulated Learning?

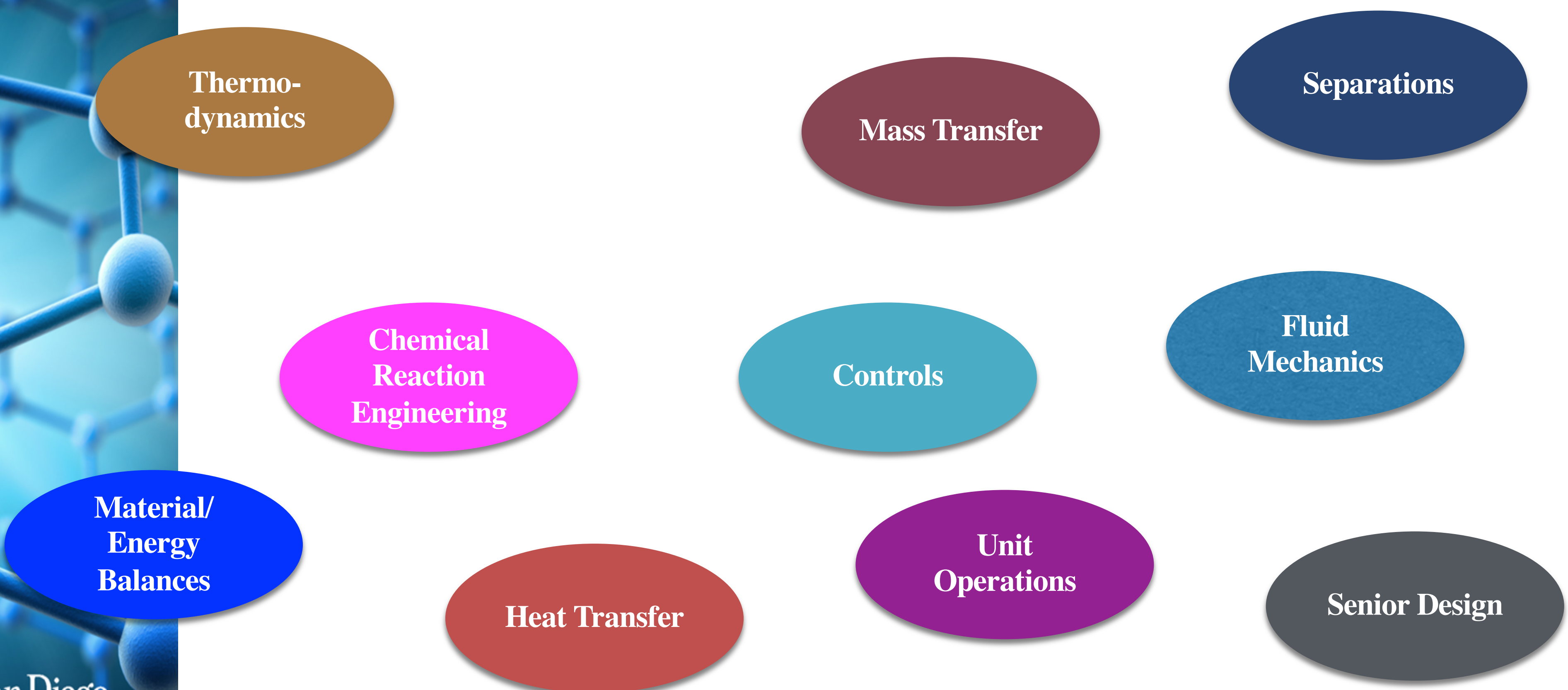
- How do students see the curriculum vs. our expectations

<u>Chemical Engineering Curriculum</u>

- Material/Energy Balances
- Thermodynamics
- Chemical Reaction Engineering
- Fluid Mechanics
- Heat Transfer
- Mass Transfer
- Separations
- Process Dynamics & Control
- Unit Operations
- Senior Design/ Engineering Economics

Problem:
Discrete or Accumulated Learning?

- From the student perspective, each of these classes are still taken in isolation from each other



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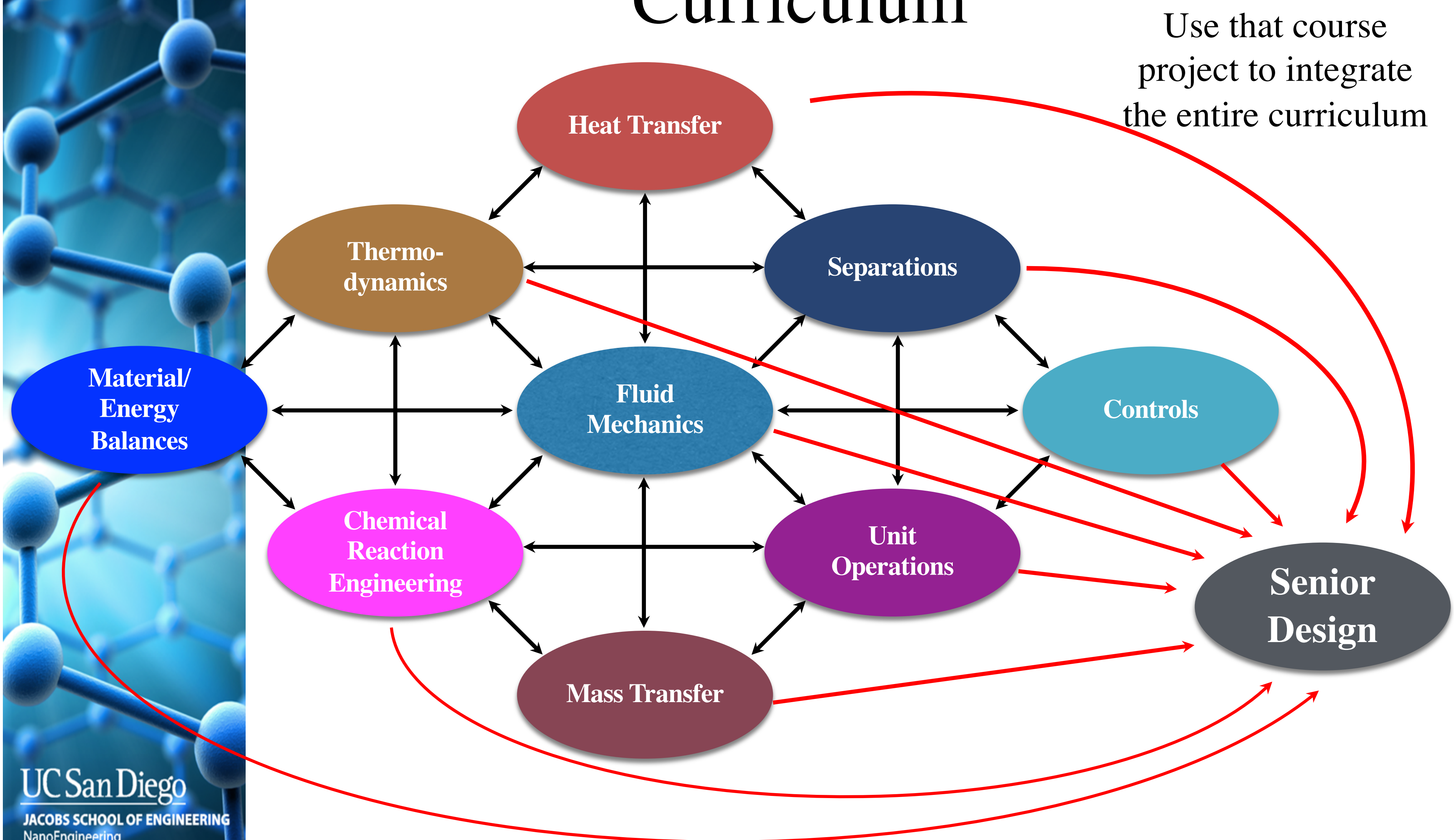
Connecting the Dots: A Single Project Spanning the Full Curriculum



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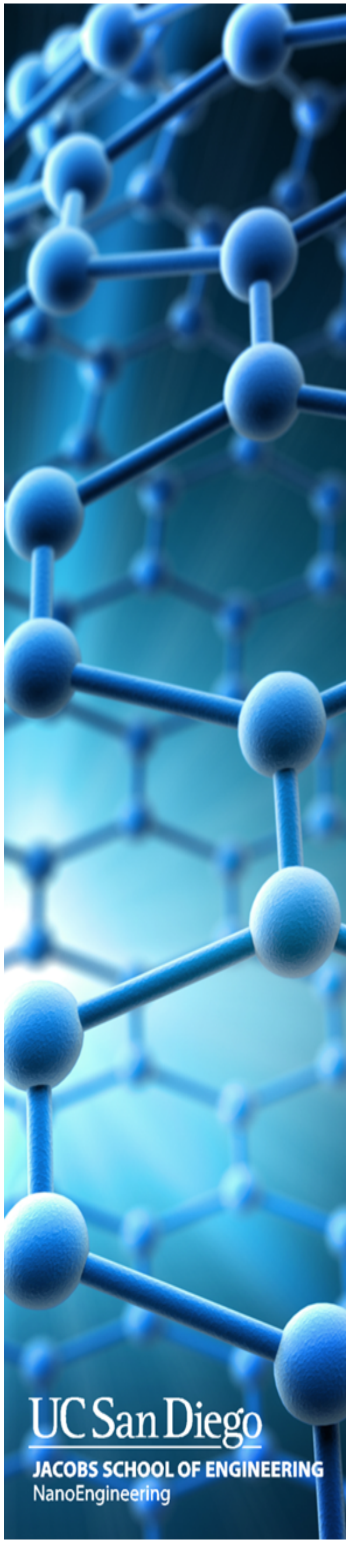


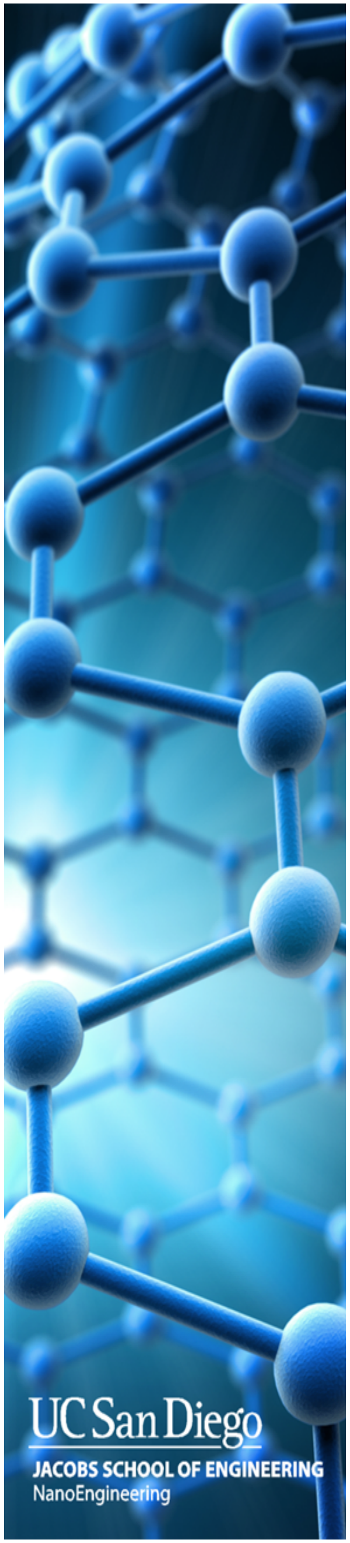
Integrated Curriculum

The Impact of Vertical Integration of Design Teams on the Chemical Engineering Program

Sandra Spickard-Prettyman[1], Helen Qammar[2], Francis Broadway[3], H Micheal Cheung[4] and Edward Evans[*]

Abstract **- For the last five years, the Department of Chemical Engineering at The University of Akron has implemented a Vertically Integrated Team Design Project (VITDP) involving our department's entire undergraduate student population. Teams, consisting of freshman through seniors, work together with an industrial or faculty mentor to solve an open-ended design problem over a five-seven week period during the Fall semester. Each project is designed to require positive interdependency between the team members, thus creating an instructional framework where students learn through teaming rather than group work. All freshmen learn what chemical engineering is about, sophomores enhance their learning in process economics, juniors and seniors improve their proficiency with process simulation, and seniors make major improvements in their ability to lead or guide other people. When the design project introduces a concept or topic that has not been fully integrated into the curriculum, all students, including those who prefer to work alone, effectively increase their knowledge of that topic. The vertically integrated team structure provides a way to learn information in context, which has a particularly strong effect on women in the program. Overall, the VITDP has a positive impact on the chemical engineering program.**

University of Akron, Ohio



Integrated Curriculum

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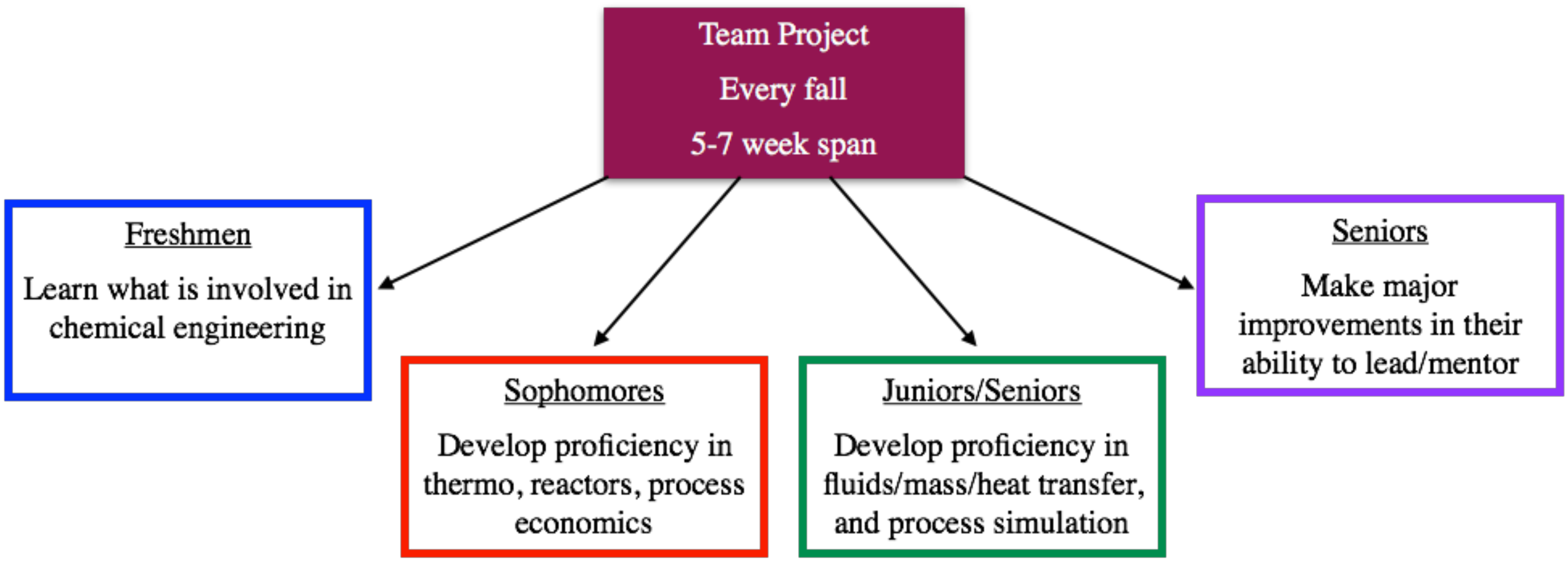
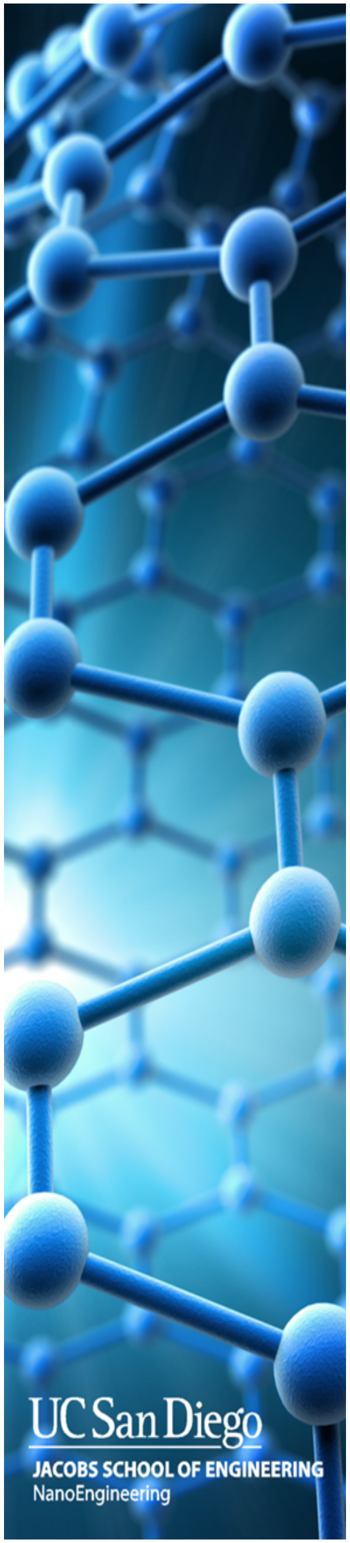




Integrated Curriculum

The Vertical Integration of Design in Chemical Engineering

Ronald J. Gatehouse, George J. Selembo Jr., and John R. McWhirter
The Pennsylvania State University

Abstract

The purpose of this project is to better prepare chemical engineering students for their senior design course and for industry by exposing them to more design-oriented problems much earlier in their undergraduate careers. The feature that distinguishes engineering from the purely theoretical sciences is that of synthesis. Any meaningful synthesis requires two basic components, one that arises from the order of our scientific knowledge and another that arises from the spontaneous thought of the individual performing the synthesis. Until now, the undergraduate chemical engineering curriculum at Penn State University has focused almost entirely on the former; this project requires students to recognize the latter. Two entire chemical process plants have been divided into several design projects to be used in the core undergraduate chemical engineering courses, and each design project requires that the students use concepts learned in a given chemical engineering course (e.g. heat transfer, mass transfer, kinetics, etc.) to arrive at a fully specified design. The students will follow the same or similar chemical process plants throughout their undergraduate careers so that, by the end, they will understand many of the details of designing the plant without losing focus of the ultimate goal of the process. Most importantly, however, at some point in the project they will have to make some of their own decisions. There will be more than one way to attack the problem, and the students will have to make appropriate assumptions, research several alternatives, use common sense and think both logically and physically in order to arrive at a practical solution. If this project accomplishes its goal, the chemical engineering curriculum at Penn State University will take a step away from being a mere extension of theoretical science and a step toward being an actual preparation for a career in thoughtful problem-solving and design.

Integrated Curriculum

The Vertical Integration of Design in Chemical Engineering

Ronald J. Gatehouse, George J. Selembo Jr., and John R. McWhirter
The Pennsylvania State University

Chemical Process Chosen - Every course in curriculum has project related to specific process

Sample Process: Acrylic Acid

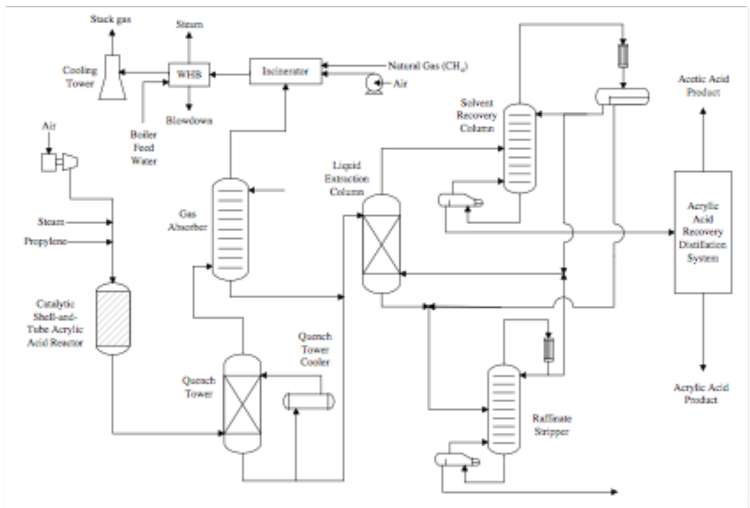


Figure 1. Acrylic Acid Production Plant

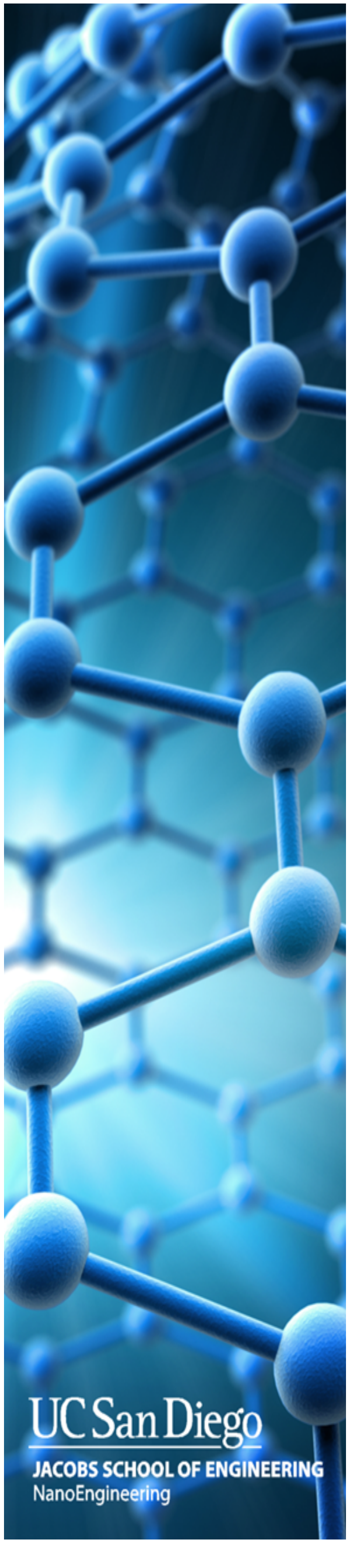
Ultimately, a project in each class - all under the general theme of "acrylic acid production"

Chem E 301: Material Balances - Perform balances around major pieces of equipment

Chem E 302: Fluids/Heat Flow - Perform analysis of process heat exchangers

Chem E 303/304: Thermo, Phase+Chemical Equilibria - Energy balances & equilibrium analysis around major equipment

Chem E 413/414: Mass Transfer, Kinetics, Industrial Chemistry - Perform analysis of separators and reactors



Integrated Curriculum

<u>Alternate Proposal:</u>

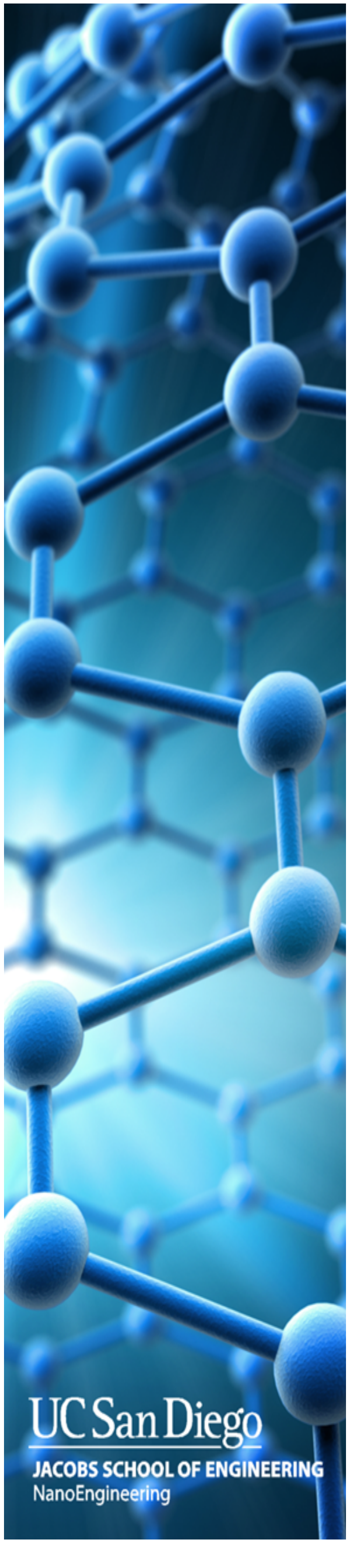
Give the SAME project in EVERY course

- In the introductory class, make the simplest assumptions and analyze the general system - each component is still just a black box
- With each subsequent course, gradually modify each component of the process until everything is modeled accurately
- Effectively, connects the dots and serves as a 2-3 year design project

Integrated Curriculum Case Study: Methanol Synthesis

Haldor Topsoe

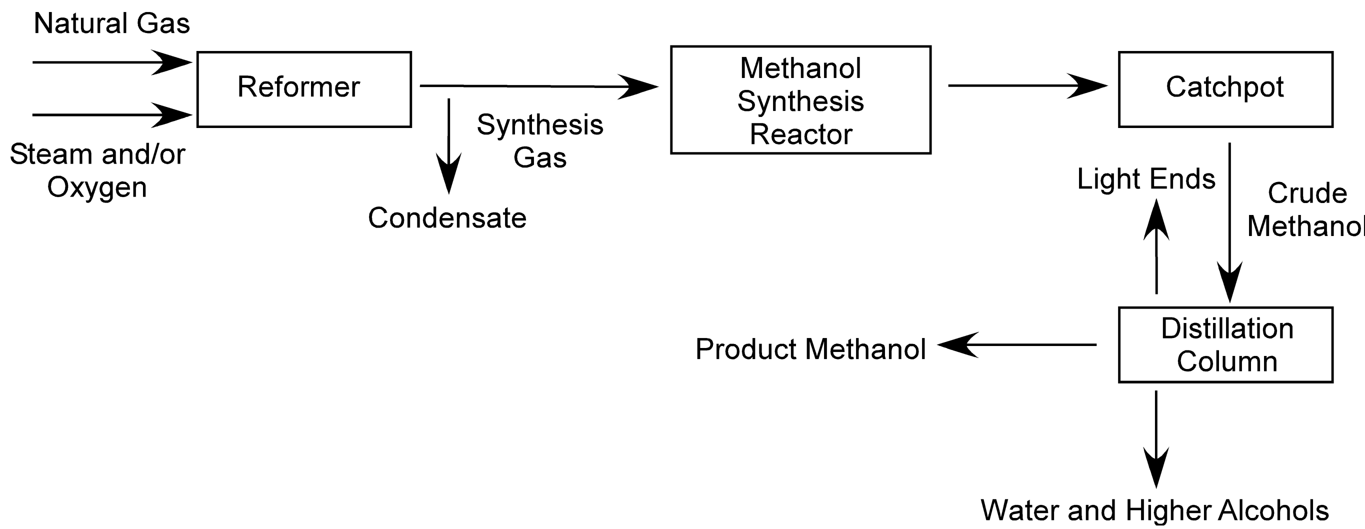
UC San Diego
JACOBS SCHOOL OF ENGINEERING
NanoEngineering



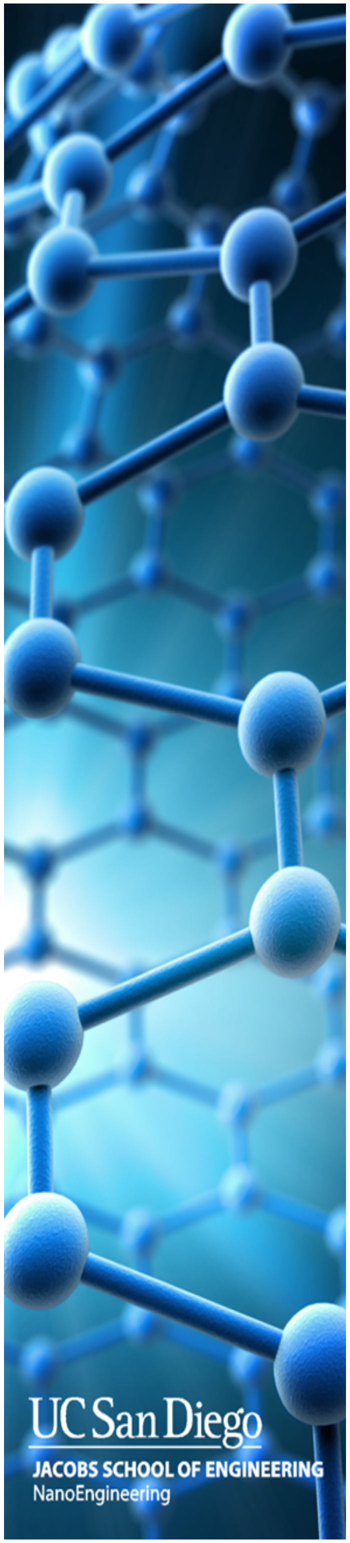
Integrated Curriculum Case Study: Methanol Synthesis

Introduction to Material and Energy Balances

Year 2, Quarter 1



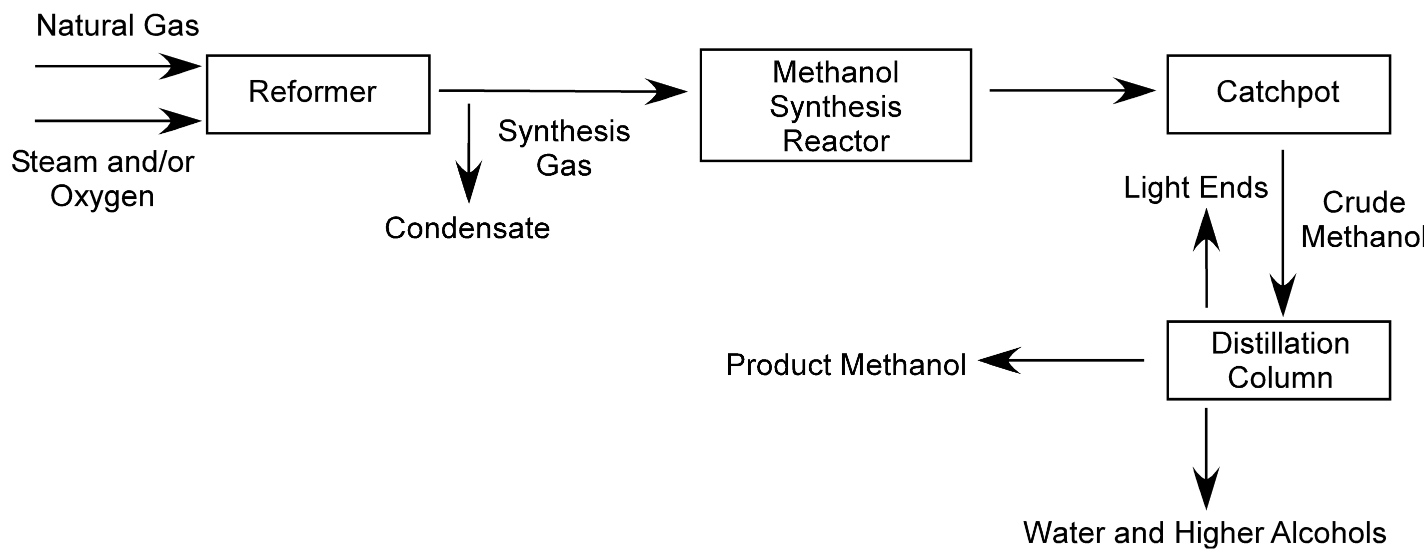
- Simplified Block Flow Diagram provided & analyzed
- Overall mass/mole/energy balances performed
- All systems modeled ideally



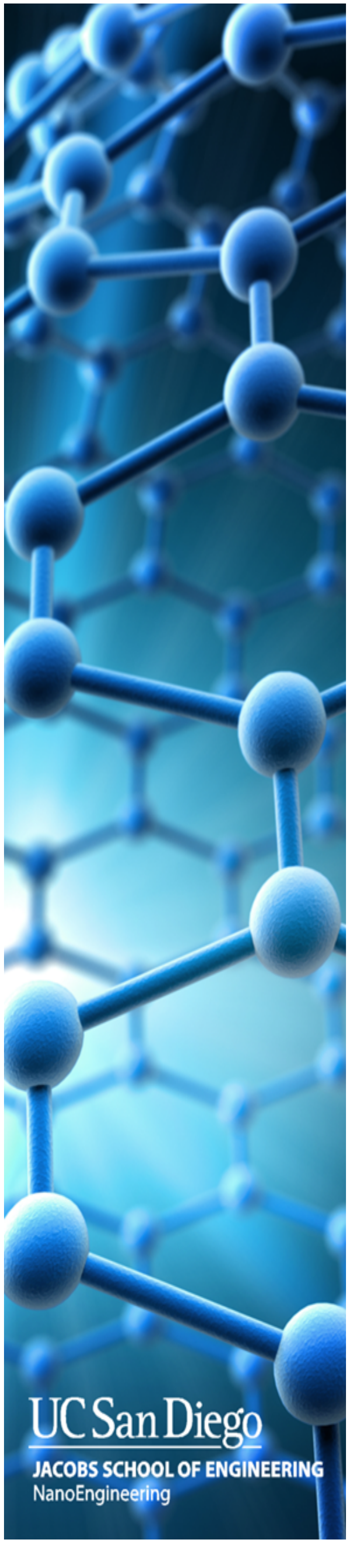
Integrated Curriculum Case Study: Methanol Synthesis

Chemical Engineering Thermodynamics

Year 2, Quarter 2



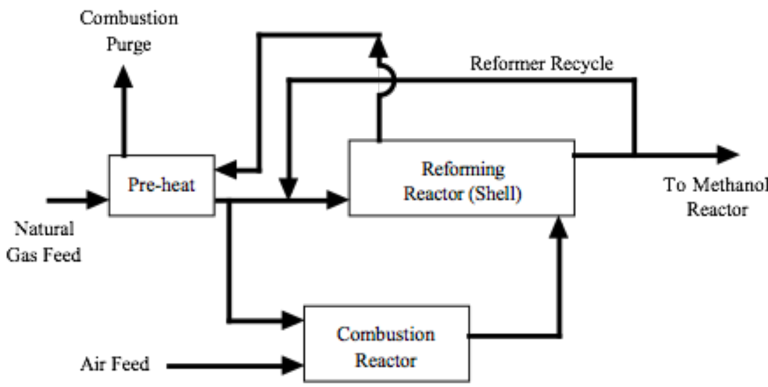
- Compressor/pump work evaluated
- Correct models for equilibrium in reactors & separators - modify resulting process material balances



Integrated Curriculum Case Study: Methanol Synthesis

Chemical Reaction Engineering

Year 2, Quarter 3



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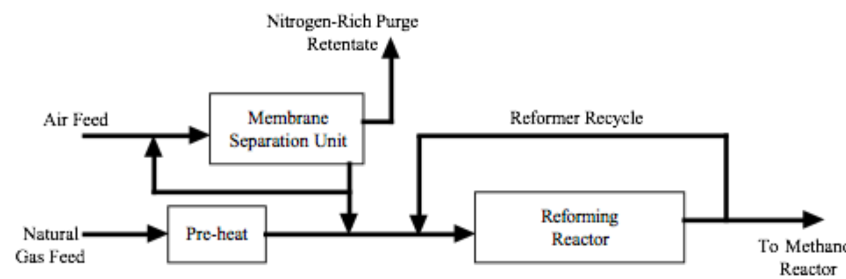
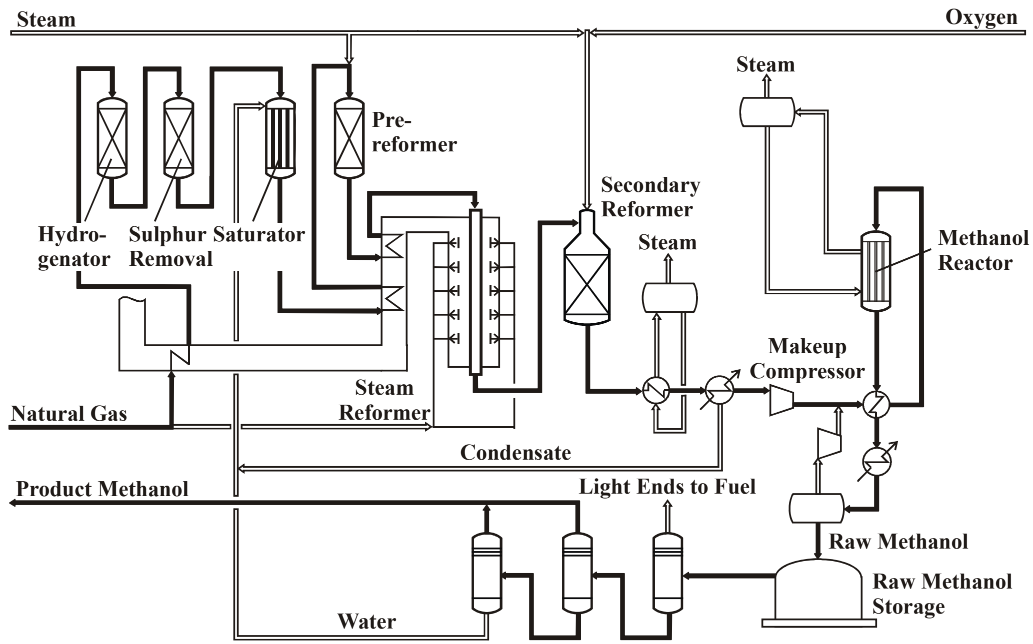


- Develop kinetic models for reactors for sizing and catalyst loading
- Optimize recycle structure, interstage cooling, conversion

Integrated Curriculum Case Study: Methanol Synthesis

Fluid Mechanics, Heat/Mass Transfer

Year 3

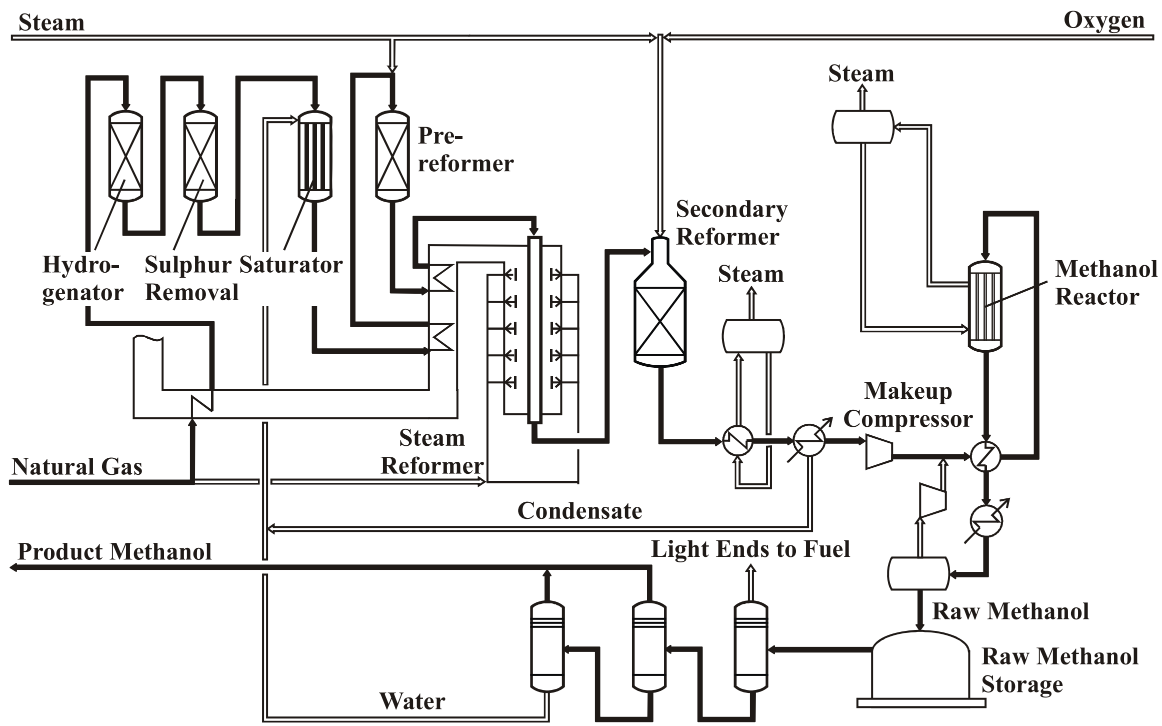


- Model heat exchangers, pressure drop through piping/reactors, condensers, purifiers, and mass transfer units

Integrated Curriculum Case Study: Methanol Synthesis

Separations

Year 4

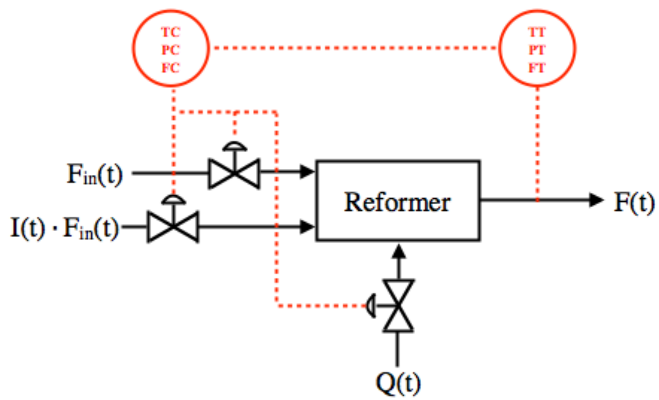


- Replace “simple” flash separation units & compare with accurately modeled extraction/ absorption/ stripping/ distillation columns

Integrated Curriculum Case Study: Methanol Synthesis

Process Dynamics & Control

Year 4



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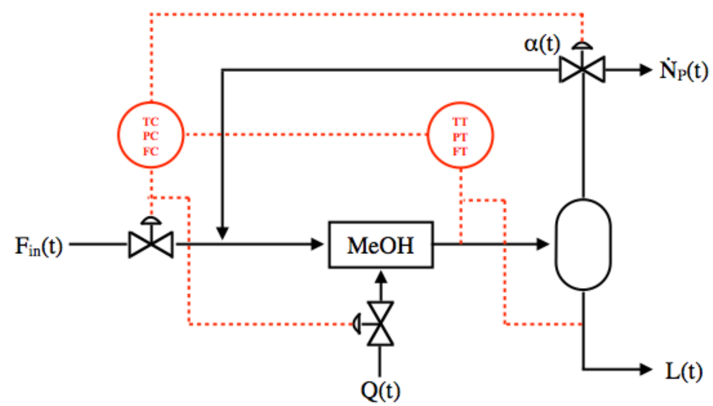
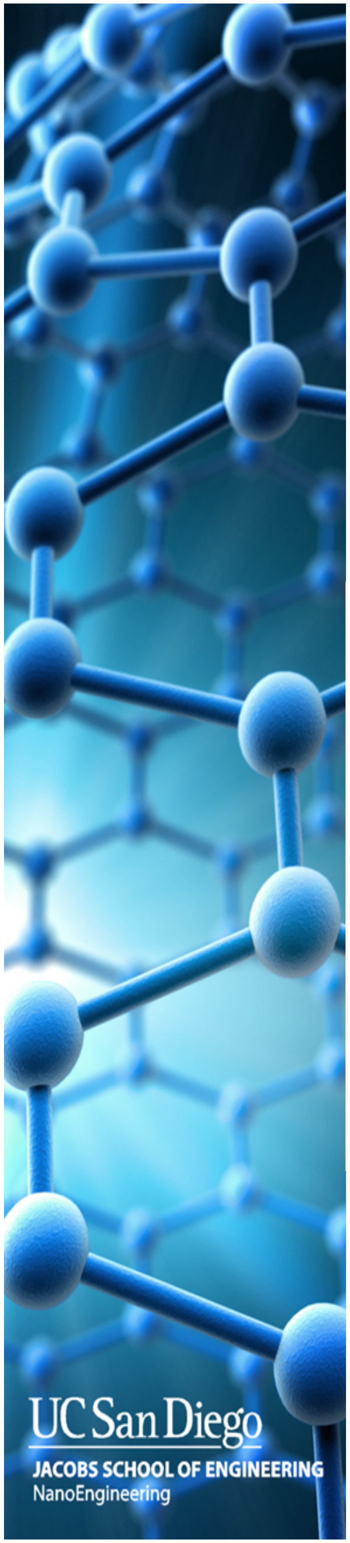


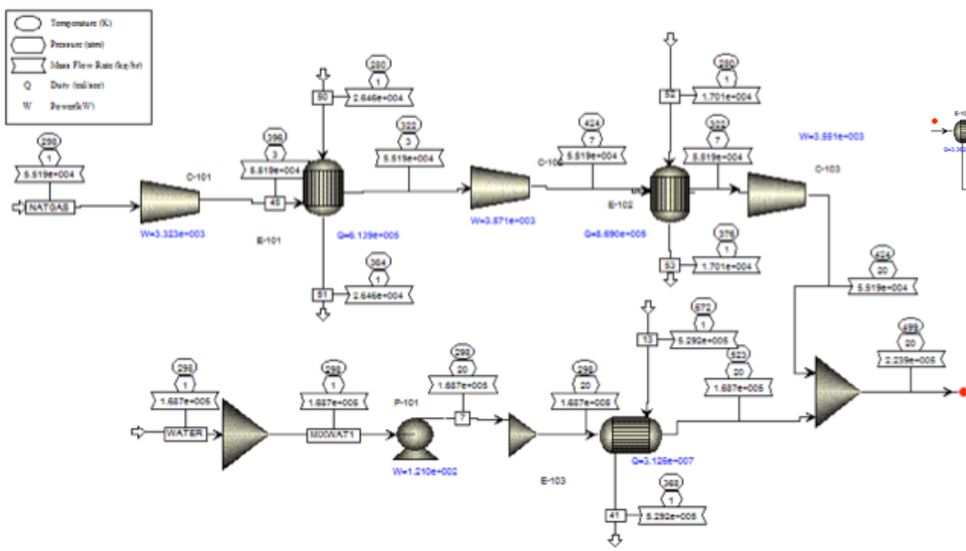
- Using modeled dynamic process, design and tune controllers for reactors, distillation columns, storage tank levels

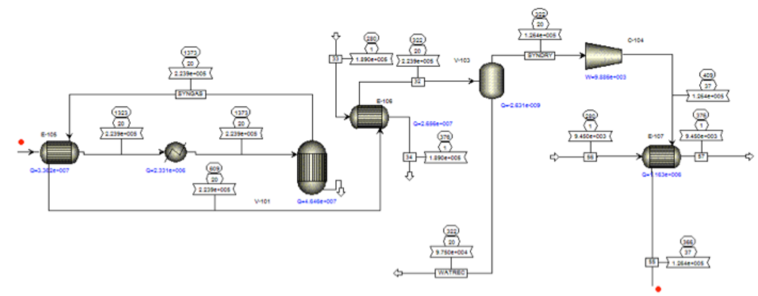


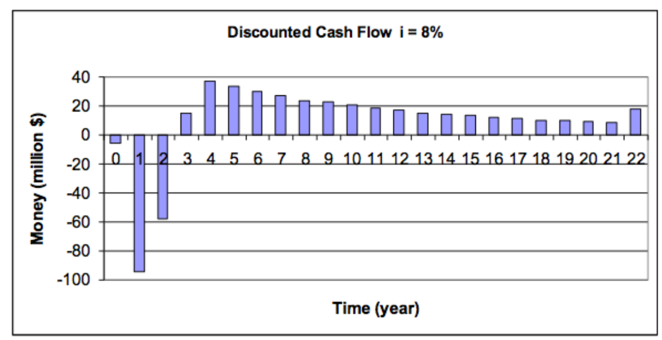
Integrated Curriculum Case Study: Methanol Synthesis

Chemical Plant and Process Design

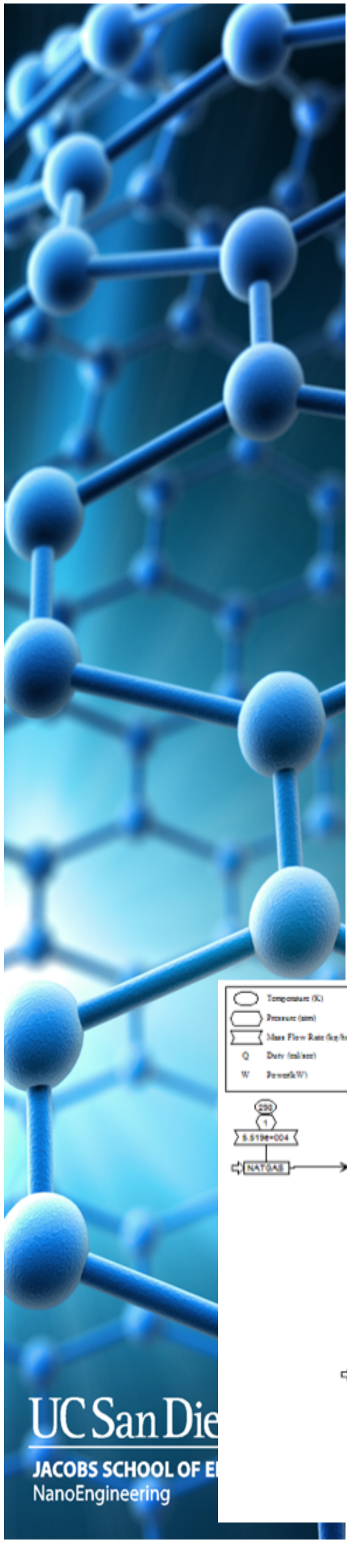
Year 4





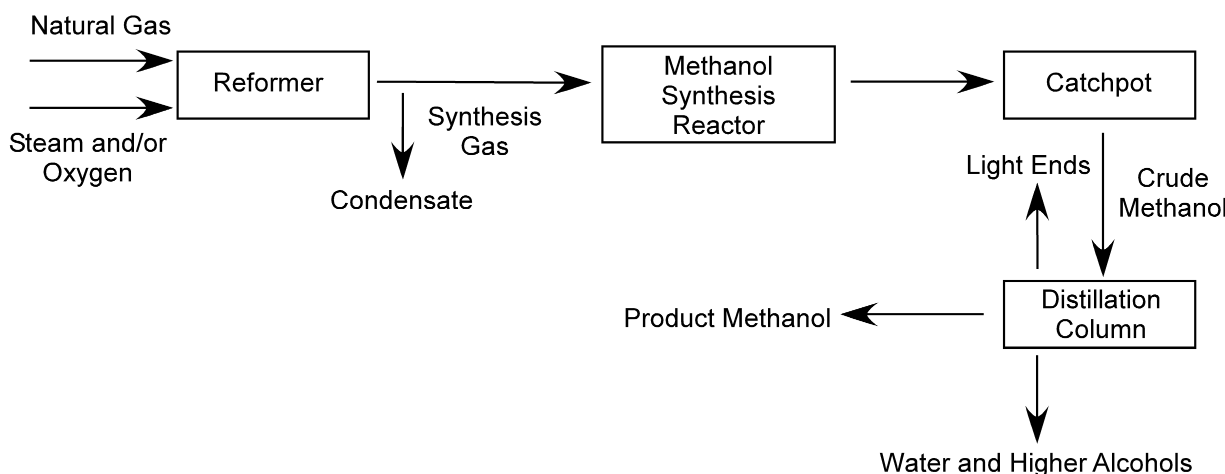


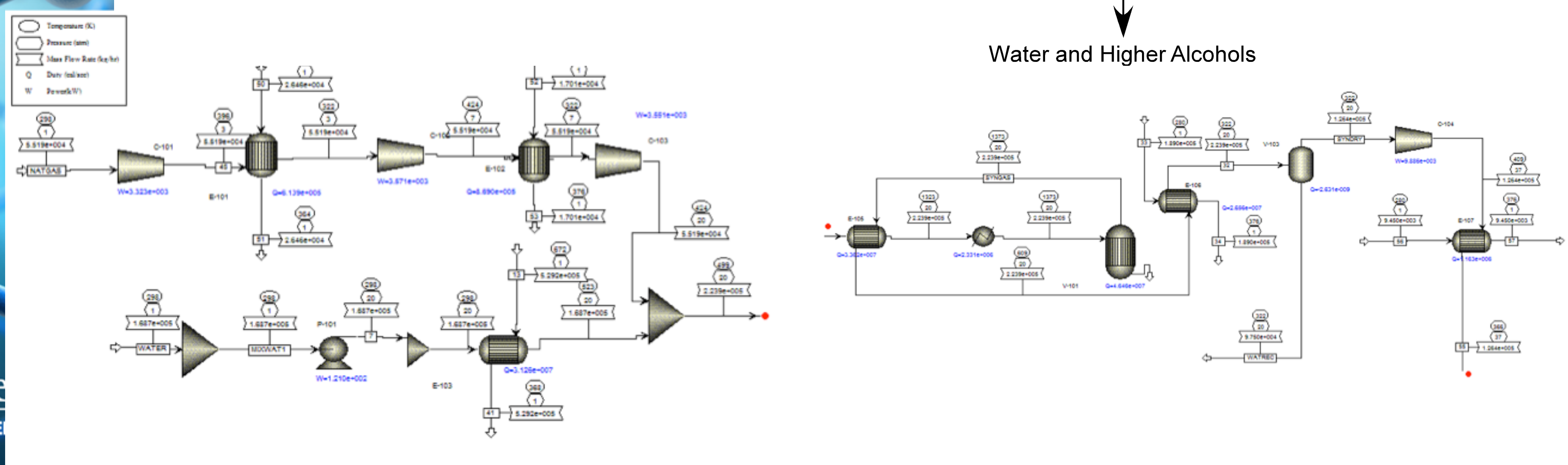
- Simulate the entire process, comparing to previous analyses, and full economic analysis

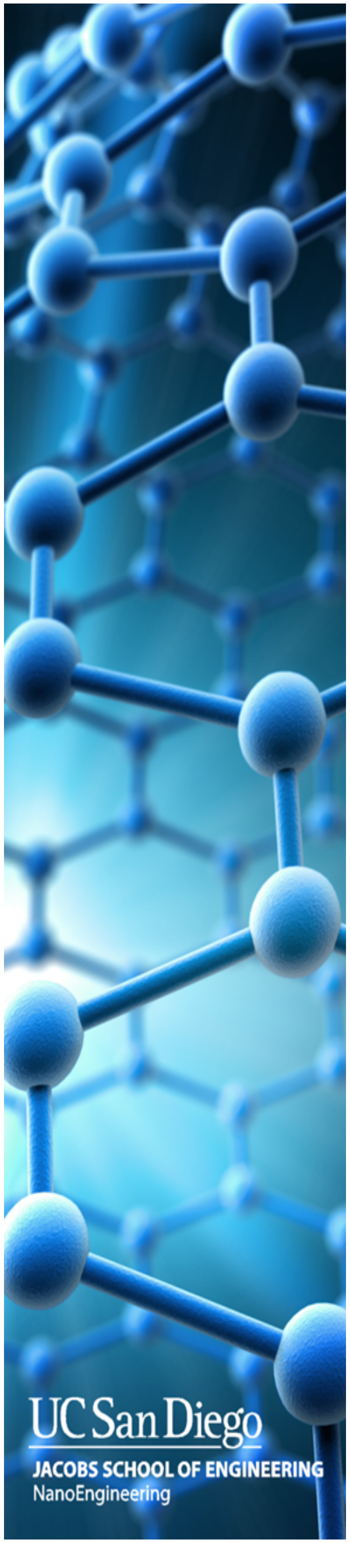


Integrated Curriculum Case Study: Methanol Synthesis

- Students learn the value of each individual course/topic as applied to this one, specific design project







Integrated Curriculum: ABET Student Outcomes Satisfied

(1) Ability to identify, formulate, and solve complex engineering problems…

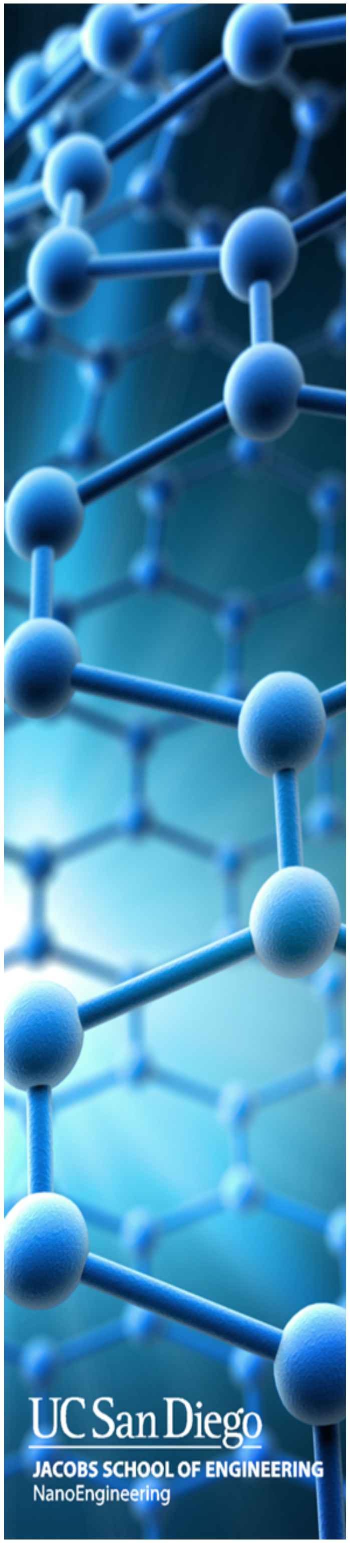
(2) Ability to apply engineering design to produce solutions that meet specified needs…

(3) Ability to communicate effectively…

(4) Ability to recognize ethical and professional responsibilities…

(5) Ability to function effectively on a team…

(7) Ability to acquire and apply new knowledge…



Conclusions

- Tie courses together with group-oriented projects
- Integrate the entire curriculum to foster greater learning of and appreciation for the subject materials of ALL courses

UCSD
Structural and Materials Engineering Building