A COMPLETE REDESIGN OF FRESHMEN ENGINEERING COURSE

Professor Ryan Munden, Electrical Engineering
Professor Shanon Reckinger, Mechanical Engineering

Fairfield University’s Center for Academic Excellence
Collaborations for Empowerment and Learning
Innovative Pedagogy & Course Redesign
12th Annual Summer Conference
May 29th-31, 2013 | Fairfield University, CT

Motivation

EG31 – Fundamentals of Engineering
  • First engineering course for all undergraduate engineering majors (Mechanical, Electrical, Software, Computer)
  • Freshmen and mostly traditional students (very few part-time, adult students)
  • Cornerstone course
  • Many students are declared “undecided engineering”
  • Some students are undecided, in general

How can we develop this course for maximum learning and make it most useful for the students?
Outline

- Background of EG31
- CAE's Summer Institute on Integrative Learning 2012
- EG31's Backward Design Process
  - Course Goals
  - Course Outcomes
  - Assessment
  - Curriculum
- Linking Course Goals
- Reflections on the Redesign

Background

- EG31 – before the redesign
  - 2 semester sequence, 6 credits total
  - Course content was technically heavy (topics included DC circuit analysis, digital logic, stress and strain in solids, programming, etc.) with little to no retention by students
  - Software training (including Excel, MATLAB, Multisim, Working Model, etc.)
  - One Instructor: part time, adjunct, Electrical Engineering, taught course for 5 years.
  - Traditional course format: lecture based, in class exams, turbos.
Background

<table>
<thead>
<tr>
<th>Old EG31</th>
<th>New EG31</th>
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<tbody>
<tr>
<td>2 semester sequence, 6 credits</td>
<td>1 semester, 3 credits, no turbos!</td>
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<tr>
<td>Content Technically Heavy</td>
<td>No “Technical Content”, links to math &amp; physics</td>
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<tr>
<td>Software Training</td>
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<td>1 Instructor, adjunct</td>
<td>2 Instructors, full time, multidisciplinary</td>
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<td>Mostly lecture based, traditional exams</td>
<td>Active learning, based off of education research, hands on, project oriented</td>
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*This training now takes place in EG145, a new course taught by Professor Reckinger

Where it all began...

2012 CAE’s Summer Institute on Integrative Learning!
- Munden (EE), Reckinger (ME), and Yoo (SE) participated
- Many ideas were implemented in redesign of EG31
- Learned about techniques for course design

Photo credit: Fairfield CAE
Backward Course Design

Thank you
Dr. Christine Siegel &
Dr. Larry Miners!

• Course Goals
  • What will the students take away from the course 5+ years from now?
• Course Outcomes
  • What do we expect the students to learn?
• Assessment
  • How will we know the students have learned?
• Curriculum
  • Through what experiences will the students learn best?
Backward Course Design

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Course Goals

What will the students take from the class 5 years from now?
• Create a passion for engineering.
• Develop an engineering mindset, problem solving skills, and critical thinking.
• Develop engineering professionalism.
Backward Course Design

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Course Outcomes

What do we expect the students to learn?
- Understand the roles of engineers in different fields and different industries.
- Be familiar with the different engineering majors at Fairfield.
- Develop an awareness of modern technology and its use in the engineering field.
- Develop skills in:
  - Oral communication
  - Technical writing
  - Team work
  - Project and time management
  - Problem Solving
  - Engineering ethics & best practices
Course Outcomes

What do we expect the students to learn?

• Understand the roles of engineers in different fields and different industries. (I)
• Be familiar with the different engineering majors at Fairfield.
• Develop an awareness of modern technology and its use in the engineering field.
• Develop skills:
  • Oral communication
  • Technical writing
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  • Problem Solving
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Industries

Roles

Fields
Course Outcomes

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• Be familiar with the different engineering majors at Fairfield.

• Develop an awareness of modern technology and its use in the engineering field.

• Develop skills in:
  • Oral communication (III)
  • Technical writing (III)
  • Team work (II,III)
  • Project and time management (III)
  • Problem Solving (II)
  • Engineering ethics & best practices (III)

Backward Course Design

• Course Goals
  • What will the students take away from the course 5+ years from now?

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• Curriculum
  • Through what experiences will the students learn best?
Assessment

How will we know the students have learned? (code for: how did we grade them)

- Regular Assignments
  - Weekly problem set (PS) (CO8)
  - Weekly writing assignment (WA) (CO1-5,9)
- Projects
  - Individual Technical Writing Piece (ITW) (CO5)
  - Individual Technical Oral Presentation (ITP) (CO4)
  - Team Final Design Project (TDP) (CO6-7)

Assessment – PS

Problem Set - Example

EG31 Fundamentals of Engineering
Munden/Reckinger
Due Date: C02-10/22/2012, C01/03-10/23/2012

Problem Set #4
Terminal Velocity

1. Felix Baumgartner just became the first person to break the sound barrier in free fall while skydiving (on Oct 15th, 2012). He reached a maximum speed of Mach 1.24 or 833.0 mph. He jumped from a balloon lifted capsule at the height of 128,100 feet (over 24 miles) above the surface of earth and free fell for 4 mins 20 sec. Assume Felix weighs 170 lbs. What was his drag coefficient during free fall?

Problem Set #4

1. An air balloon has a mass of 300 kg. It is in the air, and it is hot air that provides lift. The air temperature is 30°C, and the air density is 1.225 kg/m³. If the air current is 60 km/h, what is the lift force on the balloon?

\[ V = 300 \text{ m/s}, \, T = 30^\circ \text{C}, \, \rho = 1.225 \text{ kg/m}^3, \, U = 60 \text{ km/h} \]

2. A wind of 60 km/h is blowing against the balloon. What is the lift force on the balloon?

\[ V = 300 \text{ m/s}, \, T = 30^\circ \text{C}, \, \rho = 1.225 \text{ kg/m}^3, \, U = 60 \text{ km/h} \]

3. The balloon is carrying a weight of 300 kg. What is the force required to lift the balloon?

\[ W = 300 \text{ kg}, \, g = 9.8 \text{ m/s}^2 \]

4. The balloon is carrying a weight of 300 kg. What is the acceleration of the balloon?

\[ \text{Mass} = 300 \text{ kg}, \, g = 9.8 \text{ m/s}^2 \]

5. The balloon is carrying a weight of 300 kg. What is the force required to maintain the balloon in the air?

\[ \text{Mass} = 300 \text{ kg}, \, g = 9.8 \text{ m/s}^2 \]
### Assessment - PS

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Assessment – WA

• WA1: Interview an engineer and explain where they fit in to the field, role and industry discussed in class. (CO1)
• WA2: Explain how something works. (CO3)
• WA3: Tell about a time you learned the most or were most fascinated by a speaker. Explain why. (CO4)
• WA4: Reflective writing on what you learned about technical writing from your own writing or your peers. (CO5)
• WA5: Reflective writing on three things you could do to improve your presentation skills. (CO4)
• WA6: Review Popular Science article. (CO3)
• WA7: Find a photo that represents each Computer and Electrical Engineering and write 1-2 sentences about it. (CO2)
• WA8: Find a photo that represents each Mechanical, Automation and Software Engineering and write 1-2 sentences about it. (CO2)
• WA9: Reflect on the industry visits and the class field trip. (CO1)
THURSDAY, SEPTEMBER 20, 2012

Locks and Keys

Locks and keys are still used in today's society as a way to keep items secure. Inside the inner workings of a lock are many different pieces that fit together. Each key can only fit one lock, unless they are mass-produced and are exactly identical. Most complex locks are made of components that are required to be used in companion locks. These kinds of locks are more commonly used for mass production, and only when one asks for a more high-security lock will the company have to use more intense material and a more complex lock.

In order to open a lock, the key must be slid into the opening, and turned to the right. To unlock the door, the key must be turned to the left. This system works the same as tightening and loosening caps or screws. Once the key is inside, it fits along a set of pin tumblers that are raised to the height of the key cuts. The pins hold the pin tumblers in place are turned by the rotation of the key. The pin tumblers must align perfectly with the key cuts or the lock will not open. This helps to ensure that locks are not easily picked. In order to pick a lock, the pin tumblers must meet an object at the same height as if the pin tumblers were the same height as the key cuts. Otherwise the springs will not release and the lock will remain closed. When the key is turned, the pin tumblers will release and the lock will open.

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FRIDAY, OCTOBER 26, 2012


The tragic collapse of the World Trade Center on September 11, 2001 was a source of deep grief for the American population. Now, upon the construction of the new World Trade Center (WTC), the site can be seen as a symbol of rebirth. Not only is the new WTC being constructed with “the most environmentally advanced technologies,” according to “How the Greenest Skyscraper Complex Ever Is Rising Out of the Rubble of the World Trade Center,” it is also in line for a gold certificate from Leadership in Energy and Environment Design (LEED). Since LEED serves as “an internationally recognized third-party verification system [that]...” to confirm that a building is designed and constructed with the aim of improving energy savings, water efficiency, CO2 emissions, indoor environmental quality, and intelligent resource management,” this is a significant achievement. Indeed, the construction of the WTC is impressive on all these accounts. During construction contractors could only use “ultra-low sulfur diesel fuel” to “reduce nitrogen oxide and particulate emissions.” The vehicles used by contractors used “extra particulate filters” to reduce CO2 emissions, and, to ensure that emissions stay at a low rate, WTC is planning on “reducing the amount of vehicular traffic in the area by providing ample public transportation access and extensive facilities for bicycle commuters.” Already 75 percent of the building is composed of “post-industrial recycled content,” and the construction project itself recycles 90 percent of the waste generated at the site. Consumption of energy and water are also at a low rate. WTC reduces the need for energy by implementing “daylighting,” sensors that automatically dim interior lights if there is enough sunlight coming in through the building’s ultra-clear glass. Hydrogen fuel cells take wasted steam from steam
Three rounds of review (idea from 2012 CAE Summer Institute):

- Self review
- Peer review (read aloud in trios, as in EN 11/12)
- Instructor review

Final grade was received after instructor read second draft

Library class

5 references, 2 library references
Assessment - ITP

- Student presented on same technical topic as they wrote about
- Presentations were video taped, so students could watch themselves presenting and reflect on their own presentation skills
- Grade was determined by on-the-fly peer and instructor review via Mentor

Assessment - ITP

Individual Technical Presentation - Example
Assessment - TDP

**Design Goal:**
Teams must design a system that propels a single person (the “operator”) across the entire length of the RecPlex swimming pool with a walking or running motion above water.

**Project/Competition Rules:**
1. All systems must fit in single regulation sized swimming lane.
2. Total project cost must not exceed $100. However, no materials will be provided so it is encouraged that you find spare, unused, and recycled materials to work with.
3. If the operator falls into the water they must either: (a) get back up in that location unassisted or (b) return to the start and have their team help them remount.
4. Absolutely no cardboard or paper can be used in the design of the WOW system. Be considerate and do not use any materials that could potentially cause damage to pool drains.
5. The operator must be able to swim and we highly recommend that you wear a helmet.

YOUR TURN: What would YOU design?

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Assessment - TDP

Assessment – Outcomes Connection

We moved from graded assignments:

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### Assessment – Outcomes Connection

#### To provide “graded” course outcomes

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#### Assessment – Outcomes Connection

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Outcomes c,i,j,k were graded objectively, as the score translates more accurately into the rubric value. For outcomes h,l;j, they were only measured by completion of the writing assignment, or only chose a rubric value between 2.4. Any of these can be varied based on instructor perception of student performance on an in class, unevulated activity.

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, societal, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

CAE 12th Annual Summer Conference
May 30th, 2013 | Fairfield University, CT
Backward Course Design

- Course Goals
  - What will the students take away from the course 5+ years from now?
- Course Outcomes
  - What do we expect the students to learn?
- Assessment
  - How will we know the students have learned?
- Curriculum
  - Through what experiences will the students learn best?

Curriculum – In Class Design Projects

- Hands on, Interactive, In-class design projects
  - Design a method for transferring radioactive golf balls from one location to another
  - Design a prosthetic leg
  - Program an arduino to turn on a light
Curriculum – Team Building

- Fun, teamwork, creativity activities
  - Estimate the height of the Engineering building using only a mirror, a pencil, and a piece of paper
  - “Cross the river” with only a few supplies
  - Brainstorming activities

Curriculum – Communication Skills

- In-class activities to improve listening, writing, reading, and speaking skills
  - One-minute technical speeches
  - Writing instructions for using “technically challenging” devices (iPods, toaster ovens, microwave, hair dryer, etc.)
  - Instructor reads technical article out loud, followed by clicker quiz to see if anyone was listening
  - Blind Building
Curriculum – Professional Engineering

- Various professional engineering activities
  - Mindmap of engineering industries, fields, and roles (idea from CAE Summer Institute 2012)
  - Professional Engineers gave presentations to students from Covidien, ASML, and Yale ROTC
  - Optional field trip to Sikorsky Aircraft for tour
  - Class visit from career center, resume writing, engineering ethics discussion, case studies from real engineers solving problems, intro to project management.

YOUR TURN: Radioactive Golf Balls

- **Objective**: Using the supplies provided, design a device to see who can transfer 5 golf balls from one bag to the other in the shortest amount of time.

- **Rules**:
  - The teams may alter the supplies in any way necessary;
  - The golf balls must be moved one at a time;
  - No part of a person’s body or clothing may touch the golf balls. The balls must stay at least 3 inches away from any body part—notably the hand.
  - If anyone touches a ball or if a ball gets dropped, there is a contamination leak! A member of the team must return the contaminated ball to bag #1;
  - This is a speed competition! The team whose device successfully completes the task in the shortest amount of time wins.
**Linking Course Outcomes to...**

- Course Goals
- Accreditation Board for Engineering and Technology (ABET) Student Outcomes
- Fairfield University’s Core Pathways

**Linkage – Goals/Outcomes & ABET**

**Course Goals**
1. Motivate learning of, and create a passion for, engineering.
2. Develop an engineering mindset, problem solving skills, and critical thinking.
3. Develop engineering professionalism.

**Course Outcomes**
1. Understand the roles of engineers in different fields and different industries in a global, economic, environmental, and societal context. (h) [I]
2. Be familiar with the different engineering majors at Fairfield. [I]
3. Develop an awareness of modern technology and its use in the engineering field. (i, j) [I]
4. Demonstrate effective oral communication about technical content. (g) [III]
5. Demonstrate effective technical writing. (g) [III]
6. Be able to work in interdisciplinary teams. (d) [II][III]
7. Be familiar with project and time management. (d) [III]
8. Be able to identify, formulate and solve engineering problems. (e) [II]
9. Develop an awareness of best practices and ethics in engineering and their use by professionals. (f) [III]

**ABET Outcomes**
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
Linkage – Core Pathways

- Quantitative Reasoning and Scientific Reasoning – obvious linkage
- Global Citizenship – solving problems that benefit humanity.
- Rhetoric and Reflection - communicate clearly with peers, clients, and customers
- Reflect on the various Pathways and draw those connections between seemingly disparate courses. Find ways in which one course or activity benefits understanding of another—Connection to English and Physics

Reflections on Redesign

A few comments from student evaluations:
- “This class has inspired me to become an engineer.”
- “Great class, I learned a lot of technical concepts when she was teaching. Fun while challenging at the same time.”
- “Very interesting class. Great group work skills. Fun yet challenging class.”

Anecdotal Comments from students:
- “I really liked working on an engineering project with a team. It was rewarding to actually get it to work.”
Reflections on Redesign

From IDEA Evaluations:

- 96%/88% of students ranked 4 or 5 out of 5 “Acquiring skills in working with others as a member of a team” *(Essential)*
- 92%/77% of students ranked 4 or 5 out of 5 “Developing skills in expressing myself orally or in writing” *(Essential)*
- 80%/81% of students ranked 4 or 5 out of 5 “Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course” *(Important)*

Lessons Learned

- Make two “tracks” through EG 31, PS 15, MA 145, with a cohort of students in each track to maximize the benefit of being a cornerstone
- Use Mentor for blog instead of Tumblr!
- Get help with grading (teaching assistant)
- Consider giving more time for TDP. Have students check in or turn in project progress.
- In-Class participation, 10% of grade, more rigorous assessment of this? (2/7 absences)
Participant Reflection

- What methods have you learned that you can apply in your courses, and how?
- Were there any activities that we did that you can apply to your course?
- Could you use backward course design to improve one of your courses?

Thank you!