Engr 4001: Engineering Professionalism
Teaching the "Soft Side" of Engineering

Christopher R. Carroll
Director of Undergraduate Engineering
College of Science and Engineering
University of Minnesota Duluth 55812-2496
(218) 726-7530
ccarroll@d.umn.edu

Abstract

Engineering is more than just numbers and equations. Engineering exists to serve society, to make knowledge unearthed by math and science accessible to humanity. Engineers must understand the physical nature of the world around them to utilize the technical knowledge available to them effectively, but they also must understand foundations of the social settings in which they wish to apply that technology.

In the Fall, 2003, accreditation review of engineering programs at the University of Minnesota Duluth (UMD), the Accreditation Board for Engineering and Technology (ABET) visitors suggested that a way be found to instill in students a more complete appreciation for this "Professional Component" of engineering. According to ABET criteria, students should understand how engineering relates to activities in

- Economics,
- Environment,
- Sustainability,
- Manufacturability,
- Ethics,
- Health and safety,
- Society, and
- Politics.

Accordingly, the College of Science and Engineering at UMD has developed the course "*Engr 4001: Engineering Professionalism*," to address the relationship between these topics and engineering practice. This course will not focus on issues that are traditional, technical engineering topics, but instead will explore the "soft side" of engineering as it relates to the social issues listed above.

Engr 4001 will be a design oriented class, required as a pre- or co-requisite for capstone design courses in all engineering programs at UMD. It will bring together junior and senior students from Chemical, Industrial, Mechanical, and Electrical and Computer Engineering programs to work together in a multidisciplinary setting to solve design problems and to learn how engineering solutions impact humanity in the social areas listed above. The course will prepare students to use knowledge from their respective disciplines for the good of humanity with both technical competence and professionalism.

Background

Engineering programs at UMD are relatively new, originating in the mid 1980's with three programs that were prescribed to be different from those existing on the Twin Cities campus of the University of Minnesota. Our original mix of programs, consequently, was an interesting collection of Computer Engineering, Industrial Engineering, and Materials Processing Engineering, in order to avoid the "traditional" programs that existed in the Twin Cities. As our programs have matured, the restrictions imposed by the Twin Cities campus have relaxed, and the three original programs evolved into Electrical and Computer, Industrial, and Chemical Engineering programs, respectively. About a year ago we added a Mechanical Engineering program on the Duluth campus, and we are looking ahead to expanding into more areas of engineering as needs demand and resources permit.

Engineering programs at UMD have been continuously accredited by ABET since the time we produced our first engineering graduates. The UMD programs were visited for an accreditation review, our first under the new "Engineering 2000" accreditation criteria, in the Fall of 2003. Although final results of that review were not available at the time of this writing, the visit went well, and the accreditation team left with only a few suggestions for us to implement.

One of the suggestions mentioned by the ABET accreditation team was to improve our coverage of the "soft" topics listed in the ABET "Criterion 4" specifications, identified as the "Professional Component" of engineering by ABET. These topics (listed in the abstract section of this paper) are covered adequately in our engineering programs, but are not clearly identified as distinct topics in the curriculum. ABET suggested a more formal approach to address these "Criterion 4" topics specifically.

A second suggestion mentioned by ABET focused on the need to provide students with experience in multidisciplinary design in our programs. Although each separate program claims "multidisciplinary" experience within the program (for example, Electrical and Computer Engineering includes everything from device physics to computer architecture), no structured opportunity exists currently for students to interact between programs. ABET suggested that we provide a mechanism for engineering students in different programs to work together on design problems.

To address these two suggestions, the College of Science and Engineering at UMD has defined a new course, "Engineering Professionalism," that is intended to serve as a pre- or co-requisite for the capstone design courses in each of our engineering programs. This 2-credit course is intended to provide specific coverage of the "soft" engineering topics identified in ABET's "Criterion 4," and also to provide multidisciplinary design experience for students in all the engineering programs at UMD.

ABET's Professional Component

The "soft" engineering topics identified by ABET as the "Professional Component" of engineering programs in their accreditation Criterion 4 include the following eight topics:

- Economics,
- Environment,
- Sustainability,
- Manufacturability,
- Ethics,
- Health and safety,
- Society, and
- Politics.

Obviously each of these topics is broad and can be expanded into a whole course series by itself. The Engineering Professionalism course is only a 2-credit course, with one hour of lecture and two hours of lab each week for just one 15-week semester. When time for tests, lab descriptions, and other necessary support work is included, only about one hour of lecture during the semester is available to cover each of the topics listed above. However, what is crucial for engineering students is that they be made aware of the importance of each of these topics and how these topics relate to their engineering careers. No practicing engineer can avoid any of these topics in his or her job performance. The Engineering Professionalism course will emphasize the importance of being aware of the issues in each of these areas.

Multidisciplinary Design

Creating design experiences for a class that includes Electrical and Computer, Chemical, Industrial, and Mechanical Engineering students is a challenge. Finding design problems that exercise the technical abilities of students in all of these areas is daunting. Most topics that come to mind will require only rudimentary knowledge from one or more of the engineering programs.

For example, take the problem "Design a battery." Okay, it's electrical – check. Okay, it must be packaged, so it's mechanical – check. Okay, it must be manufacturable, so that's industrial – check. And then there's the chemistry involved, so it's chemical – check. So, true, all four of the engineering disciplines at UMD are included. But probably the chemical engineering component will dominate the design work, so the chemical engineering students would have some "advantage" with this problem, or examined from the other viewpoint, engineering students from non-chemical disciplines would not have much to do. Although real engineering design problems almost always involve engineering from many disciplines, design problems suitable for an instructional lab environment are not as far-reaching and tend to be more focused, involving only a single, or just a few, engineering issues. Since this course is to be offered frequently, perhaps every semester, many different appropriate design problems must be created to provide new experiences for successive classes of students. This is hard.

However, there are many simple design tasks that do not involve a particular engineering field. For example, "Design a bathtub," or "Layout a kitchen." Yes, there are components of these tasks that could be classified in one or more engineering disciplines, but no one discipline is an obvious focus for the design, and no specialized engineering knowledge is required to complete the task. These are true design experiences, but no one category of engineering student has any particular advantage. This is the type of design project that will be assigned in the course Engineering Professionalism.

Another attribute of the design side of this course is the fun that students should have. Students must enjoy this course. Otherwise, it will be viewed as a necessary obstacle to an engineering degree at UMD. The design experience in this class should inspire students to apply the engineering skills developed in their particular program, without requiring any specific knowledge from any particular discipline within engineering. The design projects must intrigue students without becoming chores to complete. They must be fun!

As instructor for this class, I am looking forward to incorporating some of my own interests in the design aspect of the course. Two design problems that I expect to assign are "Produce a model train track layout given space and resource constraints," and "Choreograph a square dance routine given a description of available calls and timing constraints." Neither of these tasks is obviously Electrical and Computer, Chemical, Industrial, or Mechanical, but both tasks require engineering skills to complete.

Many different "model train layout" projects can be defined. My initial plan is to restrict students to just straight track (any length), a specific curve radius and arc length, and crossings, and require students to design a layout with maximum continuous track length in a space of a given size. Depending upon the curve radius specified and the size of the layout, the problem can be trivial (i.e. there's room for just a circle of track and that's all) or extremely daunting (i.e. 9-inch radius curves on a 4-by-8-foot piece of plywood). I will pick some intermediate design setting.

Square dancing is really based on mathematical set operations. Manipulating the eight dancers in a square through the various calls in square dancing is just like manipulating the six sides of a Rubik's cube. It is a mathematical problem right down the ally of an engineering mind, but one that does not favor students in any particular engineering discipline. I will define for students a collection of square dance calls with their starting and ending positions and the number of beats of music required for each, and ask students to choreograph a dance that takes dancers through a number of formations and returns them to their original positions after a given number of beats of music. All engineering students will be intrigued by these design tasks.

Summary

The new Engineering Professionalism course in the College of Science and Engineering at UMD has been created to address accreditation suggestions made by recent ABET visitors during a scheduled review of our engineering programs. The course is a design course, and will include multidisciplinary design experiences for students in all engineering programs at UMD. The course will also provide a setting in lecture format for describing to students the "soft" engineering topics identified as the "Professional Component" of engineering by ABET, including engineering ethics, engineering economics, and other similar topics. Through a series of lectures and lab assignments, this course will specifically address the "Professional Component" ABET topics and provide multidisciplinary design experiences that students will enjoy.

References

1. Seebauer, E. G., and R. L. Barry, *Fundamentals of Ethics for Scientists and Engineers*, Oxford University Press, 2001.

2. Fleddermann, C. B., *Engineering Ethics*, Prentice Hall, 1999.

3. King, J., *Exploring Engineering*, Second Edition, Prentice Hall, 2002.

Biography

CHRISTOPHER R. CARROLL
Christopher R. Carroll earned his academic degrees from Georgia Tech and from Caltech. He is Director of Undergraduate Engineering in the College of Science and Engineering at the University of Minnesota Duluth and serves in the department of Electrical and Computer Engineering. His interests include special-purpose digital systems, VLSI, and microprocessor applications, especially in educational environments.