

They Will Build Our Dreams: capstone design in E&CE at Rutgers

Christopher Rose
Chair, Capstone Design Committee

ABSTRACT

In a state of intellectual bliss that probably dates back to the dawn of the university system, undergraduates don't know what they don't know, are unconstrained by "wisdom," and are consequently bold and fearless. Thus, the Rutgers E&CE Capstone Design program, initially an ABET-inspired requirement, has grown into one of the most vibrant and exciting programs we offer. This success prompted a reassessment of Capstone Design's role in our department. It seems likely that Capstone Design will form the basis of a broad curriculum reform geared toward getting our students to think big early, acquire necessary skills along the way to build their dreams. Our goal as a department is to provide dream-building infrastructure. If the past is any indication, our students will regularly generate news and business-worthy projects and be able to tell the world what they did, how they did it and most importantly, *why it matters*.

1 Introduction

The Rutgers E&CE capstone design program was initially formed response to an ABET evaluation. Overall the E&CE capstone design program has been extremely successful, judging not only by student and faculty enthusiasm but also by the creative projects pursued and the high quality of many capstone design presentations and reports which are often conference-quality efforts. Particularly satisfying has been the teamwork necessary for capstone design which has encouraged collaboration not only among students, but even between groups of students working on different projects. Furthermore, the types of projects undertaken cannot help but display undergraduate exuberance and creativity, and are thus generally of much wider interest (and might also be of greater societal importance) than typical academic research projects.

In short, we found that E&CE capstone design seems to bring out the best in our undergraduates, and perhaps in our faculty as well. Thus, as our program matured, it seemed reasonable not only to reflect upon its success, but also upon how it could become a springboard toward greater international prestige for our engineering students who will ultimately build society's dreams.

In what follows we discuss our past experiences and then define what emerged from faculty discussions of capstone design *desiderata* in E&CE at Rutgers. We then outline and discuss the revisions which form the basis of our new capstone adventure – beginning this Fall term of 2011.

2 What is a good capstone design experience?

Most faculty designed their capstone offerings to encourage open-ended problems defined and solved primarily by the students in what might be called “blue sky” capstone experiences. In contrast, some faculty designed their courses more rigidly and offered essentially the same design problem from year to year, changing context and/or design parameters in what might be called “cookie cutter” capstone experiences. (Note that the terms “blue sky” and “cookie cutter” are equally laudatory or derisive, depending upon one's perspective!)

To begin our deliberations, we formed a committee (for which almost half our faculty volunteered) and took a poll about what constituted good capstone design experiences. The (purposely independently solicited) responses were remarkably similar:

Ethos

- “Real world” (multiple possible solution) problems
- Creative exploration – *“gee whiz” factor important*
- Hands on experience with some degree of autonomy
- Teamwork – *2+ students per team*
- Learning to learn – *critical thinking and knowledge acquisition*

Structural

- Careful faculty supervision
 - project proposal
 - problem solving
 - ethical issues
 - equipment selection and purchase
- Working Prototypes
- Conference-Quality (aspiration)
 - Formal Oral presentation
 - Formal Written Report
- Peer assessment
- Internal awards and external publicity
- Faculty workload

3 Where We Were

A key issue for our capstone program was sustainability (faculty workload). Rutgers E&CE is a relatively small department (< 30 regular faculty) with a moderately large undergraduate body (120 students per graduating class and rising). Our capstone design program was arranged to have a fall term component of capstone-targeted coursework, taught similarly to a “normal” course, and a corresponding more loosely organized spring term course where designs would be discussed, pursued and built under faculty supervision. These offerings were tightly tracked in that spring term courses had a (usually single) fall term pre-requisite.

The range of pursuits under the E&CE banner is broad. We therefore had 12 separate spring term capstone design courses in our curriculum and a corresponding number of fall term pre-requisites. Almost needless to say, this drove us all a bit batty come faculty workload scheduling time.

Laboratory space was also a problem. Most capstone designs that appeal to undergraduates involve physical construction. Usually the instructor who provided a laboratory and equipment purchased and maintained through a variety of means. Professors of typical spring term capstone courses expended on the order of \$1500 per term for equipment and supplies, although this figure had been as high as \$3000 and as low as \$0 for more theoretical pursuits. In short, the laboratory experience was completely controlled by the instructor with little or no direct departmental involvement. There was no official “Capstone Laboratory” where students could congregate and collaborate.

4 Where We Wanted To Go

Without exception among our committee members, a blue sky approach to capstone design was preferred since it fosters independence, self-motivation, rational team-building and greater creativity – and often produces that delicious “gee whiz” factor associated with the best projects. However, the practicalities of the Rutgers undergraduate environment led to discussions about the unevenness of the capstone experience and what, if anything, should be done to make it more uniform. Some students may not be capable of self-motivated high level efforts without excessive supervision. In 2009/2010, 90 students undertook blue sky projects while 22 undertook cookie cutter projects.

The idea of an honors capstone track was raised – with honors students being offered the blue sky option and weaker students being steered toward cookie cutter options. However, reports from capstone instructors suggested that GPA was not necessarily an accurate measure of blue sky capstone performance, especially at such an early stage of technical development.

The rigid prerequisite structure of fall/spring capstone pairs was also problematic. Design projects can certainly be contrived to fit within a specific subdiscipline, and students who are topically at sea can benefit from such rigid guidance. But in general, the more interesting projects often spanned multiple areas. Furthermore, no engineer learns everything they need in school. Rather, *good engineers learn how to learn*. Therefore, it seemed reasonable for capstone students to assemble their pre-capstone coursework however they like and then choose a project that interests them not by area but by topic. Such students would augment their knowledge on-the-fly as do all practicing engineers.

Finally, we felt that many of the projects completed by students might be of general interest beyond the confines of the Rutgers, in many cases patentable and perhaps even of national interest. Such quality reflects wonderfully on our students and it seemed a pity not to explicitly use project presentations (in addition to external publicization) as a recruitment vehicle for our students seeking employment.

5 Where We Are Going

We have almost completely done away with formal pre-requisites for spring term capstone project courses. Instead, students will choose a variety of regular electives in the fall term to help them acquire key skills for successful capstone project completion. The hope is that students, rather than being identically prepared, will collectively have a much broader range of expertise to apply to projects with consequently broader scope and higher impact. To this end we have consolidated our 14 spring term capstone courses into 5 general area courses for greater flexibility in student project selection. This reorganization also represents a dramatic reduction in the faculty workload footprint associated with our capstone design program.

To help enable our students build their dreams, we are developing a capstone “skunkworks” laboratory – where students can not only build out their projects, but also have the sorts of informal collaborative discussions that lead to those precious eureka moments. Also, to help fuel technical fire in the belly, lectures and resources associated with entrepreneurship are also planned on an *ad hoc* basis for the coming fall term. The idea is to make our students

understand that their ideas and projects, though certainly required for graduation, have a much wider audience than their peers and professors. Knowing their projects could form the basis for the next Intel or Google drives home in a way like no other that what they have chosen to learn is *important*, not only to themselves but to society.

In the past, our faculty has felt that good projects did not get their proper due in the asynchronous rush of term-end activity. We have therefore established common preliminary due dates for project mid-course correction report/presentation and final project report/presentation. Earlier due dates will enable appropriate evaluation and publicization of especially good projects.

Evaluation and publicization will take a number of forms. Certainly one or two department-wide awards will be given for the best projects. As previous projects have often been newsworthy, we will more vigorously advertise our students' best work. But perhaps most important for graduating students, two other vehicles for project publicization/socialization are planned. Potential employers will be apprised of proposed capstone projects (and could be allowed to share their own project ideas) and then invited to capstone poster sessions and talks. Sessions will also be held for entrepreneurs and angel investors. We suspect that this latter set of presentations will powerfully motivate our students by explicitly preparing them for a world where, increasingly, job security means running one's own business. Both venues, employment and entrepreneurial, will showcase the tremendous talents of our Rutgers E&CE undergraduates to an outside audience. Thus, we fully expect to have wonderful things to report for the Fall 2012 issue of ECEDHA Newsletter.