

UNIVERSITY of DELAWARE

“All the Elements in Place” for a Program

The following review of recent developments at Delaware raises a number of issues faced by other campuses having to do with *sustainability* and *growth* of courses about engineering for non engineers. How to maintain a course, for example, that is the product of a single faculty member’s passion and willingness to work overtime to design and teach - after the special circumstances of his or her availability comes to an end? How to populate a course that should attract students from a wide range of other programs and program majors when, because it is cross disciplinary, is hard to get students or faculty advisers across fields to recommend? How to encourage new offerings and avoid redundancy or turf battles at the same time? And, not least, how to cover (fund) the special needs of the course or courses after the initial launch?

Among the remarkable new offerings that have been advanced at Delaware in which Engineering faculty have taken the lead, are two parallel courses in Sustainable Energy Technology, one entirely original offering called Nanotech In the News, an Honors program course, Engineering in the Modern World, and a set of courses on Computer Ethics, so far limited to engineering students but a variation of which might well attract students in other fields. Looming in the foreground, is the possibility of opening Delaware’s recently revised one-semester Introduction to Engineering course to any freshman (engineer or non engineer). This course focuses on the “grand challenges of engineering” or more colloquially, How Engineers Solve Major Societal Problems of the day.

The question for the current engineering dean, and for faculty in engineering who want to teach engineering subject matter to non-engineers at Delaware, is *how to capitalize on the creative work already underway*.

The first example is in Sustainable Energy Technology, of which there are two variations, one housed in Engineering, the other in Physics, but both taught by faculty members who have at least one portion of their home in Engineering.

I Sustainable Energy Technology

When Michael Chajes returned to the faculty from his position as Dean of Engineering at the University of Delaware (2007-2011) he used the space/time in his schedule, in collaboration with adjunct professor Roland Heck, to design and a year later co-teach a course in Sustainable Energy Technology meant specifically for non engineers (CIEG 167/ENEP 167).

As Dean of Engineering, Chajes had originally brought Heck to Delaware as an adjunct professor to teach an honors colloquium for freshmen called “Engineering and the Modern World.” (see below). Roland Heck, a retired chemical engineer from Exxon Mobil and a preceptor in Princeton’s CEE 102, was well qualified and interested in co-teaching CIEG 167. With some guest speakers, the course was successfully launched in the spring of 2013, but has not been taught since due to the lack of availability of Professors Chajes and Heck.

As described by Chajes,

The course covered the major sources of energy that fuel our society and how engineers develop sustainable energy solutions. The basic scientific principles behind each energy source were presented, and the environmental and economic impact of various energy solutions were discussed.

By setting a pre-requisite of *only* high school algebra, the instructors intended to and did attract non-STEM, non-engineering majors. The list of topics included every used energy source from coal to the renewables and featured political topics such as Government Subsidies and Their Role in New Energy Technologies, Home Energy Audit, Global Impacts of Climate Change, and “novel ideas.” All were meant to stimulate and challenge a general liberal arts audience, but with specific assignments, through which students learned how to set up and solve problems related to energy technology.

Chajes and Heck selected a 2006 textbook *Energy and the Environment* by Ristinen and Kraushaar, to use as a base with additional materials supplied by Heck from his past experiences.

Since the course had no formal requirements, the students who enrolled brought very different backgrounds and levels of understanding. Some of them found what engineers would consider simple mathematics intimidating. Nonetheless, Chajes insists that they, the non engineers, brought a perspective to the issues “beyond engineering,” such as: Whether a new technology would be politically viable? How does the influence of Big Oil make itself felt? Students also were asked to make presentations, each on some new energy technology. Local experts were invited in to speak. And the class incorporated an “In-the-News” segment each day.

Student assessment included several quizzes, a midterm and a final exam. Students also participated in debates, had to choose a project with associated presentation and write a term paper. They were assessed as well on class participation. End-of-course evaluations revealed that the students were very satisfied with the course and learned a great deal. They especially enjoyed the engineering perspective. From the two faculty members' perspective, the course went well. Goals for the next time the course is taught would be to increase the level of sophistication of class discussion as well as finding ways to have the non engineering students become more comfortable with engineering calculations. The instructors' biggest surprise was students' level of interest, even passion, for learning about *new* energy technologies.

At the same time this course was being developed and taught, a engineering colleague with a joint appointment in Physics, Ismat Shah, was offering two other related courses:

PHYS 143 010 Energy Technology and Society

Basic principles of physics are applied to discuss forms of energy (mechanical, thermal, chemical, electrical and nuclear), and how energy is derived from sources such as coal, petroleum, solar, nuclear fission and fusion. Environmental consequences of energy use are treated. Prerequisite: College Algebra

And, as part of Delaware's Freshman Year Experience, another course;

ENEP117 010 D Science, Society and Energy

Basic science and societal issues related to energy production process and effects of their uses. Topics include ethics of energy production and uses, scientific principles that govern production and use of energy, environmental issues related to the use of energy, e.g., global warming, acid rain.

Future Prospects for Courses in Energy and Sustainability at Delaware

In the case of CIEG 167, the proximate reason the course was not taught the second year was that the instructor (Chajes) went on sabbatical and his associate (Heck) had to take leave for medical reasons. *No one was available to fill the breach.* And, when Chajes returned from sabbatical, there was a pressing project awaiting him: a redesign of the freshman engineering course (see infra) to work on. In addition, Chajes was asked to take over a key class (CIEG 402) within the college that is a requirement for the Civil and Environmental Engineering department's *own* sustainability minor program. This sustainability class (CIEG 402) could not, and would

not, replace CIEG 167. To be in the sustainability minor, students need not be engineers, but few non engineers get into the course because of limited class size combined with high demand within the department (department students are given preference in enrollment over non engineers).

Due to his two new obligations, Chajes has not been able to offer CIEG 167 again.

In the case of Ismat Shah, the reasons for not developing a wider-ranging energy and sustainability *program* have to do with his multiple commitments to innovation. He collaborates with a faculty member in philosophy to co-teach a course on “Ethics and Science” and is currently running a “Science Cafe” which sponsors talks on science topics that attract the larger campus community. Twenty years ago, he introduced a study abroad course for engineering undergraduates, a five-week experience in Turkey, Germany, France, Spain or Greece. If Shah were willing to change the format of his course on energy to accommodate twice or three times the enrollment, it could meet a campus need. But he prefers the smaller class size.

The questions this instance raises are central to any expansion of engineering subject matter to non engineers: how to *expand* popular courses *about engineering* without changing their nature (small size, discussion-oriented); and how, once they are on the books, to make them harder to cancel.

Factors Limiting Enrollment

The reason for the double designation, CIEG 167 and ENEP 167, is that the first and only time it was taught, Chajes’ course was targeted to students in energy and environmental policy (ENEP), a department that was in the College of Engineering at the time, but is no longer in the college. Even with this designation, recruitment was somewhat haphazard. Across campus, one member of the Environmental Science department broadly advertised the course to their majors, and several took the course. Nor was there any indication that the course would eventually have formal recognition. It was too new, and time was too short. Ismat Shah would like the course or something like it offered as part of the Freshman Year Experience at Delaware, as an alternative (or supplement) to the kinds of topics routinely considered relevant to students having suddenly to cope with being on their own.

III Targeting Honors Students: ARSC 390 Engineering in the Modern World

On the other hand, Roland Heck's freshman honors colloquium "Engineering in the Modern World: From the Steamboat to the Internet and Beyond" had no such "target." The course, though new to the Honors program in 2010 when it was taught for the first time, was meant to attract Honors freshmen, just arriving at Delaware, and was taught annually from 2010-2015 until Heck stopped teaching due to health reasons.

As is quite common at other large state universities, Delaware's honors program offers *writing intensive* colloquium courses on many different subjects. Honors freshmen are required to take one such colloquium in either their first or second semester. Even though they are required to enroll in an introductory composition class in their other semester, the subject matter colloquium is expected to be writing intensive. No course having to do with technology and its impact, had been offered by the Honors program before Roland Heck arrived at Delaware. Heck was well qualified to teach the course and eager to do so. After retiring from Exxon Mobil (and having a Ph.D in chemical engineering from the University of Delaware), he had been an associate dean at Princeton and an occasional preceptor in the Princeton course initiated (and made famous) by David Billington (see Princeton's case in this collection). Then Dean of Engineering, Chajes realized that that the impact of technology on American history would be most suitable for the Honors program and agreed to pay Heck's salary out of the College of Engineering's (his own) budget. The course would be open to engineering and non-engineering honors students alike.

Interestingly, engineering had never contributed an instructor to teach an honors colloquium before in part because of the requirement that the colloquia be writing intensive and "non-technical." And indeed Heck was not allowed to give his students any quizzes or direct-answer exams. On the other hand, there was interest on the part of Delaware freshmen. Heck had no trouble filling his course at the requisite 23 students/year for six years running once it was on the books. While the Honors program is currently under an overall review, Chajes believes that Engineering could and should contribute a number of good topics in addition to the history of technology in America. From Chajes' short list to name a few: innovations in health care technologies, sustainability, renewable energy technologies, cyber security.

IV Computer Ethics

The department of Computer Science in Engineering at the University of Delaware requires a Computer Ethics Course for all majors, which because of the size of the College's enrollments is taught in all semesters, with rotating faculty, treating fairly standard topics. One route to expansion of the audience would be to reach out to computer science majors elsewhere in the university; another, to an even wider liberal arts audience. Chris Rasmussen, as a regular faculty member in the Department of Computer Science in Engineering like his fellow faculty, is regularly assigned to teach Computer Ethics and has done so twice in the past five years. He considers the course very much worth expanding to a larger set of undergraduates at Delaware.

Every one of us is faced with using modern technology every day. Our cell phone, our computer, our car, the internet... It is important that we educate students to understand the basics about how this technology works. Furthermore, as citizens, we are asked to deal with complex issues, such as cyber security. To be able to understand and vote on such issues requires a basic understanding of the underlying technical concepts. Having college students exposed to these concepts will make them much better prepared to evaluate and provide input on these very important issues.

Moreover, Rasmussen believes that there is a way of presenting the material taught in Engineering to reach non-engineering students at their level of technical competence. To be sure, he admits, non engineers will be learning about computing for the first time. He compares teaching a computer ethics course to non-majors, to that of a professor of English designing a course in science fiction for engineers. (The reason for the reference: an English professor called a meeting of science and engineering faculty at Delaware recently to get help on just such a challenge.)

Among the topics Rasmussen thinks would interest and attract liberal arts majors are "The legal rights of Robots" for which he would begin with the fundamentals of ethical theory to teach students not what to think but how to argue methodically and rigorously. Other issues have to do with knotty questions of ownership: In how many configurations does ownership of software exist? And what are the options? Paying for software or licensing it for free? Music streaming, starting with Napster and its impact on the music industry.

He believes that because there is a natural audience in Arts and Sciences, among students going on to careers in the law and business, economic policy, and journalism.

V MSEG/EGGG 288 Nanotech in the News

From the Department of Materials Science and Engineering comes another prospective General Education course, which the initiator Materials Scientist, Josh Zide feels very passionately about. From his proposal:

Nanotech in the News will provide non-majors with some exposure to nanotechnology and engineering as it impacts daily life. Based on current topics, we will discuss the underlying science in an approachable manner and consider the relevant societal, economic, and ethical issues. Students will leave with a greater understanding of the emerging technologies that shape our society.

Zide's rationale for the course is that, non-STEM students' credit requirements in science and mathematics provide little or no exposure to technology and engineering. This results in their being less well educated overall. But beyond that, and relevant to Zide's course being selected for this case analysis, is that, in addition to broadening students' knowledge base, Zide wants to increase their ability to critique misleading news clips about the "dangers" of nanotech materials,

To a significant fraction of the public, nanotechnology represents a menace to be controlled. [As a case in point] fear of the unknown led the city of Berkeley to regulate – and nearly ban – nanotechnology in late 2006.

A public that does not understand science can represent a significant threat to future scientific progress.

Zide's intention in launching Nanotech in the News in spring 2016 is nothing short of creating a "constituency for science." As a means to that end, the format of the course will pull readings directly from the pages of the daily newspaper to ferret out the science (or the putative science) behind them. Students will be instructed on making the science approachable, and evaluating claims, with assignments to write about science. In addition, Zide expressly intends the course to broaden the impact of his department and that of the College of Engineering more generally on the undergraduate population at Delaware.

VI Revising EGGG101 Introduction to Engineering

At Delaware, incoming freshmen engineering students have the option of selecting an engineering department to major in from day one, or they can enroll as “engineering undeclared.” Roughly 85% select a major from day one with the remaining 15% remaining undeclared. The engineering curriculum is designed to incorporate a common first semester, after which all of the students, including the undeclared students, select a major. The common first semester includes the students’ first course in Engineering (EGGG 101). This one-semester course is designed to provide an overview of common engineering principles, concepts and skills, as well as general university first-year-experience objectives. The revised course, taught for the first time in the fall of 2015, is organized around the NAE’s Grand Challenges, as well as the 4-stage design process of problem definition, concept generation and selection, prototype construction, and validation. Even with two large sections of 300 to 350 students, class time utilizes state of the art interactive learning strategies.

In the newly designed EGGG 101 class, all freshmen are doing the same assignments and at a significantly greater level of engagement than is usually the case in large Intro courses: a) responding to daily clicker questions based on the previous lecture; b) assigned activities done in teams of 4 people, having to work together during the semester on three projects; and not graded by their performance on exams. The planners, Michael Chajes, Lori Pollock, Jenni Buckley, and Jeannie Stephens believe that opening the class in the future to non-engineering majors would allow the course to incorporate “broader aspects of the design process, including economics and the social impacts of technology.” Also, they argue that the four-phase design methodology is a good background for problem solving in other fields.

Delaware’s Dean of Engineering, Babatunde Ogunnaike, believes that there are many opportunities for the College of Engineering to educate Delaware’s non engineers. He is excited about what has already been developed, and hopes to find ways to provide stability to the already developed courses, as well as expand the number of options for non engineers through classes like EGGG 101. He sees a great benefit to society of having more non engineers become comfortable with today’s complex technological problems.