Coming down the pipe: Engineering Students for the 21st Century

One of the critical challenges for the United States is creating enough engineers to support our economy, infrastructure, and national defense; all of which rely heavily on technology. Unfortunately, the long term outlook for meeting this challenge is dismal. While it is impossible to give a balanced view of the interdependent societal, economic, and cultural factors involved in training future engineers in two pages, I would like to give a snapshot of some alarming statistics.

- The number of students obtaining a B.S.E.E. degree dropped 40% from 1987 to 1998. While the total *number* of graduates has increased slightly since 1998, the *fraction* of engineering degrees granted compared to other degrees fell 12% from 1998 to 2001.
- About half of the students who start off in engineering will graduate with an engineering degree. If you are female or a minority the odds you will complete your engineering degree falls to one in three.
- Only 13% of engineering students are women, and less than 16% are Black, Hispanic, or Native American. OSU's program is much less diverse.
- Nationally, 56% of all graduate engineering degrees are to foreign citizens.
- One decade ago the smallest feature size China's integrated circuit industry could create was five times larger than their US competition (smaller feature sizes allow more powerful chips). Today the difference is less than 50%.
- 95% of today's engineering students cheat at some point in college, primarily to keep up with the pressure and workload. 67% will cheat more than once in a semester.
- Since 1982 the cost of a college degree has risen 220% more than inflation.

The government, National Academies, and some business leaders are acutely aware of this looming crisis in the United States' continual demand for a scientific workforce. Several national-level panels have been formed to give advice on this need, but it is still an open question about how universities can accomplish reform that it is cost effective and sustainable.

For several years a core of dedicated faculty in ECEN have been quietly and systematically looking at the causes of these problems and examining possible solutions. This work paid off this year when ECEN won a prestigious and competitive National Science Foundation award to redefine the process by which students become engineers. This one million dollar grant, *Engineering Students for the 21st Century* (*ES21C*), will enable ECEN to begin the slow process of redefining how we prepare tomorrow's engineers.

Currently, our program—as are most undergraduate programs—is built on the paradigm that covering a specific set of concepts will prepare students for a career in engineering. The assumption inherent in this paradigm is that specialized information can *only* be found and learned at universities. Today, with the rise of the Internet, the validity of this underlying hypothesis is questionable. As pointed out in several years ago in the journal Science, "*Today's production and distribution of information are undermining the university structure, making it ready to collapse in slow motion once alternatives to its function become possible*". Our program, at its core, offers information that can now be found elsewhere. For example, all of MIT's course materials are available on-line at no charge.

OSU is not tackling these issues alone. The pressing questions that *all* universities are struggling with are: what should replace production and distribution of information, and what is an

engineering degree if it isn't mastery of some set of knowledge? OSU's new administration has chosen to follow most other universities by: 1) building research infrastructure to produce more information (and the potentially lucrative intellectual property it creates), 2) embracing technology to help distribute information more efficiently, and 3) continually updating the curriculum to keep up with the exponential growth of information produced by universities. Whether this model is sustainable is questionable since it creates built-in positive feedback that demands ever-increasing investment.

Engineering Students for the 21st Century addresses some of the difficulties inherent to the third point, updating the curriculum. Curriculum updates are typically attempted through removing "legacy material"; knowledge that is no longer useful or current. ECEN's attempts to update the program this way have generally flopped. We have learned from bitter experience that removing legacy material is nearly impossible since there is no universally accepted way to identify what constitutes legacy material. What knowledge is useful depends entirely on the *context* in which it used rather than any *intrinsic merit* of the material itself. Since over 40% of newly minted BSEE's take a job outside electrical engineering, and only 50% work in an area closely related to what they studied, it is impossible to foresee what students need to know.

If removing legacy material will not help up teach future engineers, what can ECEN do? The key thesis of *ES21C* is that all knowledge must be learned in context. Without practicing being an engineer, it is difficult to train a student to become engineers. *Engineering Students for the 21st Century*, changes our degree program from the old, knowledge-based paradigm (acquiring a set of concepts) to one that is development-based (emphasizing students' development). Students at all levels will be taught how engineers tackle design problems, how to monitor their own development, and how to find, evaluate, and communicate information. This approach redefines the role of both faculty and the university, and represents a fundamental shift in the focus of an engineering degree. During the next three years ten courses will be tagged as development courses and focus more on teaching students *how* to solve engineering problems than any specific set of concepts. If you are interested in the specifics of how Engineering Students for the 21st Century will redefine an engineering degree, keep an eye on our web site and future newsletters.

Will we succeed? Probably not. Machiavelli once commented that changing institutions is the hardest thing a man can attempt because everyone knows exactly what they have to lose while no-one can judge accurately what they have to gain. Two decades of investment in engineering education has yielded little change, and OSU is both conservative and tradition-bound. Help from our alumni is needed to support change as well as to forge long-term partnerships with industry that will support the facilities and equipment needed by our students. Ultimately, the question 'will we succeed?' is not important; the attempt must be made since the problems that loom in our country's future are too great not to try. As Tennyson said in the closing of *Ulysses*:

It may be that gulfs will wash us down…[but]
Tho' much is taken, much abides; and tho'
We are not now that strength which in old day
Moved earth and heaven; that which we are, we are:
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield.