Re-Engineering Engineering Education

• Broad view of what we should look and work toward for the Engineering Education of the future.

• Looking beyond the details such as freshman/sophomore experience or the upper division specific disciplinary experience.

• Looking holistically at the education of the students of the University and the role of a College of Engineering.

• Issues pertain to undergraduate and graduate education

• Excerpts and thoughts from 3 different venues:
  • COE Blueprint Committee
  • Additional points from NAE Presentation
  • Chronicle of Higher Education article
(Synopsis from the COE Curriculum Blueprint Committee)

Broad Conceptual Issues

- Greater program flexibility, adaptability, and student choices.
- Less time in classroom. – Educate vs. Train
- Diverse backgrounds of incoming students.
- Broad array of careers for engineering graduates.
- Changing expectations for the practice of engineering.
- Engineering practice is increasingly done at a systems level.
- Lattice of multiple educational paths to be available to the students.
Engineering the Educational Enterprise for the Future
• Inquiry-based (open ended) education.  
  *(A liberal arts approach to engineering education)*

• Define the educational intellectual core (foundation) and build programs that integrate around that core. However, core is not absolute and will change with time.

• Modularize curricular content to enable flexibility of both student paths and educational programs.

• Use the vast array of information technology and tools available.

• Students should learn how to learn  
  *(i.e. intellectual investigation – research and seek out solutions)*

• Links with other segments of the University for new educational opportunities.

• Recognize the curriculum as the educational enabler but not the totality of the educational experience.
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• Focus more on non-traditional disciplines and subject matter.

• Consider a thematic concept for design and include multiple disciplines (engineering and non-engineering).

• Make Co-op an integral part of the intellectual framework of a Drexel engineering education.

• More faculty-student interaction and a sense of community building.
“Technology Hits a Midlife Bump”  
(from the NY Times 9/4/03)

“The industry, according to Irving Wladawsky-Berger, a strategy executive at I.B.M., has entered "the post-technology era." It is not that technology itself no longer matters, he explained. Instead, he said, the steady advances in chips, disk storage and software mean that the focus is no longer on the technology itself - with its arcane language of processing speeds and gigabytes - but on what people and companies can do with it.”

While the point refers to one industry sector, it is more broadly applicable to the evolving engineering workplace

What are the implications for us?

• Educate for different sets of career paths.
More global and cross-institutional educational linkages.
Greater flexibility and more intellectually broadening programs.
Students working with facilities with teams of colleagues across many geographic boundaries.
Much of the changes in educational delivery will be technology enabled.
Remotely controlled experiment, operation or product development with visual, touch, force, and maybe even olfactory sensory feedback.
Web based information in digital library environment.
A student working with computer based educational modules developing solutions, through sophisticated artificial intelligence interaction, to an open ended engineering problem.
  As he/she works through several scenarios the names of important historical figures, places or events associated with the concepts, theories, and applications appear as sidebars.
  The student can digress and learn about those individuals, places and socio-economic issues of the periods.
• provide the opportunity and encouragement for students to pursue other intellectually broadening combinations with such areas as business, economics, marketing, entrepreneurship, education, and psychology and other social

• Technology will continue to be the driver of the nation’s economic engine. This will create increasing need for those in the non-technical disciplines to gain a knowledge base in technology concepts appropriate to their disciplinary level.

• This will create a relatively new role and opportunity for the College of Engineering.

• It will require the College of Engineering and its faculty to function in different educational settings.

• The student audience will be very different in preparation and expectation. The ratio of learning outcomes to time on subject will be expected to be great.

• Will offer an unparalleled opportunity for the College of Engineering to cement linkages with other segments of the University and come closer to the centerpiece of the University
BUT

• Are we looking broadly enough and without blinders?

• Are we still thinking of just engineering?

• Are we thinking of engineering as a distinct, clearly defined discipline, into which we fit an educational program that produces what engineers think is needed?

• What if we look at how others may, perhaps see it and what the future may hold?
Education for the Profession Formerly Known as Engineering
By ROSALIND WILLIAMS, Director of the MIT program in science, technology, and society

Excerpts from an article in the Chronicle of Higher Education 1-24-03 which in turn was adapted from “Retooling: A Historian Confronts Technological Change” (MIT Press, 2002).

- Engineering is undergoing an identity crisis. The mission of engineering changes when its dominant problems no longer involve the conquest of nature but the creation and management of a self-made habitat.

- One side of engineering diffuses into the microscopic world of biology, another into the ethereal realm of cyberspace.

- An equally strong ... trend in engineering is to move engineering education, and to some extent engineering research, ... toward the realities of industrial practice.
Practice defined

... how things are designed, how they are manufactured, how organizations work, how innovation is brought to market -- all of which are often lumped together under the label "practice."

There are two major ways that engineers define getting back to practice.
• One group of engineers looks to a renewed emphasis on design;
  • Often identified with entrepreneurs.
  • Many design advocates, whatever their age, have a sort of Young Turk quality.
  • They challenge what they see as the engineering-science establishment, asserting that they do real engineering by designing and building useful things that actually work.

• The other group advocates a new emphasis on large technological systems.
  • Advocates identify with managers.
  • Tend to be experienced individuals accustomed to working outside their departments or even outside their school.
• Both the design movement and the systems engineering movement seek to reclaim a distinctive identity for engineering: to proclaim that here is something engineers do that scientists and businessmen do not do.

• In the end, however, the reclamation efforts only underscore engineering's loss of identity.

• In both design and systems work, many people other than engineers are in on the act. In design today, engineering, programming, science, language, and art converge.

• In dealing with technological systems, it is even more obvious that engineers have to collaborate with political scientists, economists, lawyers, and managers, just for starters.

• In fact, the constant dilemma for engineers at MIT and other universities is whether to hire these collaborators as faculty members or to try to get other departments and schools to hire them.
• The good news is that engineering education is becoming more and more socialized.

• The bad news is that this is happening almost entirely under the aegis of business.

• Students are looking for an education that is socially aware in a very pragmatic sense. They are increasingly aware that they need to know how society works, which is not necessarily the same thing as an education that highlights social responsibilities.

• As a result, engineering education today is, as we say in the humanities, contested terrain -- a site where different strategic goals collide. Most students want a socially aware (in the practical sense) and technically oriented education. Design advocates and systems advocates want to reorient engineering education away from engineering science, but no one wants to give up the strengths of an engineering-science education. Yet the boundaries between engineering and science keep getting fuzzier as the biological sciences challenge the whole idea of "fundamentals."
• What engineers are being asked to learn keeps expanding along with the scope and complexity of the hybrid world. Engineering has evolved into an open-ended Profession of Everything in a world where technology shades into science, art, and management, with no strong institutions to define an overarching mission.

• All the forces that pull engineering in different directions -- toward science, toward the market, toward design, toward systems, toward socialization -- add logs to the curricular jam.

• Inevitably the profession formerly known as engineering will multiply into a much wider variety of grades, types, and levels because engagement with technology has far outgrown any one occupation. The future of engineering lies in accepting rather than resisting this multiplicity.

• In terms of education, that means that the trend toward cramming more and more into the engineering curriculum runs in exactly the wrong direction.
• Few students will want to commit themselves to an educational track that is nearly all-consuming.

• What we now call engineering education should be lowering the threshold for entry, mixing itself with the larger world rather than trying to keep expanding its own world. Students are trying to do this mixing on their own, but in too many cases they are trying to pour new educational wine into old institutional containers.

• The most obsolete institutional container is that of the "engineering school." Its raison d'être is to educate students for engineering, defined as a distinctive profession with its own well-defined identity.

• As this professional identity dissipates in a process of expansive disintegration, engineering schools will have to evolve or else find another mission.
• The segregation of engineering education served its purpose in the 19th century, allowing an alternative form of education to develop. Now this segregation defeats the purposes both of engineering education and of higher education, at once marginalizing engineering and depriving the rest of higher education of its benefits.

• The convergence of technological and liberal-arts education is a deep, long-term, and irreversible trend.

• Students need to be prepared for life in a world where technological, scientific, humanistic, and social issues are all mixed together. Such mixing will not take place if students have to decide from the outset that they are attending an "engineering school" as opposed to a "nonengineering school."
• No matter how excellent the engineering school, and no matter how racially and ethnically diverse, if it attracts mainly faculty members and students who gravitate toward the technical problem-solving approach, then those students have an education that does not prepare them well for life experience.

• Students need to be educated in an environment where they get used to justifying and explaining their approach to solving problems and also to dealing with people who have other ways of defining and solving problems.

• Only a hybrid educational environment will prepare engineering students for handling technoscientific life in a hybrid world.