Bachelor of Arts in Engineering - A Proposal for Curriculum Design

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> I think we have to de-emphasize narrow disciplinary approaches, particularly in our curricula and in the way we teach students to think. We need to pay more attention to the context in which engineering is practiced,... This sounds simple, but we're finding it, at least at my institution, very challenging. [1]

Objective:

To provoke discussion of, explore the realistic possibilities for, and engage in preliminary design of an MIT undergraduate program leading to a *bachelor of arts degree* in engineering on the part of faculty (and Deans) so inclined.

Motivation:

Engineering work is a challenging mix of the (engineering) sciences and the social. Engineering tasks are inherently multidisciplinary. Participants in a project - whether it be design, fault-finding, product or system development - have different competencies, responsibilities and interests and their proposals and analyses must be reconciled - better yet, brought into harmony - if a project is to proceed to successful completion.

"Dream Airplanes" by C.W. Miller, as shown in *Fundamentals of Aircraft Design*, by L.M. Nicolai

Some of the tasks in the mix require 'narrow disciplinary approaches'; the person responsible for design of the structure must know the fundamental concepts and principles of that domain and be up to date on methods for analysis and testing. So too for the electronics person, and the software designer - neither of whom may have 'had' a course in structures. Etc.
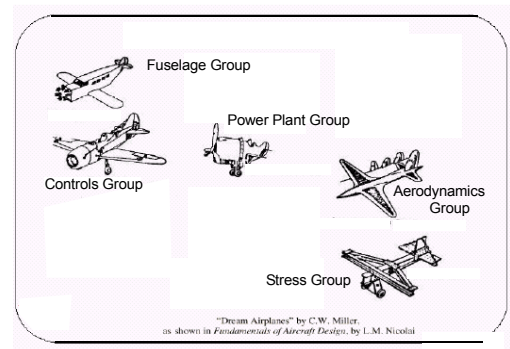
But narrow disciplinary approaches - what I call 'object-world' work[2] - while necessary, do not suffice. Participants' proposals conflict; they must be brought into harmony. And there is no over-arching, instrumental method for reconciling participants' well-thought-out claims. Negotiation is necessary. Engineering is a social process. Traditions - of the firm, of the nation - matter. Norms and beliefs - about what is a 'robust' design, about the capabilities of the user, of citizens - matter. Ethics matters. Culture matters; e.g., history, literature, philosophy, anthropology and sociology, as well as economics, political theory, and the arts. The 'context in which engineering is practiced' is value laden.

Our current undergraduate programs in engineering do very well at preparing students for object-world work. They miss the rest.

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1. *U.S. Engineering Education in Transition*. President Charles M. Vest's address to the annual meeting of the National Academy of Engineering, September 28, 1995. This address has been published in the Winter 1995 issue of the NAE journal The Bridge (Vol.25, No.4)
2. Bucciarelli, L.L., *Designing Engineers*, MIT Press, 1994.

Precedents

> The baccalaureate degree should be recognized as the "preengineering" degree or bachelor of arts
> in engineering degree, depending on the course content and reflecting the career aspirations of the
> student[3].

The National Academy of Engineers is not the first professional organization to propose a pre-engineering degree program. The itch to educate in a more liberal tradition, like they do in medicine and law, has provoked others (e.g., Wickenden, Eric Walker, Samuel Florman)[4] throughout the past century to essay on the same theme. But now we have it explicitly recommended by a prestigious engineering institution. However short on details, however ambiguous the recommendation in itself, the door is open to those who would invest time and energy in the design of a curriculum leading to a bachelor of arts in engineering.

In fact, there is one: In 2006, the Worcester Polytechnic Institute (WPI) established a four year bachelor of arts degree program in the "Liberal Arts and Engineering" (LA&E)[5].

> The LIBERAL ARTS AND ENGINEERING (LA&E) degree provides excellent preparation for
> students who want a broad background in engineering and other disciplines, as preparation for fur-
> ther studies in engineering or in other fields such as medicine, law, public policy, international
> studies, business, or wherever a solid technical background would give them a unique edge.

The four year program, is optional. It builds upon mostly existing courses at WPI. It is a patchwork curriculum. Requirements fall into 5 categories: - a "general education institutional requirement" (~ 30% of total program); "mathematics and sciences" (~20%); "engineering sciences cornerstone" (~20%); "liberal studies cornerstone" (20%); and, a "major qualifying project", that joins the engineering and liberal studies, (~10%). More than 50 courses, ranging over Art, Government, Psychology, History, Language, STS, Economics, Philosophy, etc. are available to meet the liberals studies requirement. While a student's choices must make coherent whole in the eyes of his or her faculty advisor, it is a patchwork curriculum. But the intent is right; an undergraduate degree program that serves students of varied and uncertain career interests, offering a preparation for life, life-long learning, and reaching beyond narrow disciplinary approaches.

Envisioning a Bachelor of Arts in Engineering at MIT

Here is a vision of what a bachelor of arts in engineering might look like, vague and lacking no doubt in attention to certain, perhaps many, practical (political) concerns, but laid out to provide a reference for those who might engage in this task, if funded. Consider it a strawman, a 'white sheet' conceptual design, meant to provoke.

The program would be housed in the School of Humanities, Arts and Social Sciences, administered by the Program in Science, Technology and Society. Program faculty - those responsible for setting requirements and responsible for teaching the core curriculum - would be drawn from all schools.

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3. The first recommendation put forward in: *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* (NAE, 2005)

4. Seely, B., *Patterns in the History of Engineering Education Reform: A Brief Essay,* Educating the Engineer of 2020: Adapting Engineering Education to the New Century (2005), Appendix A.

5. http://www.wpi.edu/Academics/Majors/LAE/bavsbs.html Other programs so inclined: Dartmouth's Thayer School of Engineering; University of Virginia's STS program.

Students would be admitted directly as freshmen into the program with calculus a prerequisite for admission. Enrollment would be limited to 60 students the first five years of the program's existence.

The core of the program would include a 'proseminar' each semester - a substantial course where teams of students would engage in a design project or other planning task that requires both 'narrow disciplinary approaches' and a sensitivity to, and ability to deal with, the ambiguities and uncertainties of context.

Students would be required to 'take' *a subset of courses in the engineering sciences* but these subjects would engage students in reflective, liberal study of what counts as engineering knowledge - its rhetoric, its historical development, its limitations, its power in application - as well as in the traditional activity of solving well posed, single answer, exemplary problems of the disciplines. The aim is to develop in the student the power of critical thinking, to break free of the dogmatic, authoritarian ambience of the traditional engineering classroom and open it up to allow historical and philosophical analysis and critique - the essence of a liberal education.

Students would be required to 'take' *a subset of humanities and social science courses* but these subjects would have at their core a concern for the ways in which science and technology have shaped cultures, infected the ways peoples see the world and interact with their neighbors (wherever, whomever, they may be), as well as improved our productivity, etc. School of Engineering faculty together with faculty of the School of Humanities, Arts and Social Sciences would collaborate in the planning of all required subjects.

Students would have one free elective each semester. The program's duration would be six semesters[6]. Interfacing with programs that lead to a master's degree in engineer would require significant attention and some change in current requirements for the masters. Graduates with the bachelor of arts in engineering would be free, indeed encouraged, to consider a variety of career options - management, law, medicine, education - not just engineering.

Relation to areas of interest and recommendations of the Educational Commons Subcommittee:

It is the responsibility of the faculty of the program to see to it that the spirit of the present (and proposed by the ECS) General Institute Requirements is met in the required subjects. The foundations of math and science, and the engineering sciences, would be essential foci of the core requirements; their historical development and philosophical standing a central concern. Design, design projects and activities, would figure in the teaching of the engineering sciences as well as in the proseminars. The entire program, not just the first year, would engage students in the exploration of 'questions and problems of perennial human concern'.

Budget:

The success of this curriculum design effort will require a certain level of faculty commitment by a certain critical number of faculty drawn from all schools. It will also require strong leadership, best provided by a dean, provost or someone with comparable 'authority'. Funding is of secondary importance.

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6.   To interface with programs in the EU laid out in line with the Bologna accords.