

Toward a Liberal Scientific and Technological Education

by

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I was profoundly disappointed by the Report of The Task Force on the Undergraduate Educational Commons. The task force must be congratulated for a well-written and carefully thought-out report, but it is disappointing nonetheless. The world looks to M.I.T. for leadership. But the report is incremental. It does not present a novel, powerful, and integrated approach to the educational commons. It is a lost opportunity to take a commanding position.

The problem with the report is that it persists in treating the GIRS as discrete classes. Instead, we should imagine the GIRS to be a list of Powerful Ideas that all students must come to grips with. Each GIR class should be seen as a slice through the list, touching some of those Ideas.

We all have views on what those Powerful Ideas are. We all ask, "How can we graduate someone who has not been exposed to ----?!" where this might be any of:

Univariate and Multivariate Calculus, Classical Mechanics, Chemistry, History of Science, Cell Biology, Technical Communication, Probabilistic Reasoning, Maxwell's Equations, Ethical Philosophy, Differential Equations, Linear Algebra, Computational Principles, Thermodynamics, Aesthetics, Quantum Mechanics, ...

But there are many more "essentials" than places in the curriculum for them. The current program is just one way to divide up that pie, where the ideas are in one-to-one correspondence with classes. We could encourage alternative ways to cover the GIRs, integrating the different ideas more completely. For example, consider the following hypothetical slice, covering some part of the first term curriculum:

36 Units, with some laboratory work

Coverage: Mechanics of Particles: Some 8.01

Univariate Differential Calculus: Some 18.01,
(also some 18.03, some 18.06)

Some History of Science

Some numerical computer programming

Computation of the orbits of Solar-System bodies given observations of their positions in the sky at given times. This project involves learning and using some linear algebra, elementary calculus and differential equations and the elementary mechanics of particles. There is historical context with technical and philosophical readings from Copernicus, Kepler, Galileo, Newton, Laplace and Gauss. The project involves development of experimental and observational technique, including the analysis of both systematic and random errors. A student completing this project will be able to find astronomical objects with a telescope, to make

measurements in appropriate coordinate systems, to estimate the measurement errors, to make the transformations of coordinates to other coordinate systems (with transformations of the error bars) and to understand enough of the physics to compute and improve a probable orbit, using the methods of Laplace and Gauss. Student understanding will be supported by formalization of the methods as computer programs. Students will write several papers, some discussing historical issues and other papers explaining their measurements, computations, and results. Grades will depend on the coherence of the writing as well as the understanding of the technical material.

There would be a variety of such cross-disciplinary classes, each organized around some deep theme, weaving material from the various current GIRs and requiring students to absorb the essential content. A GIR class could appear and disappear easily, whenever a few faculty members get together to make a new one or when the faculty members in charge get bored with it. We need to have only enough of these classes to cover all of the GIRs, and a requirement that every student take enough to meet the coverage requirement of the GIRs. A GIR oversight committee could readily ensure that proposed classes meet one or more GIR requirements.

You may think this is a wild and crazy idea, but it's not: Princeton is already building an interdisciplinary program. Botstein and Bialek have developed "An Integrated Approach to the Natural Sciences," combining topics from Physics, Chemistry, Mathematics, Computer Science, and Biology. See their Science paper at

www.princeton.edu/~wbialek/our_papers/bialek+botstein_04.pdf

Any argument that there are not enough faculty generalists to teach such integrated subjects is a slur on the M.I.T. faculty. And I believe this kind of plan would be no more expensive in faculty time than our current arrangement.

However, the structure of schools and departments is an impediment. Part of the funding of departments and schools is determined by the service subjects they teach, so departments are naturally loath to give up their GIR subjects. Furthermore, some departments believe that their faculty are the only ones competent to teach an elementary subject covering their area. This is a fundamental problem for the development of a coherent undergraduate curriculum that is widely based on cross-disciplinary subjects with flexible faculty involvement. It will take work from the top of the administration to fix this, but it is work that will have a big pay-off: to keep MIT at the forefront of technology education for the 21st century.