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MIT Faculty Newsletter

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this special edition is devoted to responses to the report of the Task Force on the Undergraduate Educational Commons. As a follow-up to this issue, the Faculty Newsletter Website (web.mit.edu/fnl) offers the ability to comment on individual articles online.

Overview of the Report of the Task Force on the Undergraduate Educational Commons

Charles Stewart III

THE TASK FORCE ON the Undergraduate Educational Commons was appointed by former president Charles M. Vest in the winter of 2003. It was composed of 26 faculty members and five undergraduates. The Task Force was charged with reviewing MIT's educational mission, deriving from that mission a set of goals for the education of all MIT undergraduates, articulating the content of the curriculum that should be common to the education of all MIT undergraduates, and recommending changes to the MIT curriculum as appropriate.

Following extensive information gathering and deliberations that spanned two and a half years, the Task Force submitted its report to President Susan Hockfield in October 2006. The report has been discussed at two Institute faculty meetings and many other settings since then. The purpose of this essay is to help frame the ongoing discussion by providing a general summary of the report.

The report's touchstone is a series of historic efforts to articulate the educational mission of the Institute, starting at its founding in the Civil War era, stretching to the work of the Task Force on Student Life and Learning in the 1990s. The founding vision of MIT was the creation of a university that would educate

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Editorial

Grappling with Change

THIS SPECIAL ISSUE OF the *Faculty Newsletter* is devoted to musings, suggestions, cautions, accolades, critiques, exhortations, complaints, explanations, celebrations, all sparked by the recent report of the Task Force on the Undergraduate Educational Commons. If you have not yet examined the report in detail, the articles here will undoubtedly pique your interest in learning more; if you have studied the report, you will find new angles and consequences revealed here. Above all, you will see thoughtful, responsible, engaged and – in the best sense of the word – optimistic faculty and students grappling with and discussing a topic that is very close to the heart and sense of purpose of the Institute. It's too early to predict where we will end up, but it's safe to say that this is the process by which the best gets better.

The idea for this special issue arose at the October 2006 faculty meeting where the Task Force report was presented. Subsequently, the faculty chair met with the managing editor of the *Newsletter* to arrange for a special edition devoted to faculty responses to the report. The Editorial Board of the *Newsletter* quickly approved the idea, and requests for articles went out. The large number of submissions to this issue of the *Newsletter* makes it clear that the faculty have much more to contribute and

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From The Faculty Chair
Introduction to this Special Issue

Steven Lerman

THIS SPECIAL ISSUE OF the *Faculty Newsletter* reflects the best thinking of many of our colleagues who care deeply about the quality of the education we provide to our undergraduate students. The depth and breadth of the submissions to this special issue are perhaps the clearest indicators of how deeply we as a faculty care about undergraduate education and how seriously we take both its substance and the process of changing it.

The passion that we bring to the debate about undergraduate education shouldn't surprise anyone who knows MIT well. We have always taken the enterprise of educating the future leaders of society as a central element of our university's mission. We have also always recognized that an MIT education must provide not only a superb technical education, but also the foundation for our students' participation as citizens of an ever-more complicated world.

The work of the Task Force on the Undergraduate Educational Commons is part of our long history of periodically re-examining the part of our students' learning experiences that we as a faculty believe all of them should share. I urge everyone involved in the faculty's deliberations about the educational commons to consider the various points of view of our colleagues that are in this special issue and to engage in the ongoing discussions about the framework that the Task Force has proposed.

In reading the articles in this special issue, I also urge all of us to remember that the work of the Task Force on the Undergraduate Educational Commons was motivated by important ideas that most of us support. Most importantly, the recommendations of the Task Force are founded on the premise that the education we provide our students isn't about filling their minds with a fixed body of knowledge. Rather, an MIT education must kindle and sustain a passion for life-long learning.

It is important to understand that the Task Force's recommendations are more of a flexible template than a rigid formula for our undergraduate curriculum. For example, whether we ultimately include five courses from six categories in the Science/Mathematics/Engineering requirement or adopt the alternative model that requires five courses from five categories is still unresolved. The precise definition of each of the categories and what courses might go into each of them needs to be decided. Also undetermined is the number of specific courses in the categories that any department can mandate for its majors.

Much of the discussion at recent faculty meetings has focused on the Science/Mathematics/Engineering requirements. However, the Task Force's recommendations with respect to our requirements in the Humanities, Arts and Social Sciences also require our careful attention. The idea of a more coherent structure to our freshmen's first year experience in HASS opens up many opportunities for creative thinking about new courses that have broad appeal and that allow for more of a shared experience in these fields. This would create an educational experience in HASS courses that more closely parallels what our students now get in their science courses.

The Task Force also has highlighted the importance of giving our undergraduates the opportunity for meaningful international experiences as part of their education. Our students will live and work in a world where science and commerce happen globally rather than nationally. Being leaders in this future will require that they understand different cultural norms and that they be comfortable working in diverse settings.

Other Task Force recommendations include improvements in areas such as advising, class scheduling, integrating an understanding of diversity into our curricula, shifting from double degrees to double majors, educational innovation and assessment, classroom facilities and the teaching of leadership skills. We need to move forward on as many of these as we can by working collaboratively with the senior administration and raising the funds needed.

Over the coming months we will need to integrate the ideas and comments about the undergraduate educational commons into specific recommendations that will require a vote of the faculty. The Committee on the Undergraduate Program will develop concrete proposals for changes and will continue the process of getting input from various faculty groups as they try to reconcile the diverse views of educational changes that arise from their consultations. It is important to note that no changes in our degree requirements will be made until the faculty approves them.

As I wrote in my column in the September/October 2006 issue of the *Faculty Newsletter*, our decisions about the education of our students are at the core of faculty governance. We owe our students the best education we can give them.

Steven Lerman is Professor of Civil and Environmental Engineering; Faculty Chair *(lerman@mit.edu)*.

The Best Gets Better
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are interested to learn further details about the proposals in the report.

This issue is divided into categories as defined in the Task Force report. Although some articles expressed multiple themes, we tried to place them in areas appropriate to their content, for ease of comparison. The articles are presented alphabetically by author within the individual category.

The need to complete the issue in time to inform ongoing discussion has resulted in its production on the heels of the previous one. We are particularly indebted to our very lean *Newsletter* staff for stepping up to the challenge. We also thank the individual authors, who not only take credit for most of the content, but also participated in proofing their individual pieces in the final layout to assist us in meeting an extremely tight schedule. We also thank Senior Associate Dean Peggy Enders for invaluable assistance.

Finally, we believe that this issue offers the *Faculty Newsletter* at its best: as a means for faculty to communicate directly with each other in an unfettered way about topics of importance to the entire Institute community. The contribution of students to the discussion is also most welcome. We are happy to serve as *your Newsletter*.

Editorial Sub-Committee

Stewart III
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young people so that they could provide leadership in guiding the nation's burgeoning scientific and technological enterprises toward socially beneficial outcomes. This aspiration is summarized in MIT's motto, *mens et manus* – mind and hand. This is a broad vision which measures MIT's success in terms of what happens both inside and outside the laboratory. MIT's broad educational mission was reaffirmed, after decades of drift, in the oft-quoted Lewis Committee Report of 1950. This broad vision was most recently articulated by the Task Force on Student Life and Learning, in its 1998 report, when it summarized MIT's educational mission as

"the advancement of knowledge and education of students in areas that contribute to or prosper in an environment of science and technology. Its mission is to contribute to society through excellence in education, research, and public service, drawing on core strengths in science, engineering, architecture, humanities and social sciences, and management. This mission is accomplished by an educational program combining rigorous academic study and the excitement of research with the support and intellectual stimulation of a diverse campus community."

The present report of the Task Force on the Undergraduate Educational Commons argues that MIT's technical education must be regularly reevaluated to remain relevant and peerless in terms of rigor. Because MIT intends to prepare leaders for business, research, government, education, and society at large, the faculty must also prepare MIT students to be fluent in expression, knowledgeable of a wide variety of values and cultural assumptions, intellectually agile, confident in working with and leading groups of people, and socially assured. Therefore, the faculty must also make certain that its education in fields outside of science and engineering remain relevant and rigorous.

The Task Force report affirms the many ways in which MIT's common curriculum – the GIRs – has successfully prepared MIT's graduates for a lifetime of learning and leadership. It also recognizes that changes in the wider context require us to alter this curriculum in some very important ways. These contextual changes are discussed around three major themes.

1. Science and technology are changing

The array of technical material that is fundamental to what scientists and engineers do has only grown since the 1950s, spurred in part by the emergence of disciplinary subjects that were only nascent in the 1950s (like computation). While traditional disciplinary research remains strong at the Institute, areas of research that reside at the boundaries between academic disciplines and defy easy disciplinary categorization – which address problems in areas like medicine, energy, and the environment – are becoming increasingly more important.

2. The world is changing

The impact of science and technology on the lives of all inhabitants on the planet has grown in the past half-century. Scientific literacy and technological innovation are universally recognized as essential preconditions for robust economic development. The effect of science and technology on the lives of human beings is so great that scientific advances are impossible without the active involvement of governments and the popular understanding of science by its citizens. Technological advances in computation and data transmission, transportation, and logistics have made globalization a catchword and a practical reality for which all of society must be prepared.

3. Students are changing

The student of 2007 is not the student of 1957, or even of 1987. Some of the most obvious differences are readily apparent in a brisk walk down MIT's Infinite Corridor. Students at MIT today have a broader range of life experiences and more diverse secondary education; they arrive with a wider array of career ambitions. They benefit from substantial shifts in society that have opened up opportunities for students who could not even have dreamt of attending MIT in 1957. They have also completed primary and secondary curricula that have emphasized "hands-on" learning, integrated learning, and "making a difference" through education.

In light of these changes, the Task Force report makes major recommendations that can be organized around four topics:

A. *Providing greater flexibility in the portions of the GIRs that focus on science and technology while retaining the rigor that has been the hallmark of these classes.* The report proposes the creation of a new eight-subject Science, Mathematics, and Engineering Requirement. Three of these classes (single-variable calculus, multi-variable calculus, and classical mechanics) would continue to be prescribed as is done now. The remaining five classes would be taken from a very small and tightly-regulated number of subjects organized into six foundational technical categories: chemical sciences; computation and engineering; life sciences; mathematics; physical sciences; and project-based experiences. Students would choose classes from five of these six categories. Classes in the final category – project-based experiences – would be learning opportunities that involved either design or creation, leveraging real-world problems to motivate the acquisition of disciplinary knowledge, stressing the cross-disciplinary interactions needed to address design problems.

B. *Clarifying and strengthening the portion of the GIRs that focuses on the humanities, arts, and social sciences, and encouraging more cross-school collaboration that highlight issues at the boundaries of technology and society.* The report proposes major changes in how the first two years of the HASS Requirement are structured. First-year students would take one of a small number of foundational electives affiliated with a new Freshman Experience Program. These special classes would focus on topics that have attracted great interest in human society and require multiple perspectives to grasp deeply, such as wealth and poverty, democracy, the self, and war and revolution. The remaining three semesters of the first and sophomore years would be devoted to other foundational HASS electives, distributed across the humanities, arts, and social sciences. In addition, study would be undertaken by the faculty about how best to institutionalize collaborations across all five Schools to increase the number of subject offerings about topics at the boundaries of technology and society.

C. *Encouraging MIT undergraduates to live and work abroad as an essential feature of an undergraduate education.* The report urges an ultimate goal of allowing any MIT undergraduate who wishes to participate in a meaningful experience abroad to do so without financial or academic penalty. An obvious first step toward achieving this goal is building directly upon the international experiences that have already proven successful at MIT, such as the MIT International Science and Technology Initiatives (MISTI), the Hyperstudio, the Cambridge-MIT Exchange (CME), the Minor in Applied International Studies, and the Development Lab (D-Lab). The Institute should devote the attention to these programs necessary to move them beyond their entrepreneurial phases. The Institute also should explore yet more opportunities for its undergraduates to study and work abroad.

D. *Institutionalizing MIT's commitment to continual renewal in undergraduate education.* In addition to the highly visible changes discussed above, the Task Force report urges a new commitment to building and maintaining MIT's capacity to continue its educational excellence at the undergraduate level. The Task Force encourages improving the quality of classrooms and the mix of classroom types; enhancing advising for first-year and upper-class students; developing a more unified approach to the first year experience; rationalizing the scheduling of classes; reaffirming MIT's commitment to the racial, ethnic, gender, and class diversity of its students; enhancing the expertise devoted to improving the curriculum and classroom instruction; broadening the influence of new teaching techniques; and enhancing the capacity of the faculty and administration to share in the responsibility to ensure the continued excellence and ongoing renewal of MIT's undergraduate educational program.

Even though the Task Force report contains many detailed recommendations, it was not written assuming it would be the last word on the issues it addresses. In the case of the GIR proposals particularly, as a body composed of MIT faculty members, the Task Force recognized that many of its own deliberations would be played out when the faculty-at-large began to consider the same issues. Even among the issues raised in the report that have elicited widespread support, such as improving classrooms and changing our approach to double majors, many details still need to be worked out before concrete proposals can be brought to the floor of the Institute faculty meeting. The report sets an agenda and provides a serious effort at proposing ways to improve MIT's rich, complicated educational system. It is still left for the faculty as a whole to, first, grapple with the broad issues contained in the report and then, second, to refine these issues into concrete proposals that the faculty as a whole will embrace.

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The General Institute Requirements (GIRs)

Will the Task Force HASS Recommendations Increase Student Apathy?

Thomas F. DeFrantz and Caroline Rubin '08

THE PROPOSED CHANGES TO the HASS portion of the GIRs address many long-bemoaned shortcomings of the current system, such as the somewhat bewildering complexity of the HASS-D and CI-H requirements and the paucity of collaboration between faculty in SHASS and those in science and engineering. However, the proposed First-Year Experience classes jeopardize one aspect of the current system that is not only unproblematic but actually beneficial: the wide variety of intimately-sized HASS-D classes available to incoming students. In attempting to fix what isn't broken as well as what is, the proposed changes have the potential to degrade the quality of students' HASS education. The thoroughly researched history of HASS education at MIT and the carefully laid out suggestions for its improvement contained in the Task Force report evidence its authors' dedication to improving undergraduate HASS education, and we make these recommendations in the spirit of that shared goal.

The Task Force recommends replacing freshmen's current selection of many small HASS classes with a limited number of large-enrollment ones in the name of creating larger intellectual communities. The interdisciplinary nature of these new classes is intended to ignite freshmen's interest in their content and in the larger goals of SHASS as a result, but we are concerned that several features of the proposed requirement may work against these goals: first, the dramatic reduction in number of class choices, and second, the move towards larger, more impersonal classes. If these aspects of the proposed requirement are not addressed, student apathy towards SHASS and its goals is likely to only deepen.

Under the current system, incoming students have over 50 HASS classes to choose from, ensuring that everyone can find at least one that sparks their curiosity. If the proposed First-Year Experience classes are implemented, freshmen will have to hope that one class out of fewer than 10 options appeals to their personal interests. Since each of these classes is slated to have enrollment minimums and maximums, it is inevitable that many of the less popular classes will be filled with students who did not choose to be there. Given that the vast majority of these students will be on pass/no record and not required to do any more than is required to earn a C, they will already have little motivation to do more work than the bare minimum. Placing them in a class they felt was the least unappealing of limited choices or that they did not choose to be in at all will only lessen their incentive to put

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A "Nerd Track" for MIT?

Jeffrey Freidberg

Introduction

I, LIKE EVERY OTHER faculty member that I have spoken to, would like to thank the Task Force for their heroic efforts over the last two years, culminating in the Task Force report. In perhaps the most crucial area, they have provided the faculty with a valuable insight. Specifically, the Task Force has concluded that our current GIR structure is too rigid. They, therefore, attempted to introduce some flexibility into the structure, which is a step in the right direction. Even so, in my opinion they do not go far enough.

The problem

The basis for this opinion follows from two observations made over many years of teaching at MIT.

1. My first point has to do with the present GIR structure. Currently, the GIRs contain 17 subjects. To complete a major, in the School of Engineering, for instance, requires an additional 16 or so subjects. As pointed out by the Task Force, there is relatively little flexibility in the choice of GIRs. My problem is that I do not see why students who are interested in widely different majors such as physics or foreign languages need to have overlap in half their subjects.

2. My second point concerns undergraduate preparation for graduate work in some of the highly technical programs at MIT. Over the years, I have noticed that undergraduate students joining my department from elite international universities are often substantially better prepared for success on day one than U.S. students, including those from MIT. They have more experience in mathematics and science than many of our own undergraduates. A comparison of several representative curricula shows that international students are required, with almost no flexibility, to take more technical subjects, fewer humanities subjects, and a larger total number of subjects. Are these international students less well rounded than MIT undergraduate students? Quite possibly, yes. However, while MIT strives to produce leaders, not all students want to be high-tech CEOs, national laboratory directors, or mega-managers in government. Some are old-fashioned "nerds" who strive to be leaders by virtue of pure technical excellence – their idol might be Richard Feynman.

My problem is that neither the existing GIR structure nor the one proposed by the Task Force recognizes that there may be a substantial minority of MIT undergraduate students who fall in

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Reasons to Continue to Require 8.02

Thomas Greytak and Marc Kastner

IT IS HARD TO IMAGINE a future in which an MIT graduate has no familiarity with electric and magnetic fields. However, the report of the Task Force on the Undergraduate Educational Commons has made recommendations that could have that outcome for some students. It is therefore important to re-examine the justification for requiring electricity and magnetism (8.02) for all students. We list below six distinct intellectual reasons for retaining 8.02 as a required part of the General Institute Requirements.

It is essential to our understanding the world around us. The most fundamental processes in nature, from the forces that determine the structure of atoms and molecules to the phenomena of light to nerve impulses in living systems, depend on electric and magnetic fields.

It is fundamental to current and future technologies. Motors, power generation and transmission, electronics, sensors, and communication – both wired and wireless – involve the manipulation of electric or magnetic fields. There are few advances in technology that can be made without the use of electronic circuits or electric and magnetic fields. Of the current freshman science subjects beyond 8.01 – 8.02, chemistry, and biology – 8.02 is required by the most departments.

It is the simplest example of unification in science. A large and diverse body of observational facts can be explained in terms of a few simple concepts. The phenomena of electricity and magnetism, which appear to be completely different, are shown to be two manifestations of the same physics. The theory requires few if any approximations. Results can be predicted with great accuracy.

It provides an ideal introduction to vector fields. 8.02 demonstrates real world applications of the material in 18.02. The equations are simple enough to be accessible to freshmen. Yet, since the equations are linear, they are exactly solvable in many important cases. Skills gained here can be applied anywhere vector fields are used, such as in hydrodynamics, where the fundamental equations are intrinsically more complex.

Incoming students are least familiar with this material. Of all the current Science Core Subjects, E&M is the material least likely to have been covered well in high school. In addition, the concepts of electric and magnetic fields are totally non-intuitive to most students. Thus the material is most likely to be exciting to the curious student. It satisfies their need to feel that they have learned something new and deep.

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Diversity in Foundational Skills and Knowledge

Eric Grimson

WHAT SHOULD EVERY MIT undergraduate know by the time they leave the Institute?

While this is not the only way to look at the challenge of modifying the General Institute Requirements, it provides one focal point for considering that challenge. A natural interpretation of the question focuses on knowledge: What corpora of information do they command? What specific techniques have they acquired? To what fields of endeavor have they been exposed? However, an equally important perspective is to focus on the transferable skills that students acquire: What modes of thought have they mastered? What general problem solving skills have they acquired that apply to new fields of interest? Have they learned fundamental tools of abstraction that enable them to isolate central elements of very complex systems, from any domain of intellectual inquiry? Have they learned synthetic ways of thinking?

This perspective of transferable skills is important in considering how to evaluate potential changes in the GIRs. The explosive growth of scientific and technical knowledge and techniques in the past few decades already overwhelms our ability to instruct every student in areas of knowledge that significant subsets of our faculty feel every student should master. Should every student, independent of primary interest, be knowledgeable about computation? Should every student be knowledgeable about statistics, and reasoning under uncertainty? Should every student be knowledgeable about large-scale complex systems? Should every student be knowledgeable about macroeconomics? Should every student be knowledgeable about ethics and professional behavior? Many of the faculty would probably answer yes to each of these questions. Clearly if one includes these and other essential areas with the current GIRs, we run the danger of completely filling up a student's academic agenda, leaving no room for the specialization in a major.

If we cannot cover every field of inquiry that we think is important, an alternative is to provide a system that supports a diversity of types of students – a compromise in which a student would follow one of a small number of subsets of possible GIRs. In this view, every student would have an intellectual base (spanned by their particular selection of foundational courses) that is broad enough to cover several intellectual modes of thought. At the same time, the set of choices of foundational subjects should be small enough that any pair of students would have sufficient overlap in their bases to foster easy communication of ideas, thus engendering cross-fertilization and interaction. Foundational courses should provide transferable skills so that any student can apply their personal toolkit of reasoning and problem solving techniques to new fields of interest. And ideally students will be infected with a lifelong curiosity that will encourage them to acquire new domains by applying these

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"Big Ideas" and the High School Asymmetry

Sally Haslanger and David Pesetsky

WE ARE WRITING TO express our concern about the changes in the structure of the HASS requirement proposed in the Task Force report. Our concern focuses on the "foundational phase" that would mandate the creation of a small set of *First-Year Experience* subjects and so-called *Foundational Electives* that must be entirely new and satisfy a stringent set of criteria. Thus, the First-Year electives must stress "'big ideas' concerning culture and society that have endured over time" and the Foundational Electives (despite their name) must *not* be "narrow introductions to particular disciplines" or "retreaded HASS-D subjects."

We have no quarrel with foundational courses and "big ideas," but we fear that the proposed plan will actually restrict students' access to many big ideas by denying them necessary foundations for discussing them. In particular, we believe that the "foundational phase" as sketched in the Task Force report will limit students' abilities to explore HASS fields that they did not already explore in high school. Many of them will never discover a wealth of interesting connections among HASS fields and between HASS and MIT's science and engineering offerings – connections that the current HASS curriculum does enable students to discover. Consequently, we think the proposed reforms are a step in the wrong direction. Despite flying the flag of "breadth and diversity," the proposal will lead to a serious narrowing of the HASS experience at MIT.

As is well known, many of the most important developments in the study of "what makes us human" began here at MIT, often in SHASS departments. The Institute even now boasts a special *continuum* of activity and investigation that runs from the creative and performing arts through the analytic study of the arts and history, and into the social and cognitive sciences, including linguistics and philosophy, that study the structure of human mental activity and action. The social and cognitive fields within SHASS are, in turn, the intellectual neighbors of many non-SHASS fields at MIT – the brain sciences, for example, as well as computer science and fields represented in HST. Consequently, MIT *should* be the absolutely best place in the world for an undergraduate to study human nature and human experience from almost every perspective. But there's a catch.

The continuum from HASS to the rest of the Institute might be obvious to us, but it is certainly not obvious to entering undergraduates. The reason is simple: asymmetries in the typical high-school curriculum. Almost all high schools train students intensively in a few HASS fields (history, literature, and a foreign language) and require classes in at least one creative or performing art. The other HASS fields, however, are almost entirely missing from the high-school curriculum. The asymmetry is systematic. Our entering students are unlikely to have much prior knowledge of any of the *cognitive/social* areas of HASS (including our fields, linguistics and philosophy), but have spent many

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More Science, Not Less!

James L. Kirtley Jr.

THE MEMBERS OF THE Task Force on the Undergraduate Educational Commons obviously put a lot of time, effort, and thought into their report. The report clearly articulates serious issues with our present day core curriculum and makes outstanding proposals for reform. However, one gets the impression that they worked perhaps too hard and made too many compromises.

Core Requirements

Core requirements exist for two reasons: first, they are the fundamental part of a student's general education and preparation for being a good citizen. They should impart skills and knowledge that all graduates of the Institute should have. Second, core requirements serve as preparation for future study. As the title of the Task Force report implies, core requirements should be a common experience and background for all students.

The science requirement as it is currently constituted does not specify either enough depth or breadth. The well specified part of the curriculum makes a good start, with two subjects each in physics and mathematics and one each in chemistry and biology. But that is it: the rest of the science requirement (two subjects) has been largely subsumed into department programs.

In its report, the Task Force recognizes this: saying that the science requirement "no longer provides MIT students with the type of preparation in the fundamentals that they need." The Task Force attributes this to advances in science and technology over the past 50 years. One presumes that the science core has failed to keep up. This indicates the need for either more science in the core or a better directed science requirement. What the Task Force proposes does not cure either problem. It would actually make the situation worse. The specified part of the science core would shrink to three subjects (from six) and the rest of the science core would come from a menu (one from column A…). Much of what students take from that menu would probably be specified by departmental programs.

What is proposed is far from an "Educational Commons." It would not constitute a shared experience and it would provide little on which to build subsequent education. It would ensure some rigor in our students' background, but it would make for neither preparation nor general education.

What to do?

Broadening the range of subjects that satisfy some aspect of the science requirement would not provide a broad education for any student. We need to broaden the subjects specified in the science core. Figuring out what is really required by our students, both to enable them to be good citizens of our future society and to give them the underpinnings of a professional education, will require substantial effort. But it must be done. We will probably

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Recognizing the First Rate

Steven B. Leeb

THE TASK FORCE HAS done tremendous and cogent work, for which we should all be grateful. The presentation of point and counter-point in the report is so complete that in most cases I found my concerns articulated. In some cases I draw different conclusions, and I appreciate the opportunity to share these with you.

In his 1959 inaugural address, President Stratton said, "by precept and example, we must convey to [our students] a respect for moral values, a sense of the duties of citizenship, a feeling for taste and style, and the capacity to recognize and enjoy the first rate." A basic approach for meeting this charge is offering our students appropriate challenges at appropriate points in their careers. When I arrived here as a freshman, I expected to be posed a set of challenges, developed by a community of people I admired and sought to emulate more than any other, anywhere else. I expected completion of these challenges to signal readiness (in theory at least) to make intelligent choices about my career and my work. A person is not ready to be a team member, to exercise choice, to plan wisely for the future, until they have individual skills to use and share. We meet President Stratton's charge by leading by example, by offering an educational experience that reflects our consideration and values, by offering crafted opportunities that are first rate. Our students' successful experience with these first-rate opportunities cannot rely on wisdom and perspective that they may not yet have.

The report offers "menu" systems for the science core, either a "five-out-of-five" or "five-out-of-six" structure. Each category will have multiple choices, so that under either system, students will be forced to choose a subset of classes from a larger pool, e.g., "five from fifteen" or eighteen. This menu plan is a lowest-common-denominator solution that will encourage entertainment over education. It will encourage grade inflation.

The report acknowledges potential deficiency on page 52: "With certain GIR choices made in the five out of six structure, it is easy to see how [students] could find some majors impossible to complete in four years." It is equally easy to see this impossibility in the "five-out-of-five" (resulting in a five from fifteen choice, for example). The report prefaces this concern with a presumptively ameliorating provision demanding "excellent first year advising to reduce the incidence and impact of bad academic choices in the first year." Unfortunately, no advising system can flawlessly advise entering students who have not decided their paths. The menu plan imposes an impossible burden.

An essential benefit of our current science core is that it intentionally does not handicap a subset of students through a lottery whose winners are selected based on their prescience.

A Task Force member characterized the plan as one that would leave "some departments feeling burned." I agree with this

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Five-Out-Of-Six Model is Not Viable for MechE, but Five-Out-Of-Five Model Is

John H. Lienhard

THE MECHANICAL ENGINEERING FACULTY see many positive elements in the Task Force report, and we are actively considering how some of its recommendations may be used to improve our program. Here, I write to present our concerns about a single aspect of the Task Force report: the "take 5 out of 6 columns" proposal for the new Science, Math, and Engineering (SME) requirement.

A typical undergraduate program includes four subjects per term for four years, for a total of 32 subjects. Our experience has been that a substantial number of students get into academic trouble if they go beyond this level of effort. As a result, we regard 32 subjects as a reasonable maximum size for a degree program. The three SB degrees in our department each require 32 subjects, plus a 1/2 subject taught during IAP of the sophomore year.

After deducting four unrestricted electives and eight HASS GIRs from a 32-subject program, 20 subjects remain: eight within the new SME GIR, and 12 within departmental programs.

For any accredited engineering degree, ABET requires the equivalent of 12 engineering subjects and eight basic math and science subjects. Here is where difficulties arise. The SMEs as proposed contain two columns in which some subjects may have engineering content (Computation/Engineering subjects and Project-based subjects). In the 5-out-of-6 variant of the SME requirement, students could take zero, one, or two GIR engineering subjects; and students may have anywhere from 6 to 8 basic math and science GIR subjects. Engineering departments are therefore challenged in using a 12-subject program to ensure that the ABET mandated engineering and math/science content is present. The solutions are unattractive and largely contrary to the Task Force goal of increased flexibility:

- Departmental programs can grow to encompass all possible variations on the SME science or engineering content. Since only six math/science subjects could be assumed in general, departmental programs would have to require 12 engineering subjects and two more math/science subjects, for a minimum program size of 34 subjects (additional subjects might be required, if necessary math/science subjects were not among the 6 SMEs). This would not be helpful to MIT's engineering students, some of whom would be pushed to a 4.5-year program.

- To avoid growth, departments could write conditional program requirements: "*If you have taken eight SME math/science subjects, you must take 12 engineering subjects in Course 2; if you have taken seven SME math/science subjects and one SME engineering subject, you must take 11 engineering subjects and one math/science subject; if you took . . . etc.*" One can imagine the confusion that this would bring to the students, their advisors,

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The Changing Nature of "Fundamental"

David A. Mindell

IN THE COURSE OF our investigations, the Task Force received detailed presentations from faculty currently teaching the GIR science courses, people clearly among MIT's most dedicated and skilled teachers. We asked each of them: "Why is this course important for MIT students?" Here are their replies (in paraphrase): "Chemistry is a unique, coherent way of thinking about the physical world. It is important for students to learn how chemists think." "Biology is so important today, from basic science to public policy to healthcare decisions, that no matter what students end up majoring in they will need to know some biology to be informed scientists, engineers, and citizens." Physics faculty replied "electricity and magnetism are so fundamental that every student should learn them in order to move on to further study in the sciences or engineering," or they stated "Maxwell's equations are philosophically important and represent an ideal union of mathematics and physics that characterizes the sciences." (We also learned that we as a faculty do a poor job of communicating these rationales to the first-year students).

What is striking about these rationales is their diversity, a diversity we should celebrate. Surely other instructors of the same subjects find them essential for yet additional reasons. But these multiple perspectives belie the assertion that the "fundamentals" are obvious, predetermined, somehow inherent in the structure of knowledge and uniquely necessary for advancement in a scientific or technical education. Over time, the nature of these fundamentals can change, and they should change (as they did in 1964, or in 1994 with the addition of biology). Might there be other rigorous pedagogical explorations of the sciences that would provide similar fundamentals for MIT students? The Task Force report does not specify what those might be, but merely stipulates they are conceivable and leaves it to the faculty to propose them. Are there no scientists at MIT (or engineers for that matter) who might propose a course for freshmen that epitomizes the union of mathematics and the physical world?

The Task Force was also clear that the GIRs, in addition to their prescriptive role, represent a statement by the faculty to the students about what is intellectually important. Unfortunately, the way the Task Force conducted its business (with separate consideration of the science core and HASS requirements), the way the current report is written, and the changes it proposes underscore the old "two-cultures" divide between science/engineering and the humanities and social sciences.

Of course opportunities exist today for faculty members to teach collaborative interdisciplinary subjects, as many faculty do. But the structure proposed in the Task Force report lacks a compelling vision for collaboration across the "two cultures" divide. Hence it lacks a clear statement to our students that the Institute and the faculty value such syntheses. As the faculty considers and debates revisions to the GIRs in the coming months, I urge us to

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AP Credit for 8.01 is Appropriate

Nicholas M. Patrikalakis

ONE OF THE RECOMMENDATIONS of the Task Force is the elimination of AP credit for all required science subjects, with the exception of calculus. The Task Force report (p. 53) refers to

"…a growing body of compelling evidence that students who receive top grades in the AP exam typically have difficulty when they proceed to the next subject in the sequence at MIT."

The report does not explain this evidence, but subsequent discussion with Dean Silbey revealed that it refers to the AP exams in chemistry and biology. For those exams, the faculty have indeed found significant differences between the AP material and that covered in the corresponding subjects at MIT. The Task Force recommends replacing AP credit by MIT administered advanced standing exams.

The ME faculty were quite surprised by this recommendation as it applies to 8.01. Our experience has shown that students with AP credit for 8.01 do very well when they proceed to the next subjects in the sequence at MIT, which for Mechanical Engineering students are 2.001 and 2.003J.

First, how is AP credit currently awarded for 8.01? The Physics Department has set a high standard: to obtain AP credit in 8.01, students must have a score of 5 on both parts of the Physics C exam (i.e., they must have the top mark on the hardest AP exam in both mechanics and electromagnetic theory). Roughly 16% of MIT's incoming freshmen meet this standard.

Second, what are 2.001 and 2.003J? The former is our introductory subject in mechanics and materials, covering statics and elasticity. The latter is our introductory subject in dynamics, covering kinematics and dynamics of linear and rotary motion. Both are entirely dependent upon the students' knowledge of elementary classical mechanics as covered in 8.01. Our students generally take 2.001 in the second term of the freshman year or the first term of the sophomore year; 2.003J is usually taken in the first term of the sophomore year. The prerequisites for these subjects are 8.01 and 18.03 (18.03 is co-requisite for 2.001).

To assess the performance of students who received AP credit for 8.01 (and who did not take 8.01 or its variants at MIT), we reviewed the grade distributions for AP students in comparison to all other students taking 2.001 and 2.003J. We observe that students with AP credit for 8.01 receive grades in the A range at a rate of roughly 60% for both subjects, as opposed to rates of around 35% for students without AP credit. (Students with advanced standing exam credit are included in the non-AP group.)

We conclude that students with AP credit for 8.01 outperform those without AP credit in the next subjects in the sequence in Mechanical Engineering. We therefore see no need for the extra student and faculty effort that would result from replacing

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The SME GIRs: Arguments for Five-Out-Of-Five

Robert P. Redwine

A KEY ASPECT OF the recommendations of the Task Force on the Undergraduate Educational Commons concerning the Science, Mathematics, and Engineering (SME) GIR is the requirement that students complete, in addition to 18.01, 18.02, and 8.01 (or their variations), at least one subject in at least five of the following six areas: Chemical Sciences, Computation and Engineering, Life Sciences, Mathematics, Physical Sciences, and Project-based First Year Experiences. Careful readers of the Task Force report will have noted that, while this recommendation was favored by a majority of the Task Force members, a significant minority favored a "five out of five," or 5/5, requirement as opposed to the "five out of six," or 5/6, version. We actually spent a lot of time in the Task Force discussing the pros and cons of the two approaches and, since I was one of those favoring the 5/5 version, I have been asked by a few people to write a piece expanding on the reasons a number of the members of the Task Force favored this approach. I will not claim here to represent all those who favored the 5/5 version, but I believe I can summarize the key arguments.

A goal that pervaded many of the Task Force recommendations was that of allowing our students more flexibility, or choice, in designing and completing their undergraduate curriculum, including the General Institute Requirements. This goal was considered to be important primarily because it is expected to lead to more ownership and engagement by the students in their educational process. However, the Task Force members also realized that with increased flexibility will come increased probability that students may make choices early in their studies which reduce flexibility later on. A significant number of our students do end up majoring in areas that they would not have chosen as incoming students, and others change majors while at MIT. One can easily see how choices made in a 5/6 SME GIR could later limit the ability of a student to major in some departments and graduate in four years. We have long prided ourselves on a system in which students receive a basic education which allows them to major in essentially any department, and the 5/6 version would erode this aspect of our system. The 5/5 version will not, of course, eliminate the possibility that students make choices in the first year that limit their major options, but it certainly would reduce this possibility.

In fact, the crucial point here is that we are trying to find the optimal compromise between increased flexibility for students and a set of SME GIRs which provides an appropriate base for all majors. Many of us expect that flexibility within an area will be more important for students than flexibility across areas, and therefore the 5/5 approach is closer to the optimal compromise.

A related issue is how departmental major programs connect to the SME GIRs, even for students who do not change major plans after they arrive at MIT. I believe others will address this

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The Case for a Shared Freshman Knowledge Base

Caroline Ross

FIRST, I WOULD LIKE to compliment the Task Force on the thorough and far-reaching work that has been done to date. This is a complex problem that defies a simple solution. Within the recommendations, the major area of concern, from my point of view, is the plan to have students select five out of the six science and engineering distribution categories. This is problematical, both in general terms (i.e., it allows students to graduate from MIT without any chemistry, or without any biology, surely an undesirable outcome) and in terms of the burden it imposes on the departmental programs, which will have to change significantly in order to accommodate the few students who have decided to omit each of the categories. For example, we in Course 3 can assume, at the moment, that sophomores will have taken at least one chemistry subject, 5.11 or 3.091, and we have designed our sophomore subjects accordingly. However, under the new plan, a few of the incoming sophomores will have decided to omit chemistry in favor of the other five categories. We therefore will have to introduce substantial freshman chemistry content into our departmental program for the benefit of these few students, even though all the other students will have already seen it. Similarly, we will no longer be able to assume any background in biology, or in physics beyond mechanics, and will also have to include elements of these topics within our major.

Including parts of what was freshman chemistry, biology, or physics will require an expansion of our basic core subjects, and therefore a loss in depth in our major as students progress through the remainder of their degree programs. Additionally, the need to include parts of what was freshman chemistry, biology, or physics will be repetitive and potentially boring for the majority of students who did take the freshman subjects. I would expect that many engineering departments would share the same problem, leading to a great deal of redundant teaching of formerly-freshman science within each major.

One possible option is for us as a department to require students to take physics, chemistry, and biology as three of their five choices as a prerequisite for entering the department, but I am not enthusiastic to endorse this because it requires students to consider their choice of major at a very early stage. Selecting freshman subjects in order to be able to enter a particular major goes against the philosophy of the freshman experience. A far preferable option would be to reduce the element of choice, e.g., to 5/5 categories, so that we can continue to rely on a shared freshman knowledge base, as exists in the current GIRs. We also need to ensure that each subject within a given category contains an agreed subset of topical coverage, so that students will be well prepared for their major irrespective of which particular subject they select from each category.

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Educating Leaders for a Complex World

Adèle N. Santos and Diane E. Davis

FROM THE VIEW OF the departments and centers in the School of Architecture and Planning (SA+P), we ask the Task Force on the Undergraduate Educational Commons, what took so long? As faculty who represent the world of visual thinkers at MIT and who work and teach across the science-engineering-social science divide, we applaud the new concepts and approaches the Task Force proposes to bring undergraduate education into the twenty-first century. Speaking from experience born of practice and the demands of our disciplines, we place high value on a project-based curriculum, we require meaningful hands-on learning experiences, and for decades we have emphasized and provided extensive international and global learning experiences. We are pleased to see the Task Force advocate for institutional innovations which are fundamental to the culture of learning and teaching in SA+P, and will give undergraduates better access to the strengths, experiences, and contributions of this faculty and our disciplines.

Hands-on Learning Across Disciplines

Guided by *Mens et Manus*, hands-on learning is a cornerstone of an MIT education. Experience shows that MIT undergraduates are "doers" and problem-solvers who relish the pragmatic challenge of tackling large, complex problems – in the lab and the real world. The Task Force wisely builds on traditional curricular approaches that successfully engage our students while also cultivating new modes of learning. For too long MIT minimized experimental learning models and hands-on problem solving experiences as more suited for extra-curricular clubs or outside-of-classroom programs. But by offering the possibility of GIR credit for the new problem-solving module and by applying a "big ideas" possibility to the SHASS requirement, suddenly, faculty will cross disciplines to develop courses with a multitude of diverse methods and perspectives in a systems approach to teaching, learning and problem solving. We followed this method to develop the new undergraduate course, CityScope. Cityscope approaches the city as a multi-dimensional system with environmental, economic, energy-related, technological, socio-political, infrastructural and communication subsystems that can be networked together in either constructive or destructive ways. This year faculty from the School of Architecture and Planning will work with students in Cityscope and Terrascope (joint venture of the Schools of Engineering and Science) to apply science, engineering, and social science concepts to the hands-on study of New Orleans. This is only one example, but by imagining the potential to engage engineers, biologists, and computer scientists in the realms of politics, cities, history, or communications media, to name just a few, the Task Force has catapulted MIT's curriculum to new heights of innovation.

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Toward a Liberal Scientific and Technological Education

Gerald Jay Sussman

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 MIT 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,

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A Serious Equivocation: The Issue of Foreign Language Study

Shigeru Miyagawa and Edward Turk*

FOR ITS MIGHTY EFFORTS at envisioning an undergraduate curriculum appropriate to the twenty-first century, we thank the Task Force.

It is gratifying to read, with respect to international experience: "A top agenda item . . . is [to provide] a strong signal – from the faculty and the administration – that an international experience is not a luxury. Rather, it is a highly desirable component of an . . . undergraduate experience, regardless of the major" (p. 98). We also applaud the report's acknowledgment that foreign language study is "a critical starting point for students who wish to engage with foreign cultures" (p. 100).

These views are consonant with our own belief that, in an era of increasing globalization and multilingualism, every MIT graduate should, ideally, be able to speak, read, write, and think well in at least one language other than English.

We are concerned, however, that an implementation of the Task Force's recommendations would make it very difficult for MIT's undergraduates to pursue foreign language studies in a proper fashion. Language learning is a sequential and cumulative process. The best way to study a foreign language and culture is to start early and continue uninterrupted for as long as one can. Yet the report's proposed HASS requirements would make such study – be it the continuation of work begun in secondary school or the election of a new language – virtually impossible for most of our students.

To require that a minimum of three foundational HASS courses (all assumedly conducted in English) be taken in the first two years would prevent most students from building efficiently upon any secondary-level language study they would bring with them at matriculation. Inevitably excluding freshmen and sophomores from foreign language study, the proposal would also work to the disadvantage of students who hope to acquire proficiency in a language from scratch at MIT: at best, such students might manage to complete four consecutive semesters by their senior year.

These interruptions or postponements would, moreover, deprive most of our students of the opportunity to minor in a foreign language and culture, since minors require six subjects. They would also prove detrimental for students who wish to work and study abroad through the MIT International Science and Technology Initiatives (MISTI). Like most study-abroad programs, MISTI has a two-year (four-semester) college-level foreign language requirement for many of its tracks. If the proposed HASS GIRs were to go into effect, numerous students would no longer be able to attain such competence before their senior year, and would thus be disqualified from MISTI undergraduate internships and from other undergraduate programs that offer meaningful engagement with non-English-speaking cultures.

In academic year 2005-2006, a total of 1,254 MIT undergraduates enrolled in foreign language subjects (Chinese, French, German, Japanese, and Spanish.) Forty-four percent were freshmen and sophomores; fifty-six percent were juniors and seniors. Of the latter, more than two thirds were in intermediate- or advanced-level subjects that require from two to four college-level semesters, or their equivalent, of prior instruction. An implementation of the proposed HASS GIRs would drastically reduce our students' opportunity for such intermediate and advanced work at every stage of their undergraduate careers.

We thus discern a serious equivocation in the Task Force's recommendations. On the one hand, the report makes an eloquent, laudable case for internationalizing students' educational experiences. On the other hand, the report renders it nearly impossible for students to enroll in a sequence of classes that can impart the linguistic and cultural proficiency required for mind-enhancing work and study in regions of the world other than those that are English-speaking.

A monolingual education is an incomplete education. With Ivy League institutions launching bold initiatives to strengthen their undergraduate engineering programs, it will be all the more crucial in the years ahead for MIT to sustain an environment that can attract students who might otherwise matriculate elsewhere. Pedagogic wisdom and institutional strategy dictate that we not deny MIT undergraduates – the potential future leaders of science, engineering, business, and other realms – an equal opportunity to prepare for the challenges of a multilingual, transnational world.

The Task Force asserts that much of its work was triggered by a perceived need to ensure that "the study of culture and society" be "sufficiently valued" at MIT (p. 1). With this in mind, we urge fellow faculty to address the issue of foreign language instruction before endorsing any changes to the HASS GIRs.

At stake is nothing less than a clear and honest affirmation, to ourselves and to the rest of the world, of the Institute's educational priorities.

*This article was submitted by the tenured faculty of Foreign Languages and Literatures: Isabelle de Courtivron, Elizabeth Garrels, Shigeru Miyagawa, Margery Resnick, Emma Teng, Edward Turk, William Uricchio, Jing Wang.

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Project-Based Learning

Experiential Learning and the Freshman Experience

Rafael L. Bras and Samuel Bowring

Introduction

"IN LIGHT OF OUR FINDINGS, the time has come for the Science Core, REST, and Laboratory Requirements to be replaced by a newly designed Science, Mathematics, and Engineering Requirement that retains the rigorous character of the current Science Requirement, while providing more curricular offerings that *better represent the disciplinary breadth of MIT* and provide new opportunities for students to become involved in project-based experiences that *imbue excitement into the first-year experience.*" [Emphasis by the authors, from *Report of the Task Force on the Undergraduate Educational Commons*, pp. 2-12]. We could not agree more with the spirit of flexibility, exploration, and excitement that the Task Force seeks for our first year students. Nevertheless, we have some concern that the Task Force's reliance on individual departments to implement a suite of experiential subjects could inadvertently discourage interdisciplinary exploration.

Seven years ago, Kip Hodges instituted a new class for freshmen called 12.000 or Mission 20xx: Solving Complex Problems. The class teaches freshmen that the way to approach big or "unsolvable" problems is with a strong interdisciplinary focus. Each year a complex problem that involves scientific, technical, social, economic, and political aspects is chosen. The class is divided into teams that address different parts of the problem early in the semester. The students gain valuable experience in the difficulties and power of working within a small team as well as with the entire class. This past semester, the students of Mission 2010 (***web.mit.edu/12.000/www/m2010/***) tackled the problems of post-Katrina New Orleans. At the end of the fall term the class presented and defended their approach to the reconstruction of New Orleans in a public forum that included a panel of experts.

In 2002, Mission 20xx became part of a special freshman program called Terrascope, which provides experiential learning opportunities for the entire freshman year in the context of a close community of students, faculty, and staff. Students are required to take Mission 20xx in the fall and follow with Communicating Complex Environmental Issues: Designing and Building Interactive Museum Exhibits (subject 1.016) in the spring. In that class, Terrascopers design, engineer, and build interactive exhibits through which the general public can learn about the issues the students have explored all year. The exhibits are opened to the general public, and many of them have later been adopted for use by established aquariums and science

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Stakeholder Expectations of Learning in First-year Project-based Subjects

Edward F. Crawley and Diane H. Soderholm

Overview

IN THE DESIGN OF a curriculum, each subject should have a well-understood role and objective, stated in terms of learning outcomes for knowledge, skills, and attitudinal outcomes [Diamond, R. *Designing and Assessing Courses and Curricula: A Practical Guide*. Jossey-Bass, San Francisco, CA, 1998]. The authors conducted a survey to determine the degree of community consensus on the desired learning outcomes for a first-year project-based experience.

Voluntary interviews were conducted with representatives of four faculty stakeholder groups: thirteen department heads and deans; sixteen undergraduate officers; twelve faculty of first- and second-year core or department lead-in subjects; and nine members of the Task Force, CUP, and CoC. In addition, 58 students were interviewed: 20 current seniors; 20 incoming freshmen, and 18 prospective students.

Benefits

The objectives of a first-year project-based experience, within the larger framework of problem-based learning [Duch, B. *The Power of Problem-Based Learning*, Stylus Publishing, Virginia, 2001] will be summarized, with appropriate extracts from faculty interview responses, around the following four topics: excitement, skills, professional context, and pedagogic foundation.

First-year project-based subjects can *attract and excite students,* and provide intellectual variety and an opportunity to explore. They involve students "in exciting subject matter as quickly as possible" and help "solve the delayed gratification problem." Successful experiences can build student confidence that will "spill over into other learning," help to overcome the sense of being "overwhelmed or beaten down" by the freshman year, and "allow students to do what they came to MIT to do."

Particular emphasis was placed by the faculty on those transferable skills associated with self-directed learning and the value of perseverance – "trying things that don't work and understanding why they didn't work." "Creativity within the bounds that are realistic" and "learning that there is not only one answer" were also important outcomes.

Project-based subjects can introduce students to the *context of the professional domain of practice,* motivating the acquisition of and giving context to disciplinary knowledge. They "give students the opportunity to be collaborative and deeply interdisciplinary" and to "deal with ambiguous complex prob-

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The Importance of Freshman-Year Projects

Daniel Frey

IMPLEMENTING THE RECOMMENDATIONS OF the Task Force on Undergraduate Educational Commons will not be simple, but it affords us an opportunity to address some chronic problems. We admit undergraduates who are enthusiastic about engineering, science, and technology. After a short while at MIT, many students find their zeal is greatly diminished. I personally think this is not necessary and that we can maintain or increase the rigor of an MIT education while also keeping our students excited about the subjects we teach. One major element of the task force recommendation would greatly assist in this regard — a revised set of GIRs could allow freshman to satisfy requirements for graduation while engaging in authentic, project-based experiences.

To illustrate why freshman-year projects are so important, I wish to share an anecdote. Earlier this month, I was contacted by an MIT alumna who was experiencing what she regarded as a personal crisis. She had graduated with an engineering degree, but had chosen a job outside of engineering, in this case, financial services. Now she regrets her choice. She sees fellow graduates who are doing interesting work in engineering and, by comparison, her work seems less challenging and enjoyable. She wants to move back toward engineering, and I encouraged her to do so. I think this particular case is not unusual. Nationwide, roughly half of engineering graduates pursue employment outside of engineering. I suspect many of them moved away from engineering for the wrong reasons.

My conversation with this MIT graduate gave me pause to reflect. Why was it that she developed negative feelings about engineering while at MIT? And what caused her to change her mind? My hypothesis is that engineering in the context of authentic practice was interesting to her all along, but that it was not sufficiently visible to her in her first three years at MIT. In an effort to ensure she had the best possible foundation for subsequent engineering subjects, she was immersed in theory and analysis. Opportunities to experience the integrative, creative aspects of the engineering profession were deferred, causing her to drift away from engineering. When she enrolled in 2.009, the Mechanical Engineering capstone subject, she found that integrating her knowledge to solve real problems can be exciting, but by that time she was already set on a path away from engineering.

A basic assumption of the engineering curriculum at MIT (and at most other universities) is that a foundation of theory and analysis must be established before engaging in creative and integrative experiences. For a large number of our students, this is not the best approach. Our students need solid theoretical knowledge and analytical skills, but many students will acquire these most effectively if they experience their authentic value in the context of creative, integrative application. Well designed

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One Perspective on Project-Based Learning

Les Norford

I HAVE JUST FINISHED teaching a pilot version of a project-based-learning class with colleagues Jim Kirtley and Steve Leeb. It's a work in progress, but enough has been learned to merit offering a perspective as part of the faculty's collective consideration of possible changes in the undergraduate curriculum.

Our course, "Physics of Energy," is intended to be a hands-on exploration of issues related to energy conversion and use. We started it as a freshman seminar two years ago, combining three instructors and three groups of students. With support from the d'Arbeloff Fund for Excellence in Education, we significantly expanded the content last fall, still offering it as a freshman seminar. Short experiments, typically lasting 1-2 weeks, were combined with a semester-long project to construct, test, and make creative use of a small, wheeled autonomous vehicle, which we called a robot. The short experiments included measuring the performance of electric go-carts, making DC motors and induction flashlights from scratch, and constructing and testing a desk-top power plant consisting of an alcohol-fuel energy source that powered a Stirling engine. The engine was connected to a DC generator, which provided power to an LED or a resistive load. Students compared measured end-to-end efficiencies with those of real-world power plants. The robots were a lot of work and required mechanical assembly, breadboarding and testing of analog circuits, soldering of components for digital circuits, and a moderate amount of programming. Throughout the course, we related bench-top findings to global issues of energy supply and demand, including environmental impacts. Our vision for the future includes expanding the course from six to nine or 12 units, with more time to explore the analytic methods that support the design work.

All three of us are personally convinced that courses such as ours and project-based courses that others will offer for the first time this spring have substantial value and should be supported by the Institute and home departments to the extent that they are available to all MIT freshmen. Marilee Jones, MIT's Dean of Admissions, was quoted in the January 10, 2007 *MIT Tech Talk* as looking for "the kind of student who builds a telescope because they want to learn." As faculty, we get these students and have the opportunity to encourage them to keep building and learning. Jim, Steve, and I saw that last fall. After at last getting their induction flashlights to work and leaving the lab, students congregated in the hall, shining their lights at a wall and comparing notes about how to adjust the distance from the LED bulb to the Fresnel lens. Another time, two students who had successfully tuned their robots to follow a charged wire on the lab floor exchanged joyful high-fives. Many times, students learned to deal with and overcome difficulties – their mistakes, uncertainties about the best approach to a design problem, poor results

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The Commons, the Major, and the First Year

The Contribution of the Faculty to the Commons

Daniel Hastings

AS EDUCATORS AT MIT, we are fortunate to work with motivated students. They have shown by their decision to come to MIT that they are willing to work hard and are eager to learn. As faculty we have specific expertise that we want to impart to them. However, we also desire to give them the general education (knowledge, skills and attitudes) that will empower them when they leave. We wish to prepare them both for immediate contributions to society and 15 and 25 years out for continued growth and service. Part of the way we do this is through deep faculty engagement with the Commons here at MIT. To this we as faculty must commit some of our energy!

We start with the vision of what we wish to accomplish with the time we have with students. The Task Force on the Undergraduate Educational Commons identified a bold vision: At MIT we are committed to providing an education which is one grounded in science and technology that:

- Ignites a passion for learning,
- Provides the intellectual and personal foundations for future development, and
- Illuminates the breadth, depth and diversity of human knowledge and experience, in order to enable each student to develop a coherent intellectual identity (p. 19).

The need for this kind of education is greater than ever. In this century we face major societal choices that are shaped by and will shape science and technology, within a world transformed by globalization and values-driven religious and political struggles. Our education must prepare our students to serve and lead in this world.

We devote approximately half our educational effort to the General Institute Requirements (GIRs). All our undergraduates receive a core education in science and mathematics, a year's worth of humanities, arts, and social science education, and are offered the opportunity to undertake a research experience with a faculty member through UROP.

Two important principles that go back to the founding of MIT underlie this educational mission. These are the unity of the faculty and the commitment of the faculty to participate in the Commons.

The unity of the faculty means that all faculty can teach undergraduates and graduate students alike, and all faculty have important contributions to make. We do not, like some schools, divide ourselves into a Management faculty and a Science faculty and a Humanities faculty, or a Graduate School Faculty and an

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The State of Undergraduate Advising

Daniel Hastings and Julie Norman

OVER THE PAST SEVERAL YEARS, a number of reports have been produced that address advising and mentoring of undergraduate students: The Report to the Faculty on Advising and Mentoring of Undergraduates (CUP/CSL, March 2005), Report on the Advising Policy at MIT (SCEP, December 2005), and the Report of the Task Force on the Undergraduate Educational Commons (October 2006). The matter of quality advising and mentoring is a perennial issue not only for MIT, but also for our peer institutions. Perhaps it is a recurrent theme because the matter has not been resolved and the responsibility of advising is not uniformly treated as an element of the teaching responsibility of faculty. Even as we continue to wrestle with this issue, the Task Force has issued recommendations that call for more flexibility in the educational path that a student may take through MIT. In addition, with creation of an undergraduate dormitory in W1, we will be increasing the size of the undergraduate student body. These changes emphasize the necessity for us to improve the quality of our advising and mentoring.

All of these reports describe the importance students place on faculty for advice and mentorship. Faculty members are expected to provide advice on departmental requirements and guidance on available opportunities. But students have a strong desire to know faculty outside of the classroom; to develop personal relationships; and to have the opportunity to discuss complex, difficult issues with faculty. Students want to interact with faculty who will challenge their analyses, question their logic and provoke reflection, thus developing self-knowledge. Undergraduates expect faculty to play a role in their career counseling and to provide direction in their review of and preparation for graduate school options. We have not been doing well. The most recent senior survey (2006 ***web.mit.edu/ir/surveys***) indicates that between 30-40% of our seniors say that they were generally dissatisfied or extremely dissatisfied with their advising experience. At the same time, 84% of them say that they were very satisfied or generally satisfied with their undergraduate education.

While the advising experience of undergraduates is reported to vary from advisor to advisor and department to department, overall, through a best practices review presently being completed by the Office for Undergraduate Advising and Academic Programming in DUE, it is evident that advisors generally are dedicated, have good intentions, provide adequate advice and ensure that our students graduate with minimal complications.

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The Journey, Not the Arrival

Diana E. Henderson

THE QUESTIONS ASKED DURING the past months' faculty discussions have most frequently begun, "Did the Task Force ever consider…?" When Task Force members exchange a wry smile at such moments, it signifies something other than world-weariness or complacency: it is an indicator of the long educational journey we took collectively en route to these conversations, and a reminder that the report does not – and could not – capture much of that journey's value. Nor are we traveling alone: across the country, faculty at research universities are reconsidering their roles and responsibilities, and discovering some common ground for improvement. Here is a particularly pertinent instance:

When talking about teaching and the curriculum, a major theme of the professors, deans and provosts involved in the Association of American Colleges and Universities is that it is time to shift attention away from debating whether students should take X semesters of the humanities and Y years of science, and to focus instead on qualities of learning that students need…

For students to have both the rigor of critical thinking and the substance they need for the changing world, … students also need exposure to multidisciplinary approaches to learning – that don't sacrifice on subject matter, but that promote "integrative" education, combining disciplines, combining academic and non-academic experiences, and so forth.

(***insidehighered.com/news/2007/01/19/aacu***)

At MIT we have and value a distinctive mission and curricular design, and much of the Task Force's time concentrated on these. But we also learned about related student needs in light of a changing world and educational changes echoing what the AAC&U says, and found that what a student is required to take is only the first – and not the most important – step. What really matters is what the student takes in and from a class, and how it relates to the whole. Although most of the faculty reaction thus far has focused upon a few specifics of curricular design, the Task Force spent as much or more time reflecting upon learning processes, infrastructure, curricular content, and educational innovation. Granting the importance of ABET accreditations and HASS distribution, the most important questions involve the ways we can individually and collectively improve the conditions that assist both deep and broad student learning.

It is safe to say that none of the specific curricular issues raised at the faculty meetings have been entirely unexpected. These topics needed a public airing and would benefit from collective reflection: this was precisely why the report was issued with the acknowledgement that work remained to be done in refining its design and findings. The hope (not yet but perhaps soon to be realized) was that it would also occasion some searching conver-

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A Global Education for MIT Students

Linn W. Hobbs and Hazel L. Sive

A MAJOR THEME OF the Task Force on the Undergraduate Commons has been largely overlooked in critical discussions of its recent Report: namely, the desirability of injecting significant international experience into an MIT education. Its first recommendation is that "*The Dean for Undergraduate Education should convene a committee to develop a comprehensive strategy to ensure that, within five years, any MIT student who wishes to undertake meaningful study, work, or internships abroad may be able to do so without financial or academic penalty.*" In parallel with the Task Force's final deliberations, a committee of 15 faculty and staff was indeed convened in May 2006 by Dan Hastings, Dean for Undergraduate Education, to address global educational opportunities for MIT students, with particular focus on those issues raised by the Task Force. This eponymous GEOMIT Committee will issue its own report shortly. Here, we consider recommendations made by the Task Force regarding international education. We feel that these recommendations are well written and make important points. We identify, also, a potentially serious conflict with other proposals advanced by the Task Force regarding the freshman HASS curriculum. Our commentary should not be taken as a summary of the upcoming GEOMIT Report, but rather as reflecting some conclusions of our Committee pertinent to the Task Force's recommendations.

Facilitating Global Education at MIT

The Task Force points out that MIT has developed many distinctive, innovative models to accomplish international education. Roughly 15% of our undergraduates now participate in these programs. Why is this percentage so low? First, many undergraduates do not know about the international opportunities offered at MIT, and one recommendation by the Task Force is to rectify this ignorance. In response, a "Global MIT" Website, shortly to be launched, will provide more comprehensive access to the wealth of opportunities that exist already at MIT. We further suggest establishment of an Office of Global Education that will serve both as clearing-house and facilitator for international educational opportunities.

A second reason that more students do not participate in international opportunities is lack of encouragement by their major department, and their assumption that international experiences could preclude graduation in four years. Task Force recommendations call for removal of both disincentives. However, while the Task Force proposes that departments should encourage students who *wish* to participate in international education, we believe that this is not a sufficiently strong imperative. Instead, we propose that *every* student be educated to understand the importance of a global education, because a student lacking in such education will be at a significant disadvantage in the future. Simultaneously, we suggest that faculty will need to be educated

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The Broader Education

Paul A. Lagacé

THE ALARM BUZZES AGAIN. Her roommate yells at her and Elizabeth reluctantly pulls herself out of bed and into the shower. It is 8:10, but she's had only six hours of sleep as she finished an important part of a major project late last night. She hustles to get herself ready and heads downstairs to grab some juice and a bagel. A number of other tired colleagues are quickly grabbing some food as they head into a cold New England day in pairs and threes for that sometimes harsh walk. Elizabeth grabs a coffee on the way, but that makes her a few minutes late to her 9:00 class and she gets that "stare" from the professor. The information flows at a rapid pace and Elizabeth can barely keep up. She checks on e-mails using remote access and notes she'll have a few to get to, but doesn't have time to get into their contents. Normally 10-11 on Wednesdays is time to catch up, but she's meeting with one of her HASS class team members to go over some key items. She hustles to that and then back across campus to her 11:00 engineering design class. At noon she has lunch in the Student Center with some other student government associates to discuss key items from the latest meetings. This trickles over into the next hour and she decides to stay in that intense engagement. She gets over to her HASS class at 2:00 and after an hour of interesting directed discussion on their latest readings, she gets together with two friends from her morning class and they work on the latest problem set until 5:00 when she goes over to the Z-Center and her team practice. She misses dinner at the house tonight and picks up a sub at LaVerde's before getting together with her project design team to review their accomplishments. That meeting is over and she finally gets home, using Safe Ride, after 9:30. She is pretty tired, but there's a good amount of work to do. She sits around with a few sisters for awhile and they just talk, catch up, and relax a bit. Then it's to her room and some reading and work on another problem set due Friday. She gets a call at about 11:30 from a friend in a dorm who needs help on a problem and they talk it through. Her friend reminds her of their religious group activity upcoming Saturday afternoon. She calls it quits at 1:15 knowing tomorrow will be just as intense. On top of this, her cold seems to be getting worse.

What's the point of this story about Elizabeth? This may not be the typical day for our undergraduates (if there is such a thing as a typical day), but it is hardly atypical. Our students are involved in a large number and great variety of activities. Read the list of student groups recognized by the Association of Student Activities to get a feel for that. They are members of sports teams, intramural squads, houses and dormitories, religious groups, performing groups, and research groups. They have social lives, significant others, best friends, fights with friends, families at near and far distances, health issues, and favorite TV shows. They are searching for internships, careers, majors, direction, help, and friendship. *And what role do we, the*

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Flexible Majors in Engineering

John H. Lienhard

The Law of Flexibility

ONE OF THE RECOMMENDATIONS of the Task Force (p. 57, item 4) is that "Departments with large major programs should offer a more flexible degree option that requires fewer subjects." On page 54 (para. 3), we find that "large" means "larger than the constraints currently embodied in the Regulations of the Faculty"; and, by reference to Section 2.84.b.3 of the Regulations, we find, at last, the threshold of large:

"A Departmental program normally [includes] up to 132 units and the equivalent of 11 subjects; but the Committee on Curricula may approve Departmental programs including up to the equivalent of 12 and one-half subjects and 150 units. In addition, Departmental programs may specify or expect up to three subjects that are also used by students to satisfy the General Institute Requirements, with the understanding that the department would allow specified substitutions of closely related subjects in other departments where possible."

The three GIR subjects normally represent an Institute Lab subject and two REST subjects. Under the Task Force proposal, the Lab requirement will be eliminated, with units left to departments, whereas the REST requirement will be eliminated with units transferred to the SME requirement. So the threshold of large is one subject more than that given above – more than 12 is large! Sections 2.83 and 2.84.b.3 further imply a typical subject size of 12 units.

The Task Force makes reference to Course 2-A (p. 54, para. 3, line 7) as an example of the envisioned flexible degree. Course 2-A requires the same number of units as Course 2, but leaves the selection of many of the subjects in the hands of the students. We conclude that what is meant by "requires fewer subjects" is that students have more choice, rather than that fewer units are required in the departmental program.

This last point is significant in connection with accreditation. In a separate article (page 9), I have noted the accreditation requirements for engineering degrees, specifically 12 engineering subjects and eight basic math and science subjects. The 20 subjects implied would have to be wholly contained in the SME requirement and the departmental program. Since the former is eight subjects, any accredited "flexible" engineering major will need a departmental program of at least 12 subjects. If the issues raised in my other article are addressed, however, these flexible engineering majors need not exceed 12 subjects.

Why Accredit Flexible Degrees?

After the ME Department obtained accreditation for Course 2-A in 2001, the enrollment jumped from about 20 to about 100 students. Why might this be? Accreditation certifies that a program

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On the Pursuit of Beauty at MIT

John Maeda

I WISH I KNEW the actual statistic, but I find that most MIT undergrads are musically gifted. If not, they're usually visually gifted, or else great dancers, actors, writers, or even jugglers. But for all the natural creativity they bring to MIT, their expressive skills matter little when it comes to their classes. Because they come to MIT not to become great artists, but to become great scientists and engineers.

Nature's engineer, the MIT mascot of the beaver, has little care for the feng-shui or aesthetics of her dam as long as it functions flawlessly as a home. At MIT we educate a similar core sensibility for practicality and perfection, and do little to encourage the wild insensibilities associated with the latest irresponsible hack on the Dome. What if an MIT student were to hack their problem set with the same irrational drive of Warhol or Picasso? The answer is simple. He can't. Because classical problem sets usually deal with a journey towards what is "correct" *for-all-time,* versus problems in the arts which can sometimes be resolved as "kind of correct" if you're lucky, and even when you're incorrect you might be 100% spot on.

As a product of MIT's undergraduate education system, I can proudly say that I am glad to have learned the GIRs through stepping on the hot coals of 8.02, surviving 18.02 and so forth to strengthen my brain. And I'm even more grateful for the early experiences I had in humanistic learning at MIT which shaped not only my brain, but my heart. From speaking with fellow MIT alumni, I know that there's an incredible desire to engage more undergraduates in the pursuit of a balanced learning experience that spans more than just the Berlin Wall that separates science and engineering. For the "non-MIT" aspects of an MIT education are often useful when a student has left to face the final intellectual hurdle that comes with no proper course number: the big hairy problem set called "Life." There's absolutely no clever Walter Lewin or Gil Strang educational video on this subject that can lead them to salvation.

Pondering the non-scientific aspects of life, our daily existence, the pursuit of beauty, experiencing a song – these seemingly frivolous activities achieve little short-term utility. However they provide meaning to the greater context of a life to be lived past the age of 22. Today countless MIT graduates are emerging as leaders in all aspects of the art and creative world due to the fact that technology pervades everyday life. MIT students know how to *make* technology, and they know how to wonderfully *break* technology. Programs like Adobe Photoshop limit creative freedom to the source code from which images are borne, and it is 6.001-powered minds that can empower new and as yet unseen visual discoveries. Beyond just the arts, consider the potential reach of the MIT-incubated "One Laptop Per Child" initiative that will put an advanced computer in the hands of millions of underprivileged children. The average MIT under-

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Welcome to the Machine: First-Year Advising, Choice, and Credit Limits

Shankar Raman

THE TASK FORCE REPORT has rightly underscored the need for increased faculty participation in first-year advising as a means of encouraging students to engage more actively and fully from the outset in shaping their MIT education. That suggestion points to a deeper concern that is worth spelling out: we need not only increased faculty participation but, more importantly, an educational structure that allows a different kind of participation with regard to the academic aspects of advising.

Consider the guidance an advisor currently needs to provide freshmen as they select subjects. The first semester effectively prescribes single-variable calculus (or multi-variable, should the student's pre-college record allow), mechanics, introductory chemistry or biology, and a subject chosen from the distribution and communication-intensive HASS offerings that fits a schedule primarily determined by the first three choices. If the second semester is less constrained, it is not so by much: a second semester of calculus (or differential equations), electro-magnetics, (often) either chemistry or biology, and then one other subject (from the range offered by HASS). And then – at the end of a year in which opportunities to explore one's areas of intellectual interest have been so, so wide-ranging – the student is expected to declare a major.

The intellectual challenge of advising and the student's own decision-making process essentially boil down to discussions of which flavors of calculus, chemistry, etc., are likely to suit, and which humanities, arts, and social sciences subjects (depending on schedule constraints) a student should take. Within such a framework, it remains unclear to me, after years of freshman advising, why faculty participation is even necessary – surely a machine could do nearly as well.

I am, of course, making my case in an overly pointed fashion – advising involves more than academic guidance (but why would we assume that faculty are more qualified to provide that kind of support?) and students enter at different levels of preparation, leading to different trajectories. But it can hardly be contested that the first year of an MIT education currently rests firmly on a one-size-fits-all model aimed in practice at producing homogeneity. One need only compare our first-year demands with those of any other major research university to see how slight in practice is our attention and commitment to intellectual diversity, to exploration, to making active choices, to allowing room for what may sometimes (in retrospect) seem a non-optimal decision – in short, to the kinds of learning the first year should be about and to which academic advising should contribute.

And it is this endeavor that the Task Force's recommendations regarding the science and engineering core seek to support: by offering a modicum of flexibility in the choice of scientific domains of enquiry and by permitting a richer and broader mix of topics in each domain.

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A Proposal for an Alternative Framework

Emanuel Sachs

WE ALL KNOW THE FEELING of proposing a new idea to our colleagues and meeting with resistance, especially when the idea concerns teaching! Accordingly, I hope that after reading other comments in this *Faculty Newsletter*, I change my mind and come to see the proposal of the Task Force on the Undergraduate Commons as exactly what we need. For now, I would like to: i) express reservations, and ii) propose an alternative framework.

The section of the Task Force Report entitled "Educational Goals" (pp. 20-21) is, I believe, the pivotal portion of the report. Due to space constraints I can only summarize and quote selectively here, and therefore I urge my colleagues to read this section in its entirety. First, the charge to the Task Force is summarized. Some history of curriculum revision at MIT is reviewed, with an endorsement of the drive toward "…a more varied curriculum and an array of learning environments." Then, the Task Force adds its own imprint – as they ought to. The Task Force seeks to address the aspirations of each individual student. They further state that this aim, together with the addition of more flexibility into MIT's core curriculum as embodied in the proposed changes to the Science Requirement, will present students with "…important academic choices upon their arrival at MIT; these choices will make the pursuit of some academic paths considerably easier than others."

The notion of very early down-selection seems to me to violate, or at least not support, the first goal in the Task Force's own charge, "Every MIT Undergraduate will be equipped with a broad understanding of and easy facility with the most important concepts in modern science and technology." I believe that the Task Force has a fundamental misconception of what is desirable as far as variety is concerned. The Task Force seems to believe that a large *variety of subject offerings* constitutes the desired variety. Rather, I believe that *each student should be exposed to a wide variety of subjects.* Further, the report does not adequately address the issue of variety in the context of learning environments.

The stress of early down-selection on students, faculty, and advisors seems to me to be unfair and unsustainable. I can say with some certainty that very few incoming freshmen have a good sense of what engineering is about – after all, it's not taught in K-12 education. Perhaps the same is true of some other fields as well. I strongly believe that many/most of them need considerable time before they begin reducing their options. Isn't the freshman year stressful enough already (if not, why do we maintain Pass/Fail grading for part of the year)?

Through faculty meetings I have come to appreciate that part of the aim of the Task Force was to get students more invested in the freshman year and their approach to this was, in part, to have the students actively making decisions. This is wise. However, the

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The Knowledge Debate

Warren Seering

WHEN WE CONSIDER THE CORE, our debate focuses on what (or whose) knowledge should be taught. Absent a clear basis for selecting, we hear our assertions grow louder. It's fundamental; it's elegant; it's deep; it's the future; it's prerequisite.

I propose an alternative. Let's focus on what skills should be taught. The bases for selecting can be, "Will our students be well served by having this skill?" and "Is MIT equipped to help them acquire it?" We can measure the answers and prioritize from there.

Through a recent survey of Mechanical Engineering alumni,[The survey can be viewed at ***web.mit.edu/surveys/mecheng/welcome.html***] we collected information on how often 300 of our graduates, ages 30 to 34, used various categories of knowledge and skill. When asked how frequently they employ their knowledge of underlying sciences – physics, chemistry, or biology – the most prevalent response was, "Hardly ever – a few times a year." The next most prevalent response was, "Never." More than 60% of the alumni reported using calculus, differential equations, statistics, or linear algebra at most occasionally, where occasionally was defined to be about once a month. Once again, the most prevalent response was, "Hardly ever." The results were quite different when we asked about skills. When they were asked how frequently they employ the skills of working independently, setting goals, and extracting and evaluating relevant knowledge, more than 95% reported using these skills "frequently – on most days," or "pervasively – for most everything I do." For the skills of critical thinking, creative thinking, perseverance, and willingness to take risks, the percentage reporting frequent or pervasive use was even higher. Comparable results were obtained regarding teamwork and communication skills. The results were largely insensitive to choice of profession. The data suggests that the skills students acquire are substantially more important to them than the knowledge from our Core. We should keep this in mind when the sound pressure rises.

Given these preliminary measures of the importance of certain skills for our graduates, we can next address the second question, "Is MIT able to help our students acquire these skills?" The answer, of course, is "Yes, if we choose to." There can be many opportunities to teach these skills, though our current focus on knowledge constrains our options. An ideal setting for our students to begin learning these valuable skills would be a properly constructed freshman design projects course. Opportunities for learning the skills of creative problem solving, goal setting, gathering of relevant knowledge, critical thinking, effective communication, and teamwork abound in such settings. I disagree with the Task Force, however, when they suggest that such project courses are opportunities for "learning by doing." Granted, we learn when we do. But what we learn may be wrong. Assigning a group of students to a project doesn't mean

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letters

Igniting Passion in Our Students

Dear Faculty Newsletter:

I ORIGINALLY INTENDED TO submit my "Free The Endorphins" quasi-poem that I read at the faculty meeting; however, since *Tech Talk* asked to publish it, and it also ended up on the MIT webpage, I think it has had enough exposure (let me know if you want me to send you a copy). I do apologize to true poets who may cringe at my novice abilities, but it was done with the passion I feel for working with my colleagues and teaching our students.

There are two very important essences I would like to reflect on, given my 15 years as a freshman advisor, my last three years as the Director of the Experimental Study Group, and numerous trips to the CAP because of advisees who get into trouble (freshman through senior): We have such a wide variety of students that there is no one-size-fits-all teaching method/style, and therefore the best thing we can do is offer many different options for students to sample, so they can lock into the mode that most excites their passion.

For example, in 8.01, we should have "normal" 8.01 lectures and special recitations, where the lecture is given by one of our world-class physics professors. Recitations should be taught by faculty/TAs from different departments, and students should be able to move around freely. Thus a student taking 8.01 could not only learn 8.01, they could also sample several different majors. This teaching method could be used in many of the GIRs. In addition, yes we should also have TEAL, and we should also offer 8.01X….perhaps as specific recitation flavors?

With regard to helping freshmen feel less rushed and crazed and more excited about being at MIT, note that theoretically, it should be possible for a student to declare a major in any department IAP sophomore year, and then graduate on time assuming they do not fail any courses. Accordingly I strongly believe we do a great disservice and greatly damp passion in our students by essentially forcing them to select a major midway through their freshman year. We need to advise our students "If you are certain of what you want to major in, great, declare it spring term of freshman year. On the other hand if you are not certain, take your time to take exploratory and/or introductory courses in several different departments and then declare your major end of fall term sophomore year. Beware that a few departments do require you to declare spring term freshman year."

Indeed, let us encourage students to take spring term freshman year and fall term sophomore year to explore many different majors by taking several of the introductory courses in majors (e.g., 2.001, 6.001, or the exciting new GIR exploratory courses being developed and offered). Then, if the students do major in one of the departments they have sampled, they have already taken the first course; and they also have great breadth in their education. To be successfully marketed, however, each department will have to provide example tracks to graduation assuming students start in the fall or spring terms in their sophomore year. Some departments may not be able to accommodate students who do not start in the fall term sophomore year, but there is no need to force compliance, for students that want to major in that department probably know they do anyway.

And then there is what truly ignites passion, something no course can do: A real meaningful UROP where the student has ownership of an idea and the responsibility to make it into reality. We should increase the UROP budget by 10x to enable students to sample departments by doing paid UROPs, or to do their own UROP where, for example, they create a Rube Goldberg machine to practice what they learn in one of the GIRs. For example, 8.01UROP => mechanical mousetrap, 8.02UROP => electromagnetic symphony or a better bug zapper, 5.111UROP => chemistry of sports….

Furthermore, we can use the UROP model to give students an exciting, creative option to CIs (which too many students and faculty agree are needed, but loathe the restrictions and regulations). Let a student take a CI course, or let them write up/present what they did for their UROP and submit their work to a CI-review group (for example, add resources to the Writing Program to make this a possibility). In fact, we should have a UROP results symposium (conference?) during the spring weekend when prospective students visit MIT. Students would most likely want to passionately and effectively communicate their results to their potential future peers!

I believe the above will enable us to accomplish what the GIR Task Force identified as the primary goal: ignite passion in our students. The above can start in fall 2007 and can work with the current GIRs or with new GIRs (whatever they may be). I propose that the fleet of new Deans that will soon be arriving should be charged with working together creatively to make some of these ideas happen. If they fail, they will be forced to repeat 8.01, 18.01…

Sincerely, respectfully, and with passion,

Alexander H. Slocum
Professor of Mechanical Engineering
Director of Experimental Study Group
Endorphin Releaser J

A Twenty-First-Century Undergraduate Education for MIT Students

Robert Silbey

THE REPORT OF THE Task Force on the Undergraduate Commons rests on a vision of the MIT undergraduate education that I believe is shared by all of the faculty: 1) that our students are some of the smartest in the world and deserve to be broadly educated, 2) that we should do what it takes to develop a passion for life-long learning in our students, 3) that there should be a broad and rigorous core educational experience common to all students, and 4) that we should review and renew the content and structure of that core set of requirements from time to time. I believe also that we are all proud of the MIT undergraduate education program; it is one of the best there is. But we must examine the commons, exactly as academic departments examine their programs, in order to ensure that we continue to provide the best educational foundation for further study at MIT, as well as for life. And, after all, it has been over 40 years since the Zacharias committee report, the last major review that resulted in sweeping changes of our general requirements in science and math. Except for the introduction of the Biology requirement in the early 1990s, the structure of our educational commons has remained remarkably constant since 1965. We owe it to our students to think deeply about what we need to provide for them to be well-educated leaders in the twenty-first century.

All of this is easy to say, and hard to do. There has been a historic tension between what we hope is provided by the common educational experience (e.g., exposure to a variety of fundamental modes of analysis) and what the departments feel they need from the core (e.g., prerequisite material for subjects in the major). At one point, the Task Force undertook an exercise where we listed all the foundational subjects in science, math, and engineering, as well as in the humanities, arts, and social sciences that we felt every student should be exposed to. The list we developed would take 3-4 years to complete: no time left for the departmental major! At the same time, departmental programs are growing larger, straining the boundaries of even the upper limits allowed by faculty regulations. (Indeed, the recent National Academy of Engineering report on the future of engineering undergraduate education suggests that, given the broad range of skills needed by today's engineers, it may be time for five-year degree programs.). Since we knew we were not in a position to add requirements to the common core, the Task Force proposed a plan that is one model for providing more breadth as well as a base of fundamentals (while introducing more disciplinary, as well as cross-disciplinary areas into the core curriculum). It is now up to faculty to engage with the argument we have laid out and the vision we aspire to. The *specific* model we propose is a secondary consideration.

As I write this, a number of exciting experimental subjects are being planned in response to the vision of the report. A number

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Getting There From Here

J. Kim Vandiver

THE RECEPTION OF THE Task Force's recommendations has been rocky. I am hopeful that we will put in place a set of general education principles and requirements that will excite, empower and enable MIT students in this new century. As a member of the Task Force, I believe that our best work was done in the first 18 months, as we developed a consensus around a few important goals and principles. Among these were:

1. An MIT science and technology centric education should be based on a common core of knowledge, attitudes, and skills.
2. High-quality undergraduate teaching is one of our great strengths, and we should strive to continually improve.
3. For some students, the freshman year lacks opportunities to engage in interesting subjects in the fields that inspired them to attend MIT. The freshman-year curriculum needs to have exciting and engaging opportunities for all.
4. Global challenges require that our students be culturally aware and prepared to function effectively on an international stage.

I believe that the way to move forward is to resist initial debates over particular subjects and return to the discussion of the principles that we believe should serve as a foundation for an MIT undergraduate education. When we do discuss subject content, I propose that we focus our attention specifically on what we want our students to know and be able to do. Once we agree on specific goals, the strengths and weaknesses of alternate proposals can be evaluated against them.

I would like to begin that conversation by taking a deeper look at the four points above, examining them in light of the two Task Force recommendations that seem to be the most controversial: the science, mathematics, and engineering proposals (SME) and the HASS subject proposals.

A common foundation

The members of the TF agreed in principle that there should be a common knowledge base for all students, but disagreed on what constitutes that core. Wiggins and McTighe in their book Understanding by Design describe three categories of knowledge which are useful to consider when engaging in a discussion of what undergraduates should know:

- Enduring understanding
- Important to know and do
- Worth being familiar with.

The problem, of course, is agreeing on what belongs in each of those categories. I would argue that we need a set of criteria by which we can make these important decisions. I offer two examples: 1. What should a twenty-first-century MIT graduate know

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The Challenge of Multidisciplinary Education for Undergraduates

Rosalind Williams

RESEARCH AT MIT HAS been moving rapidly and definitively towards greater interdisciplinarity. External funding sources routinely ask researchers to assemble interdisciplinary teams. Two initiatives that have received strong internal support – energy and bioengineering – have repeatedly been described as interdisciplinary. This research trend accurately reflects the realities of twenty-first-century civilization. Any sustainable improvement in the human condition now requires an integrated and interactive mix of sciences, engineering, social sciences, and humanities.

In calling for more interdisciplinary education on the undergraduate level, the Task Force report supports two core principles of MIT education. First, excellence in research and education are inseparable. If our research is becoming more interdisciplinary, this should be reflected in our teaching. Second, liberal and professional education should be integrated in the undergraduate years, rather than being sequentially layered into undergraduate and graduate studies. If interdisciplinary approaches are critical in professional life, they should be part of the "learning by doing" in undergraduate education.

The Task Force report suggests two major ways of accomplishing this: a first-year HASS experience program, and a project-based first-year SME experience. While the goal of interdisciplinary experiences for undergraduates may be desirable, these particular mechanisms raise two issues.

One involves timing: the recommendations front-load interdisciplinary education in the first year. Freshmen who have not been exposed to the range of disciplines, and who have not yet begun to acquire a solid disciplinary base, will not be able to participate in rigorous interdisciplinary experiences. Their introduction to interdisciplinary inquiry should not run the risk of superficiality. There are other ways to build student excitement and engagement into the first year.

The second issue is that of over-compartmentalization. The recommendations of the Task Force separate HASS interdisciplinarity from SME interdisciplinarity, when what our students need are experiences that combines these approaches, as real-world research and practice demand. The report raises the possibility that the two new first-year requirements might eventually be coordinated, to prompt students to start thinking about "the truly trans-disciplinary context…in which virtually all the important problems facing humankind…are situated." (p. 31). If that is the case, then this coordination should be encouraged now through new curricular mechanisms. Other suggestions in the report for encouraging more collaboration among schools (pp. 83-5) do not go beyond anything presently available to MIT faculty.

I hope that faculty discussions of the Task Force report will examine these issues of timing and over-compartmentalization to arrive at even more robust proposals for multidisciplinarity experiences. I prefer "multidisciplinary" to "interdisciplinary," since the latter may imply a sort of hybrid education that displaces rather than builds on disciplines. Disciplines enable humans to address problems in an orderly way. If the unexamined life is not worth living, the undisciplined life cannot be lived effectively. Disciplines discipline.

But students also need to understand how their disciplinary specialty fits with others; where its strengths are, and where its limits are. This is not just a matter of learning how to do "teamwork" in the human factors sense. It is a matter of learning about learning, in the most genuine scholarly sense: learning about the range of approaches to knowledge, their scope, their substance, their relations to practice.

An MIT education should give students a deep understanding of this range so they can practice their disciplines more effectively. Education in the primary discipline benefits when students can relate it to the larger map of learning. MIT should strive for (to mix my metaphors) a Swiss army knife model of education. Each device works well on its own, but each is more effective when bundled together with others, and above all when the operator knows which device to use.

Faculty discussions should seek to create curricular structures that allow deep multidisciplinarity at strategic points through the undergraduate years. To do this, we need a process of experimentation modeled after the goal we are seeking. Proposals should, from the start, include the major disciplinary sets at MIT – science, engineering, humanities, and social sciences. They should be linked to current research efforts at MIT that involve a wide range of approaches, and they should have significant "learning by doing" components. Above all, they should approach multidisciplinarity not as a trend, not as a substitute for disciplinary education, but as an essential goal of university education: introducing students to the universe of learning. ■

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From The Students

The Voice of Students: Student Survey Data on the Task Force Recommendations

The Student Advisory Committee on the Recommendations of the Task Force

ON NOVEMBER 21, 2006, the Student Advisory Committee (SAC) on the Recommendations of the Task Force on the Undergraduate Educational Commons surveyed the MIT undergraduate community about the Task Force recommendations and sentiments about MIT's General Institute Requirements (GIRs). 745 students responded (18% of the student body), often with lengthy comments. This article presents the results of that survey.

Science, Math, and Engineering Core

Survey data revealed that current undergraduates agree that the present science and math core can be improved, especially in terms of engaging and exciting students, a focus of the Task Force investigation. While 74% of surveyed undergraduates agreed that the SME core should provide a stimulus for student's passion to learn, only 32% agreed that the current requirements provide this stimulus.

When students were asked which of the Task Force's models for the core (commonly referred to as 5/5 and 5/6) was best, current undergraduates very slightly preferred 5/5, but preferred the current requirements over either proposal.

When students were asked which subjects all students should be required to demonstrate proficiency in, the most important, in order, were single variable calculus, multivariable calculus, mechanics, chemistry, life science, electricity and magnetism, computation and algorithmic thinking, and engineering methodology. The Task Force's suggestion of requiring proficiency in three math subjects was considerably less popular. The average student selected seven areas that students should be required to demonstrate competency in, suggesting a core requiring seven courses, one more than the current requirements, and one less than the Task Force recommended.

Our results suggest that the primary weakness of the current core is neither the set of subjects required nor the ability of students to choose what content they study, but rather the teaching style options available in the core. 60% of students thought that there should be options to core classes augmented with hands-on experiments, in the vein of 8.02X, a recently-retired option for electricity and magnetism. At the same time, written comments were often highly critical that TEAL, the only current core class to emphasize hands-on learning, is the only option for regular 8.01 and 8.02.

Humanities, Arts, and Social Science

The most criticized proposal from the Task Force report was the First Year Experience in HASS (66% opposed, 18% supported). This strong disapproval was consistent with the opinions from both written comments on the survey and town-hall discussions. Concerns included limited ability to prepare for study abroad, limited interaction between students of different years, and decreased choice of HASS classes.

Students reacted slightly positively to the idea of combining the HASS-D and CI-H requirements into the Task Force's Foundational Electives. 42% of undergraduates thought that the current HASS-D distribution requirement was effective, while 38% thought it was not. Clearly, the requirement can improve.

Despite support for Foundational Electives, students strongly opposed making these courses "foundational" in the sense that they should be completed within the first two years (62% opposed, 17% in supported), or be introductory in nature. Common concerns included hardship for students wanting to learn a language and freedom to begin concentrations earlier.

Many students (59%) reported that scheduling conflicts have had a significant impact on their HASS education (only 13% reported having no problem). 26% of students reported that they had scheduling conflicts every semester at MIT and an additional 21% reported that they occur most of the time. Scheduling conflicts are a significant source of frustration.

Choice of major and advising

Although 41% of upperclassmen indicated they chose their primary major before arriving at MIT, many students (44%) reported that taking advanced classes helped them decide. Other upperclassmen indicated that their decision was influenced by the GIRs (24%), exploratory classes (19%), and freshman seminars (12%). 19% of students felt they did not have enough time to select their major, and 5% of students said they were not happy with their current major.

Overall, students strongly supported significantly increasing mandatory student-advisor interaction. 56% thought that midterm meetings with advisors should be required (22% opposed). A strong majority (68% for, 7% against) felt that students should be able to choose their own advisor, which is presently possible in only some departments. Associate advising was also supported, with 55% of students agreeing that all first year students should have associate advisors (11% opposed), and 59% of students indicating that departmental associate advisors should be assigned to students new to a major (8% opposed).

Kindling the Fire: Student Perspectives on the Task Force Recommendations

Fiona Hughes '09, Cassandra Roth '07, Shreyes Seshasai '08, and Aron Walker '07

THE TASK FORCE ON the Undergraduate Educational Commons made an important observation about students in the first year. They found that students arrive "with an extraordinary sense of excitement and enthusiasm" but within a few months they have a "perceived lack of enthusiasm and excitement." As students, this transformation is obvious in retrospect, and we urge the faculty to address this loss of excitement as the Commons are revised.

Increasing students' intellectual engagement and ownership of their education are key components of a successful set of GIRs. These goals can be achieved by stimulating the first years' interest through alternative pedagogies, increasing student choices in coursework, and encouraging mentor networks to allow students to discuss their long-term goals.

How we learn

When reconsidering the Commons, most important to reconsider are the pedagogies of the courses and the modes of learning they employ. How we are taught matters as much as what we are taught. Flexibility in course selection will not alleviate the grind of the first year if most Core subjects continue to be taught in essentially the same way. We need dynamic instructors across the board, different kinds of assigned work, and more varied pedagogies inside and outside the classroom.

No matter how requirements are constructed, the success of the Commons relies on the quality of teaching in the first year. While there are many gifted instructors in the present Commons, the quality is far from uniformly excellent. Mediocre instruction is perhaps the leading cause of disengagement. The classroom experience must provide something vital to an MIT education; OpenCourseWare makes the problem sets and tests available, for free, anywhere in the world.

One area the recommendations do not address effectively is the prevailing problem-set culture dominating the first year. Every week in every class, students have a problem set, generally a set of questions consisting of the same "find the formula and apply it to the problem" format. The issue is not so much the quantity of work, but the lack of variation week to week and subject to subject. The current monotony of approach shifts students' focus from learning concepts to completing assignments by the most expedient means. Far too few students take the time to explore material creatively or reflectively. Once the motivation becomes simply completing assignments, as opposed to learning concepts and engaging in the material, students optimize their habits around metrics, cramming for tests, copying problem sets, and then forgetting material once the marks are in.

Students need alternatives: more synthetic and reflective assignments, collaborative and creative projects, and work on a variety of time scales. Problem sets are effective, but incomplete, and when they are the only kind of work, the learning is not nearly as compelling as it should be.

Unnecessary requirements

In general, students are more engaged in subjects they choose to take, and frustrated by requirements preventing them from taking the classes they want. This precept can be critically applied to three of the Task Force recommendations.

1) The "Mathematics" box in the revised Science, Math, and Engineering Core

The Task Force itself concedes that almost all students already take a third math class through requirements in their major. Why require what is already required? The proposed "mathematics" box is unnecessary and unduly confining. Since most departmental programs already require an additional mathematics course, the additional Institute requirement would only affect a small number of students, most of whom would take a math course anyway (e.g., 14.30, Statistics) that may not qualify for GIR status within the proposal.

2) First Year HASS Experience

If the goal of the first semester HASS experience is to engage students and excite them about future courses, the best way to accomplish that is to allow students more choice in the selection of that first course. Limiting options to a few, lottery-filled subjects deemed exciting by faculty will alienate students interested in other areas, and frustrate those who would prefer a different kind of learning experience. Students would be excited about new HASS classes that tackle complex issues taught by enthusiastic faculty, but only if the students take these classes because they chose them.

3) Pacing Requirement for the HASS Foundational Electives

In our discussions with fellow students, we found the HASS-D requirement to be among the most frustrating at the Institute. Students generally felt the designation of HASS-D to be arbitrary and the categories strange (challenge: find a student who can name all five). The proposed merging of HASS-D and CI-H into Foundational Electives should unburden and therefore enrich HASS education.

Requiring the completion of these Foundational Electives by the end of the second year, however, will frustrate students who would rather take their classes in a different order. Many students would rather embark on their concentrations earlier. Students with strong backgrounds in HASS often find they are not challenged at MIT until they can take more advanced coursework. The proposed pacing requirement would also make the HASS classroom less varied in terms of student age and experience, a diversity students value. Finally, the pacing requirement would hurt students who intend to study abroad, as completing two

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Undergraduate Faculty, and only expect some subset to interact with our undergraduates.

The commitment of the faculty to the Commons means that we value, at every level, the unified faculty's involvement in a set of activities that help provide for or sustain this common experience for our students. This set of activities includes:

- Faculty teaching the GIRs
- Faculty involvement in reading admissions folders
- Faculty involvement in orientation (freshman picnic, FPOP)
- Faculty involvement in freshman advising/mentoring and freshman seminars
- Faculty involvement in committees (CUP, CoD, CoC, CSL, CUAFA) that oversee student education and life
- Faculty involvement in Commencement
- Faculty serving as Housemasters and House Fellows
- Faculty providing UROP supervision and IAP activities for our students
- Faculty engaging in special programs teaching/leadership (e.g., ESG, Terrascope, Concourse).

Faculty involvement in these activities allows us to help choose and set the standard for excellent students, be involved in mentoring these young people when they arrive and where they live, and introducing them to the joy and rigor of research and learning.

In order for us to more effectively pursue these worthwhile activities within the culture of a major research university, we need to come to terms with some of the barriers. The Task Force has pointed out that departments, for the most part, do not recognize or reward the desire of faculty to be involved in the larger community. This, combined with the lack of time (driven by the abundance of opportunities at MIT) that many of us feel, increases the stress levels for many of our colleagues and detracts from their ability to participate in the Commons.

The offices of the Dean for Undergraduate Education (DUE) stand ready to work with the faculty through the Faculty officers, School Deans, and Department Heads to re-emphasize the historic faculty commitment to the Commons. The DUE is committed to helping make our S&T-centric education the most sought after education in the country and to enhancing the education of all our students. We must reemphasize the faculty commitment to the Commons in a way that aligns with the faculty value propositions, recognizes the seasons of life for a faculty member, and appropriately recognizes and rewards those faculty who contribute to the Commons.

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The extent to which advisors contribute to the intellectual development of our students, participate in informal engagements, and seek to develop their individual knowledge and skills is not consistent. It is particularly around these themes of access, informal interaction and personal relationships that students recognize differences across departments and by individual.

As the Task Force on the Undergraduate Educational Commons has recognized in their report and as the detailed best practices review is confirming, existing advising resources must be strengthened; undergraduate offices must be adequately supported; advising must be recognized as a faculty role; and opportunities to develop advising and mentoring skills must be available for faculty. Part of the challenge is that no one individual has complete information. While the term "advising" implies providing advice on subjects and the curriculum, "mentoring" tends to be defined as guidance beyond the academic realm. As the Task Force described, MIT must create a network of individuals who can provide the needed advice and guidance to assist students plotting a course through their MIT journey. In the DUE we stand ready to support the faculty in this networked role as advisors and mentors.

As MIT moves forward in addressing the Task Force recommendations for the common core, regardless of the final outcome of the foundational requirements, the critical role of faculty advisors quickly becomes apparent. Faculty members have the deepest understanding of an MIT education and best comprehend the subtle distinctions of the foundational requirements. Anticipating that the new common requirements will be more complex and flexible, faculty must play an even greater role in advising students. Advising and mentoring students provides a meaningful way for faculty to effect the education and experience of young scholars and influence their transition into the community of MIT scholars.

The Task Force, in their recommendations, was clear that faculty have a responsibility and obligation to advise students, but that this service to the Commons and the departments must be recognized. Advising and mentoring of undergraduates must be acknowledged in the annual faculty review and in the promotion and tenure process.

The Office for Undergraduate Advising and Academic Programming in the DUE will be working with the Departments to promulgate best practices in advising and mentoring of undergraduates. The Dean for Undergraduate Education will be working with the School Deans to develop procedures for acknowledging faculty involvement in advising and mentoring of undergraduates.

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sation about the specific ways in which we could strengthen our sense of common purpose and community, and that MIT's undergraduate education would more generally benefit from recent experimentation and the recognition of many individual efforts, both at MIT and elsewhere. We on the faculty need to be sharing perceptions about what actually works in the classroom, how those practices reinforce or undermine one another, and how we can make the whole more than the sum of the parts.

If the work of the Task Force and its subcommittees testifies to nothing else, it is that at least 50 faculty members are willing to think long and hard about building on MIT's strengths and improving the quality of its undergraduate education for more and changing students. I have no doubt that if we can engage more faculty in the kinds of conversations and presentations we shared for over two years, the best of that educational journey will bear fruit across the five Schools. It is clear that not all faculty believe that "one design fits all" nor can we all agree what the design should be: the same, we soon discovered, is true for MIT's students. The need for more attention to individual needs – what became "flexibility" as shorthand – has so far been discussed only at the level of curricular design; however, content, context, and modes of learning are equally or more crucial. If we sacrifice flexibility of this sort to an abstract ideal model that does not capture our students' imagination, we will have failed. If our students do not understand the impulse behind and importance of the GIRs, they will be far less receptive to gain from even our best labors. Starting today, we can make a positive difference (with no more, just more efficient, effort) by repeatedly communicating the multiple values and contributions of what we are teaching – to one another, to our students, and to the MIT community as a whole. This involves active listening as well as talking.

One reason I agreed to take on a half-time administrative post in the Office of the Dean for Undergraduate Education was that the Task Force made apparent that there is still much work to be done that could be of immediate value for our educational community. We need more opportunities to learn about one another's educational priorities and practices, and the support and resources to develop our own best practices. By talking across the disciplines, the Task Force found many points of commonality and a clearer sense of the different modes of analysis expected in different fields. I think we came to respect those differences and realize that most students' experiences are made richer by the mixture itself: by the collision and cross-fertilization of disparate subjects and disciplinary approaches, not only (though also) by deep apprenticeship in one intellectual specialization.

Nor, given the diversity of our students and our fields, is there a single right combination of subjects or experiences. The world is big if not flat, and it demands scientists and engineers who understand its scale, complexity, and variety – and who can bring creativity and diverse approaches to bear upon whatever problems or situations they confront after their halcyon days in the pressure-cooker of MIT. Those last two dead metaphors are not at odds: for most of our students, an environment in which intellectual prowess is tested rigorously, where intelligence is a moral good, constitutes a paradise of sorts; it is also a special, unusual place where most likely they will not spend the rest of their lives. We must prepare them to succeed in more varied landscapes even as we hope they will value and respect the particular forms of "the life of the mind" that make MIT a remarkable, wonderful place to live and work. It is their journey as well as our own that, in the end, matters.

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about the importance of global education for their students. We feel that involvement of and ownership by faculty in devising components of a global education is crucial to its success.

We also note that the Task Force emphasizes the "international experience," alone, as sufficient for the education of a student. The GEOMIT Committee suggests a more holistic notion of global education, of which the international experience is but one part. Specifically, we propose a triad of "preparation, international experience, and retrospective" that will help a student build a "toolkit" for global competency. Where possible, we suggest integration of global education into the major curriculum.

A third reason that few students participate in existing international programs is inability to recoup financial aid while away from MIT; removing this impediment is essential, as recommended by the Task Force. More than 60% of our undergraduates receive financial aid, imposing a self-help obligation that is usually accommodated by working during the academic semesters or the summer. Many opportunities abroad preclude moneymaking activities, and the result can be a strong disincentive for many students to participate in them. Our global programs cannot come with a financial penalty, even indirect, if they are to succeed, and we suggest that the Institute modify its financial aid structures accordingly.

The innovative international programs already devised by MIT faculty and staff are enviable and provide "quintessentially MIT" models that have been proven in several years of pilot phases. However, essentially all international programs at MIT are funded outside the Institute budget. The challenge put forward by the Task Force will be to extend existing programs and develop new programs to achieve a 500% expansion over the opportunities that we have presently, all within the next five years. This expansion will require priority Institute funding, as well as acceptance by MIT educators and administrators that these opportunities comprise an integral part of an MIT education.

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faculty, play in all this? A typical undergraduate student spends 16-25 hours per week in classes (if they attend all scheduled). Not all of those are taught by faculty. Sure, we assign the problems and projects they work on, but even then, that is an additional 30-40 hours of their week and the interaction with us there is generally quite minimal.

Our undergraduates are here for four critical years in their development and growth as people. We, as faculty, do a great deal to teach the academic piece of their development, but what of their broader education? Our students are nearly always learning through a multitude of activities, engagements, and interactions – seven days a week and oftentimes 16 or more hours a day. With all this, they emerge as leaders and outstanding people in many ways. Yet so much of this is accomplished because of what *they* do, and is not attributable to *our* help. If they can accomplish so much without us, what could they do with a greater support of the faculty? As Chuck Vest noted in his 1998-99 Presidential Report ["Massachusetts Institute of Technology REPORT OF THE PRESIDENT for the Academic Year 1998-99," Massachusetts Institute of Technology, Cambridge, MA, 1999], "By engaging with students beyond the formal classroom and laboratory, we can help to develop wisdom and understanding as well as knowledge and skill." The current engagement of our faculty in such activity is more than wanting. For example, only 66 faculty serve as freshmen advisors resulting in only 37% of our freshmen *(yes, less than half!)* having that direct out-of-classroom contact with faculty when they arrive. Most of us are parents. How would you feel paying this cost of tuition and with the expectations you have sending your son or daughter to a top school, only to find out that s/he were not advised by a faculty member?

We all are faculty of MIT first. Certainly we have responsibilities to our local units – laboratories, departments, etc. But we all also have responsibilities to the broader Institute and this includes the broader educational engagement of our undergraduate – in large part, the "overall Commons." As we look at curriculum holistically, the student holistically, and the student process holistically, we must also look at the overall Institute holistically. We are one big system and must engage in that manner. It has been clear for years that there are forces in action to keep faculty from participating in these broader "overall Commons" activities. There are only two ways to overcome this. One is to provide force in the opposite direction to overcome the counterforce. This results in having forces in opposite directions with the people in between always being in tension. That's what we have now and this results in people dropping out of these engagements or having to put in more effort than is really needed. The other approach is to eliminate the force in the "wrong direction." That allows everyone to prosper in such engagements.

If we truly want to better the overall education of our undergraduates and achieve those broader visions this Task Force, and its predecessor, have laid out, we must fundamentally change our Institute and its culture to support these happenings. We need to commit to a fuller engagement in and support of the integrated educational experience of our undergraduates through their four years in this community. Central to this is support of their broader learning through participation in the multitude of activities and general day-to-day living that go beyond, and yet can be integrated with, the classroom. Let's work together to do this to make the full educational experience of Elizabeth and all her colleagues for years to come to be the one of true excellence they all deserve from MIT.

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A conflict between a Global Education and Task Force recommendations

Paradoxically, the Task Force recommendations for changes in the freshman curriculum have a significant unintended – and deleterious – impact on its recommendations for international experience. One key to success of many of MIT's innovative international programs for students is the strength of Institute resources in foreign language instruction and cultural education. The GIR curricular requirements proposed by the Task Force effectively preclude language study in the first year for most freshmen. In order to take advantage of global opportunities during IAP of the sophomore year or the summer following, beginning language study in the sophomore year is just too late – too late perhaps even for participation in the junior year. We therefore very strongly suggest that Institute requirements be structured so that students are actively encouraged to study relevant language and cultural studies in the freshman year.

A Global Educational Opportunity

MIT has not shied away from bold international initiatives in research or industrial liaison. Educating our students to be competent global citizens and leaders offers a similar opportunity for expanding existing and creating anew distinctive, innovative vehicles. Developing a truly global education is an opportunity for MIT to shine, in an even wider international context, by doing what it does best: educating its students to learn by solving important problems, this time on a more global stage.

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satisfies national standards for minimum content and quality in engineering education. Graduates of accredited programs are presumed to be competent in their discipline, as opposed to simply being well educated individuals from a prestigious school. In particular, accreditation shows that the flexible degree track is not a "second class" program producing graduates who aren't quite engineers.

What is the Value of a Flexible Engineering Program?

MIT's environment is particularly conducive to creative forms of interdisciplinary work, and 2-A gives undergraduates immediate access to an interdisciplinary education. Students obtain a strong foundation in mechanical engineering from eight core MechE subjects, three of which are student selected. Students use an additional 60 units of concentration subjects, often in conjunction with their 48 units of unrestricted electives, to build strength in a complementary area. In early 2006, our 2-A students' concentrations were distributed approximately as follows.

- 35% – Bioengineering/biomedical engineering
- 20% – Engineering management
- 9% – Product development
- 18% – Other engineering disciplines
- 18% – Miscellaneous topics, including architecture, sustainable development, and various areas of applied science.

No two students follow exactly the same path through Course 2-A. Students go various routes after graduation, including graduate study, medical or other professional schools, and, of course, employment. Details of Course 2-A are available here: ***meche.mit.edu/academic/undergraduate/course2a/***.

Administrative Issues for Flexible Degrees

One reason that we don't have a major for every conceivable specialty within engineering is that it's just too much effort to design and administer that many degree programs. A flexible program like 2-A uses its structure and fixed requirements to ensure coverage of fundamental content and certain elements required by MIT (such as CI-M, REST, and LAB) and by our accreditation board (such as a capstone design subject). It uses the student-selected content to capture the interdisciplinary aims of the program.

The student-selected content requires careful advising and monitoring. Students are required to submit a formal proposal for review. While most students choose programs that have a clear engineering theme, some students propose concentrations that are essentially minor programs in an unrelated, non-technical area. These are never approved by our department. Still, interdisciplinary work can broaden the notion of engineering in unusual ways, and so we have no single rule to define what is or is not an acceptable 2-A concentration.

A second administrative problem is that a flexible degree can appear to be a safe-haven for students who are doing poorly in a more narrowly defined major and so desire to transfer into Course 2-A in the late junior or the senior year. Such students may arrive with a scattered set of subjects from previous majors that they ask to use as a 2-A concentration; and they may attempt to complete a large fraction of the sophomore year core of 2-A during the senior year. These tendencies are contrary to the aims of the degree, and we discourage them.

More on Accreditation

Accreditation criteria for engineering degrees have two levels. The basic level includes the 8+12 content requirement mentioned before, and it requires a capstone design experience in which students apply the material learned in their other engineering subjects to design a system under multiple realistic constraints. The higher, program level criteria are what differentiate one type of engineering degree from another – for example, the required learning outcomes for mechanical engineering students are different than those for chemical engineering students.

ABET (our accreditation board) decides which criteria to apply on the basis of which words appear in the degree name on the transcript. For example, if a degree were named "SB as recommended by the Department of Agricultural Engineering," ABET would be likely to apply the program criteria for agricultural engineering. If, instead, the degree name were "SB in Engineering – Course XXX-A," ABET might apply only the basic criteria – provided that Course XXX (Agricultural Engineering) had not been promoting the degree as a program in Agricultural Engineering (e.g., via Websites or the MIT Bulletin).

Suppose that Course XXX had a flexible degree that fell under agricultural engineering standards. If the program where innovative (as defined by ABET Policy II.B.12), then some latitude is granted in meeting the program level criteria, provided that graduates can be shown to be "fully qualified to enter the practice of the appropriate discipline." This, of course, leaves something to subjective judgments by ABET's program evaluators.

Automotive Engineering

We MIT faculty may sometimes forget that our engineering degrees are Cadillacs in the sense of the content and competence that we expect. Many other accredited schools are producing Chevys in the same size curricula. Within this spectrum, our 2-A students might be thought of as Hot Rods or Funny Cars, or perhaps as one of those rarefied European sports cars that you have to order years before delivery. They are high performance products, but the specs don't match a standard production model.

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about the fundamental principles of biology in order to make informed decisions about public policy or even threats to our own health? 2. What are the fundamental skills that grow into an ability to analyze and solve hard problems? How can we provide students with opportunities to learn those skills explicitly? And once we identify those opportunities, how do we sustain them? Let's use the GIRs to strive for a small set of fundamentals on which departments can build major programs.

There is, however, one constraint I would put upon the SME core. Keep it as small as possible. The present core is six subjects, not counting the lab or REST requirements, because they are determined by the majors. A six-subject maximum is needed to protect students who come to MIT with little or no AP or advanced standing credit. Such students usually come from disadvantaged high schools without AP opportunities. Statistics show that these students have less time for opportunities such as UROP and are less likely to find supportive mentors. This situation would be exacerbated by the current proposal of eight SME subjects.

The HASS GIR is of great promise and importance. To this point science and engineering faculty have had little opportunity to participate in the discussion of the principles and goals for the HASS GIRs. A faculty-wide discussion would help us reach common ground. Again, as an example of how identifying underlying learning goals would help us focus, I suggest that the goals for the HASS GIR should be: (1) giving our students exposure to "ways of knowing" that are different from those common to science and engineering; (2) improving our students' communication skills, not only in writing, but also in oral communication and in the skills they will need in a world that increasingly relies on visual and electronic modes of communication; and (3) encouraging foreign language study and engagement in international experiences. Imagine the richness of what we can accomplish for our students through the interaction of faculty from HASS, SoE and SoS.

High-quality teaching

MIT has many great teachers, but we are at risk of falling behind our peer schools if we do not embrace recent advancements in teaching and learning. There has been an explosion in research on STEM learning in higher education over the last dozen years, and, for the most part, it has shown us that there are better ways to teach than the lecture-problem set-quiz approach that we embrace today in SME subjects.

Improving the freshman year experience

Any faculty member who has served as a freshman advisor has seen the excitement in many of their advisees wane by Thanksgiving, and has watched their students adopt a survival mentality by spring break. This is not true for all freshmen. A fortunate minority find something that keeps their interest in learning alive. For some about-to-be Course 6 majors, it is taking 6.001 fall term. For others it is ESG, 16.00, Mission 2000, or engaging in UROP. Our problem statement is: "How do we keep this level of enthusiasm in all freshmen?" The "project-based" column in the current SME proposal is an attempt to address this problem, but needs a goals-based discussion to refine it.

Preparation for the international stage: MIT has terrific international programs. We have internships (e.g., MISTI), study abroad programs and exchanges designed for MIT students, such as the Cambridge-MIT Exchange, and research and public service projects, such as D-lab, the IDEAS competition, and Public Service Fellowships. About 20% of our students are able to engage in one of these while an undergrad. We need to grapple with the problem of how to expand these opportunities to make them possible for all who want them. Moreover, any changes we make to the SME and HASS GIRs should support the goal of providing international opportunities for our students.

I believe that we can find common ground in principles and goals, which will allow us to lay a strong foundation for the next 50 years of undergraduate education at MIT. We might begin by appointing a study group, which will engage the faculty in a discussion of concrete principles and goals, and then turn to the task of reviewing specific proposals for the HASS and SME core.

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of pilot project-based subjects are being offered to first-year students this coming term; a new life sciences subject that is an introduction to neuroscience is being planned, a new computation/algorithmic thinking subject is being developed in EECS, and a number of "freshman experience" HASS subjects are being developed and will be launched beginning in the spring. The Task Force report is a call to all faculty to consider new ways to teach the old material as well as to design new curricula that will lead to a more intellectually satisfying first year and beyond for our students. I have confidence that adding this sort of flexibility and breadth to our core program will improve MIT undergraduate education.

As we said in the report: we live at a time in which citizens steeped in the fundamentals of science and technology will make important contributions to solving the growing array of societal problems. We must educate our students with a breadth of social vision as well as a depth of technical knowledge to take on these problems. MIT plays a special role in this: we are the premier technical university in the world. Others are looking to us for wisdom and guidance. What we do will be noted. I urge the faculty to come together to produce the best education we can for our students.

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this category. From my point of view, the GIR structure does not serve these students well.

A possible solution

A more revolutionary approach to introduce flexibility into the GIRs to address the problems raised above is the following. Separate the GIRs into two groups. The first group represents the freshman year GIRs and these will be taken by all entering MIT students. The second group divides into two subgroups: (1) a "balanced program" which is very similar to that proposed by the Task Force, and (2) a "technically intensive program" that focuses on mathematics, science, and engineering. A similar "humanities intensive track" could be added but, because of my own lack of HASS educational experience, I will leave this to my HASS colleagues. A simple representation of the structure is illustrated below.

Freshman GIRs
2 Math
2 Science
2 HASS
1 Engineering
1 Computation

	Balanced Program	Technically Intensive Program
GIRs	3 Math/Science	7 Math/Science
	6 Humanities	2 Humanities
Major	12 Technical	19 Technical
	4 Free Electives	2 Free Electives
Total	21 Technical	32 Technical
	8 HASS	4 HASS
	33 Total (including electives)	38 Total (including electives)

Observe that subgroup (2) represents the "nerd" track. The overall number of GIRs is 17 for both tracks. There is some, but not a lot, of flexibility within either track. The main flexibility lies in the fact that there are two distinctly different tracks. Within the technically intensive program, students graduate with 11 more math, science, and engineering subjects than in the present system. This is equivalent to a full additional year of technical subjects and should put these students in an excellent position to compete on day one in any graduate school of their choice.

The problems raised have thus been addressed. The details of implementation clearly would require a huge amount of discussion, but at this point are not the main issue. The primary question I pose to you is whether or not a two-stage GIR structure, as described above, is a worthwhile approach to pursue. ■

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DeFrantz and Rubin
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in more effort than is required, especially if the class consists mainly of large lectures in which students neither have a relationship with nor are personally accountable to their professor – a format the proposed Freshmen Experience classes will hopefully strive to balance with smaller, more intimate sections. We hope that students will never be forced into classes that do not interest them, and therefore provide little incentive to strive for excellence.

Ideally, all MIT students would appreciate both the importance of science and engineering and the world in which science and engineering takes place. The goal of the HASS requirement is to instill this appreciation in students, a goal that is undermined when, as is the case for some students now, the HASS requirement is not taken seriously. Introducing students to the HASS requirement by mandating enrollment in a large class on a topic they are not interested in when they have no incentive to put in any more than minimal effort is not likely to make them take the requirement more seriously. For incoming students to have a positive HASS experience that sets the stage for a positive future outlook on the HASS requirement, they need to be able to take a class they are interested in that has at least some section small enough for them to have a relationship with and feel a sense of responsibility to the section instructor. The proposed Freshmen Experience HASS classes should balance small-group meetings with large-group lectures, should not be mandatory for students whose interests lay outside of the available options, and should be closely monitored to ensure that they are of the high quality definitive of an MIT education. As members of the HASS Overview Committee it is our responsibility to ensure the quality of students' HASS education, and therefore we feel it is critical that these concerns be addressed in the process of implementation. ■

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years studying the *cultural/creative* areas. Consequently, most students come to MIT ignorant or even unaware of disciplines that provide important links between the other HASS fields and the sciences. How can they see a continuum if large parts of it are absent from their experience?

This "high-school asymmetry" lies at the heart of our concerns. The Task Force's HASS recommendations presuppose that subjects for students in their first semesters should focus on "'big ideas' concerning culture and society that have endured over time" rather than on "fundamental methods of scholarship and areas of knowledge." But to meaningfully address most "big ideas," students must first acquire the intellectual tools and factual knowledge relevant to the questions addressed by these ideas. In HASS fields where this does not take place in high school, the Task Force recommendation is putting the cart before the horse.

Of course the cognitive/social fields do teach "big ideas about culture and society" too. For example, MIT's introductory linguistics course (24.900, a HASS-D) often ends with a discussion of dialect variation, with a particular focus on African-American English. The students listen to a rant delivered by Bill Cosby to an NAACP meeting, in which he mocks African-American English and derides it as "crap coming out of your mouth." We then examine the actual facts of the dialect. Students discover that the object of Cosby's derision is in fact a law-governed linguistic system just like any other. It has a sound system, sentence structure, and lexicon whose properties are just like the properties of all the languages that the students have just spent three months studying – through problem sets, reading, and essay writing. The striking contrast between the stigmatization of this dialect and its formal status as a language just like any other leads to discussion of important general questions about language and society. These are exactly the kinds of broad questions that should be welcome in foundational-phase HASS courses, but because of the high-school asymmetry, students cannot meaningfully address them until they have learned the basics of a discipline first. That is why "language and society" is a topic for the *end* of the semester, not the beginning.

We suspect, in fact, that almost all current HASS-D subjects address "big ideas." The Task Force report, however, by insisting that the replacements for the HASS-D requirement not be "retreaded HASS-D subjects" or "narrow introductions to particular disciplines" effectively removes from the introductory curriculum those subjects whose "big ideas" are deeply bound up with a disciplinary background not provided in high school. Many students, for example, encounter philosophy for the first time in the HASS-D subjects "Justice" and "Minds and Machines." *Justice* and *thought* are "big ideas," but a course that properly engages them can hardly avoid being an introduction to political philosophy or philosophy of mind, respectively. Take these subjects out of the first-year curriculum and many students will never learn what they have to offer. Worse, suppose we do figure out a way to "retread" these classes as First-Year Experience offerings. We then face a different problem. First-Year Experience classes are for freshmen only. How, then, would students gain access to this material after their first year? Will we have to devise a second set of introductory courses in political philosophy and philosophy of mind? These would be not only redundant, but would stretch our tiny faculty too thin.

We think it should be possible for a freshman or sophomore to enter fields like ours in fulfillment of the pre-concentration HASS requirement, if only because of the place that such fields occupy in the continuum of topics that link the SHASS fields to the rest of MIT. "Big ideas" classes are great, but so is the discovery that there is a whole intellectual world waiting to be explored in fields that a student never met before. Encountering unexpected topics of interest is, after all, one of the joys of learning. We think it is one of the jobs of a great institution to provide not only a structured curriculum but also adequate time and space for such serendipitous encounters. It is easy to denigrate the current HASS curriculum as an "an incoherent academic arcade," as the report does, but one should not forget that people do win prizes in arcades, and that the best education is not necessarily a tightly managed education.

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It represents the most quantitative mode of inquiry of all the sciences. Of the various ways to approach science, physics in general, and E&M in particular, starts with the smallest set of fundamental assumptions. Quantitative rigor in solving important problems is rewarded by unprecedented agreement with measured results. Chemistry and biology demonstrate different, complementary approaches to dealing with natural phenomena.

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transferable skills. This is particularly important when one considers the data on where our alumni pursue careers. Even as few as 10 years after graduation, a striking number of our alumni/alumnae are working in fields unrelated to their major discipline as a student – yet clearly, as they are usually the first to acknowledge, they benefit from the analytical, critical, and problem solving skills that they acquired along the way.

Of course, to support a system that encourages diversity of intellectual bases, there is a responsibility on the part of the faculty to provide appropriate mentoring and advice. While many students will come to MIT knowing what they want to study, none will have the breadth and depth of experience of our faculty. It is up to us to engage deeply with students – to provide advice and suggestions on selections of foundational courses, on the kinds of careers such choices enable, and on the exciting opportunities at the interfaces between and boundaries of existing disciplines.

What should every MIT undergraduate know by the time they leave the Institute? While it is no longer possible to empower students with knowledge in every relevant field of inquiry, it is possible to provide them with the curiosity and learning skills to acquire new fields as needed. By providing students with an opportunity to tune a foundational basis to meet a diverse set of needs, we enable them to step into leadership roles when they leave the Institute.

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Listening to the currect debate about the GIRs reminds me of similar meetings when the faculty discussed the recommendations of the Curriculum Content Planning Committee (CCPC) in the '60s and a comment made by Prof. Sam Mason. Sam was an EE faculty member with great empathy for students – he was a Housemaster and an active member of the department Stu-Fac committee. His comment (perhaps paraphrased somewhat from passing through the mists of time) was:

"The MIT undergraduate is like a sailor crossing the North Atlantic in a rowboat – tossed about by winds and weather and struggling mightily. To such a student, the deliberations of the faculty are like the mating of whales 10 fathoms down – fascinating but of little practical effect."

– art smith

Kirtley
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conclude that more than two terms of physics are necessary. We might also conclude that some of the science subjects need to be larger than 12 units.

Many of the observations and recommendations of the Task Force are valid. We should expose the students to real-world engineering challenges early in their time at MIT. (This is part of "lighting the fire.") The project-based subjects now being developed could serve this purpose, perhaps as enhancements to freshman seminars. Computation and programming skills should also be part of the undergraduate curriculum. Opportunities for introducing computation skills will arise in mathematics and science subjects. Perhaps the otherwise poorly used time in the students' first IAP could be used for a first subject in programming.

HASS requirement and unit creep

The expository writing requirement is a long awaited improvement. A common first year experience is a good idea, but as one of the students who, in 1963, suffered through 21.01, I have to say that designing such a subject will be a real challenge.

To fulfill the objective of educating our students to be good citizens, it is most important that the HASS curriculum incorporate elements of history and social science (including economics). While the "Arts" are fun and interesting, it is less clear that they are necessary in a general education.

Finally, in the 40 years since the Zacharias Committee report, the HASS requirement has grown from 72 to 96 units plus parts of two department subjects (the CI-Ms). We should determine if this is really what we want. Sizing the first year HASS subjects at nine units would leave enough time in the first term to accommodate a nine unit project based lab subject within the 54 unit freshman credit limit.

The Task Force is on to something

A lot of good work and effort went into the Task Force report. These remarks are not intended to be a negative comment on the work of the Task Force, but rather a recommendation for strengthening the Educational Commons that arises from its conclusions.

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disappointing assessment. The proposed plan does little or nothing to promote collegiality and understanding.

The most important aspect of our core should be committed and passionate instruction for every minute of these classes. These teachers must bring a love for the material they teach and for the intellectual growth of the students. The menu plan offers only competition and a curricular maze. It would be an "every person for himself" plan, for both the students and the faculty. It offers no compact with the Institute leadership, and no assurance that resource allocations will be made for the greater good of our faculty, staff, and students.

Many other possible plans would address the goal of igniting passion. For example, with no other change to the science core as currently incarnated, we could replace the Institute Laboratory requirement with a requirement for one engineering project-based (PB) "sidecar" class selected from a menu, possibly specifically identified as pairing with a particular science core class. These PB sidecars, already in concept demonstration with D'Arbeloff funding, would provide hands-on learning, experiment planning, a serious research experience, and closer faculty contact for the freshmen. They offer the possibility for science and engineering faculty to collaborate and to potentially support the first-year advising program in new ways.

There are subtle concerns with other recommendations in the report. For one example, the report recommends "making assessment an Institute policy." Of course, we must hear and be responsive to the voice of our customers. Great care must be taken, however, as this information is mined and milled to play a finer role in our administrative processes. The report makes the inarguably laudable demand to employ the same "scholarly rigor and data-driven attitude" as employed in our scientific research. Will we deploy resources to conduct honest double-blind studies of different teaching methods? If we choose other methods such as longitudinal or statistical studies, will we develop reliable means to distinguish generalized best practices from what amounts to Hawthorne effect? If taking advantage of a practical Hawthorne effect is its own best pedagogical practice, how much additional assessment is needed over our current practices to simply support sustained pedagogical renewal? A recent move to on-line evaluation was touted as "more convenient for those students who don't go to class to get their voices heard." Are we comfortable having such "data" used with thresholds for evaluating promotion cases? If not, will we invest the resources to nurture pedagogy and conduct compassionate and meaningful assessment *before* we further expand the administrative role of assessment data?

We led the world with the education system we developed in the last half of the twentieth century. In the twenty-first century, every university faces the straining challenge of breadth. We have the opportunity to rise to this challenge. A gift of our past success is access to resources and collaborative opportunities unavailable in many other venues. We need to articulate a sound, clear vision in order to plan, to build, to embark on fund-raising, and to win.

I hope to assist with whatever program we decide to pursue, and I appreciate your time and patience.

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consider structures that make such a statement. The "project-based" requirement makes some progress in this regard, but interdisciplinary teaching across the two cultures may or may not be project based, and should not be limited to that category. Moreover, there is no overlap between such "project-based" experiences in SME and the "freshman experiences" in SHASS.

Finally, as I said in one of last fall's faculty meetings, in all the debate about changes to the GIRs we should not blind ourselves to the smaller recommendations in the Task Force report that could be implemented quickly, with broad consensus, and at relatively small cost. Chief among these is the recommendation to change the "double degree" requirement to a "double major" (p. 107). This change will strongly encourage students who have deep interests in two departments to pursue two majors simultaneously. The Task Force was unanimous in supporting this idea, having heard no objections to making the change (if such objections do arise they clearly need to be addressed). But with the stroke of a pen (or a vote of the faculty) this change would radically increase the ability of MIT undergraduates to master multiple disciplines in a rigorous way. I urge the faculty to take up this question this spring, and to implement this simple measure as a welcome, satisfying sign of progress. No other Task Force recommendation would energize so many students in such a short time.

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and the process of degree auditing (especially for programs with a large number of students). It would also encourage the creation of relatively arbitrary requirements to round out the necessary number of subjects.

- Departments can specify as requirements a sufficient number of the SME GIR options to fix the number of engineering GIRs taken. For the ME programs, 18.03, 8.02, and a chemistry subject are needed; the only way to make the remaining two options predictably engineering or science would be to specify them both. In short, *we would have to specify all five options*. Slightly different calculations would apply to other engineering departments, but most are likely to reach a similar conclusion.

In contrast, a 5-out-of-5 model could allow a predictable mixture of science and engineering preparation at the GIR level, while retaining student flexibility within some columns and without driving the departmental programs toward growth. This is most easily explained by examples.

- Suppose the five columns to be Physical Science, Chemical Science, Life Science, Computation, and Project-based subjects. ME degrees would require 8.02 and an engineering project (chosen from any of several in the Projects column). We may or may not need to specify the Computation subject (at present, it's hard to tell what that column would contain). Thus, two or three of the columns would be flexible (Life Science, Chemistry, and Computation) and a fourth would have more limited flexibility (Projects). We would require 18.03 in our departmental program.

- Suppose the five columns to be Math, Physical Science, Chemical Science, Life Science, and Computation. We would specify 18.03 and 8.02 as GIRs, and treat Computation as in the previous example.

- Suppose the five columns to be Math, Physical Science, Chemical Science, Life Science, and Projects. We would specify 18.03 and 8.02, treating Projects as in the first example. We would cover basic computation in the departmental program, as we do now.

These arrangements would each allow us to meet accreditation standards without completely eliminating flexibility. In each example, by the way, the Course 2 degree would have to give up one or two 2.xyz subjects to avoid growth; however, the new GIRs in computation and engineering projects have the potential to mitigate programmatic damage. Note that: each example separates engineering from the computation column; each retains 8.02, Chemical Science, and Life Science as GIRs, the last two reflecting the general consensus of ME's faculty; and each requires 18.03 either as a GIR or as a departmental subject.

A final variation that I will mention are the 4-out-of-4 models that have also been suggested. The deterministic nature of such models would allow us to construct departmental programs meeting the essential requirements outlined above.

In its 5-out-of-6 proposal, the Task Force specifically recommends against letting departments specify all five options. Indeed, a 5-out-of-6 model in which departments may specify all five columns looks a lot like a 5-out-of-5 model. It differs from a true 5-out-of-5 model in its increased opportunity for freshman to choose SME subjects that would not be applicable to a departmental major chosen later on. It would also allow departments to exclude some fundamental areas, such as Chemical Science, in favor of areas that are less obviously fundamental, such as Project-based subjects.

In summary, the ME faculty strongly endorses a reduction in the number of columns in the SME GIRs. From our perspective, each of the 5-out-of-5 examples described above can be made to work; and as it becomes clear what subjects might go into the four proposed new SME GIRs (Math, Computation, Engineering, and Projects), we will undoubtedly develop a preference for one or two of them.

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AP credit for 8.01 by an MIT-administered advanced standing exam.

As a final note, we have asked the Physics Department about AP student performance in 8.02. In fall term, the non-AP students taking 8.02 are predominantly sophomores who for one reason or another did not complete 8.02 in the freshman year (e.g., they failed 8.01 or 8.02), and the AP students outperform them. In the spring term, very few AP students take 8.02. As a result, a useful comparison is not easily made.

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issue directly in this *Faculty Newsletter*. I will just say here that the 5/5 version will likely make this connection more straightforward for many departments and students.

An argument which I feel strongly about is the simplicity and clarity of the 5/5 approach. Whatever GIRs we as a faculty ultimately adopt, we will be sending messages both inside and outside MIT. I believe that a clear message about what we believe is important for all of our undergraduates to know has considerable merit. For example, I believe we were correct in the early 1990s to require some knowledge of life sciences of all of our students, and I would not want that and other important messages to be muddied.

There are of course many ways one could contract the 5/6 formulation to a 5/5 formulation. Perhaps the most straightforward and practical way would be to combine the Computation and Engineering and Project-based First Year Experiences areas. Unlike the traditional areas of Chemical Sciences, Life Sciences, Mathematics, and Physical Sciences, the area of Computation and Engineering and that of Project-based First Year Experiences would be new to the GIRs. It will take some time and experimentation to get to the point where appropriate offerings are available to large numbers of students. It may be sensible to combine those two areas into one during that time of development so we would not be misleading students about availability. One might define a five-year period of development, after which the faculty would explicitly evaluate subjects that had been developed, how the 5/5 approach was working, and whether there were good reasons to go to a 5/6 approach. Another suggestion which was discussed by the Task Force was the possibility of eliminating the Mathematics area, thus leaving a 5/5 formulation. This suggestion came from the realization that requiring a third math subject would actually be an increase over the current requirements in mathematics, that most of our students now take more than two mathematics subjects, and that this would certainly continue in the future under any of the schemes we eventually adopt. In any event, if the faculty ultimately decides that the 5/5 version is preferred, a complete discussion of how best to define it must take place.

Finally, while many of the discussions in the Task Force and afterward have been heated, I periodically remind myself that all of the changes to the traditional Science and Mathematics core we are considering will likely be viewed from a distance as essentially tuning an already strong and challenging educational system. There seems little possibility that changes will be interpreted, by our prospective students or by educators in general, as a weakening of MIT's commitment to a first-class and demanding undergraduate education in science and engineering. Our current system works well. Many of us believe it can work even better, and we want to make it so.

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Educating the Global Citizen

Knowledge is being created all over the world, and the Task Force recognizes that MIT faculty and students learn from, add to, and participate in its creation. We need only to look across the Institute to see an astonishing array of programs offering opportunities for international learning, many of which are in SA+P or call on our faculty. For several years, the faculty of SA+P, often in collaboration with faculty from across the Institute, have offered international practica, studios, or exchanges in places like China, India, Mexico, Japan, Mozambique, Turkey, or Brazil. The Beijing Design Studio with Tsinghua University is one of MIT's oldest collaborations in China. The Task Force call for more attention to the maintenance and growth of these programs is one that is long overdue. The faculty and the students will be better served with improved coordination and support of global learning experiences.

In the May/June 2006 *Faculty Newsletter*, Charles Stewart reminded us that at the end of the day, we all work to prepare our students for a lifetime of learning – in the sciences, the arts and the humanities. This is what the Task Force strives to do; it is what the School of Architecture and Planning has successfully done in the last several years with new curricular innovations intended to implement exactly the ideas developed by the Task Force. Engage students in on-the-ground problem solving or design, usually in teams, and confront some of the big challenges of our times: environmental degradation, poverty, over-urbanization, insufficient access to water and sanitation, unemployment, and sustainable construction; do this by building inter-disciplinary collaborations with other programs at the Institute such as history, political science, and engineering; teach, learn and research across cultures and across countries; rethink our conception of design to include technology, engineering, and the arts.

With thanks to the Task Force, the educational imperative is clear: prepare our students to be fluent in science and engineering to capably and competently understand and address complex problems of the human condition. With this as our goal, the proposed changes to the GIRs will lay the institutional foundation to better draw on the strengths of the entire MIT faculty to ready generations of leaders who can solve complicated, interdisciplinary problems, in a team, across cultures, and in multiple domains – whether labs, companies, cities, or nations. The faculty in the School of Architecture and Planning stand ready to do our part.

With thanks to Athelia Tilson for her assistance with this article.

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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 MIT 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 payoff: to keep MIT at the forefront of technology education for the twenty-first century.

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particular decisions required may not be in the student's best interest – for the reasons described in the previous two paragraphs.

I propose below a concept which, as I understand it from two members of the Task Force, was not identified (and therefore not evaluated). The proposal has an aspect concerning subject matter and packaging, and it has an aspect concerning teaching and learning.

Subject Matter and Packaging

I propose that for the freshman year only we run a quarter system with the beginning of the first and third quarters coinciding with the beginning of our standard semesters and with the ends of the second and fourth quarters coinciding with the end of our first and second semesters. Some subjects would be two quarters long. Others would be one quarter long and would be designed to expose the student to the particular character and perspective of the discipline in question. With a quarter system, there would be more opportunity to sample from the breadth of human knowledge. Some of this sampling can be prescribed and some can be by choice. However, the broader exposure will allow students to make a more considered choice of major and they will be better equipped to work at the fertile boundaries between disciplines.

Teaching and Learning

I propose that an aspect of choice and decisions be presented explicitly to the students on the question of teaching and learning environments and styles. It should be a goal of their freshman year to understand a variety of approaches and to understand how they can benefit from each modality. Perhaps personal preferences will develop which students can use to help guide their educational careers. The faculty would, through coordination, offer different subjects in explicitly different modalities of teaching and learning.

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museums. In addition, some students in the spring take the optional subject SP.360, Terrascope Radio, in which they develop and produce a radio program on the year's core topic; the program is broadcast on the MIT campus radio station, and is then made available for use by public radio stations nationwide. During spring break, Terrascopers participate in an optional field trip to a region closely connected with the year's core problem.

The Terrascope community benefits from the active participation of alumni of the program with many of them serving as Undergraduate Teaching Fellows (UTFs) for one or more years. A remarkable fact is that Terrascope students and those that become UTFs come from a broad cross section of the MIT community. Their dedicated participation is the result of understanding the value of solving big problems with an interdisciplinary approach, regardless of their major.

Extensive annual assessments have led to constant improvements of the individual classes and program and provide evidence of the satisfaction of the students. When asked "Knowing what you know now about Terrascope, would you recommend it to incoming first year students who share your interests?" 67 percent said "definitely would," 29 percent said "probably would," four percent said "maybe." Creativity is at the heart of the Terrascope experience. Quoting from a student:

> *You come to MIT with all these great ideas about what you're going to do and you get totally bogged down with the problem-set routine. . . . And (Terrascope) definitely improved how I felt about my academic freshman year because it was challenging in an intellectual sense . . . you have to think creatively . . . .*

The Terrascope program resides within the Office of Experiential Learning, recently created by the Dean of Undergraduate Education. Although two departments (Civil and Environmental Engineering and Earth, Atmospheric and Planetary Sciences) have generously supported the program and continue to provide faculty time and some space, the budget is outside of their control. Student recruitment to those two departments is not a program objective, and, in fact, over the four years of operation only 43 students of the 343 that have participated in Terrascope and/or Mission20xx have joined Civil and Environmental Engineering or EAPS.

It should be clear that a key element of Mission/Terrascope success is the problem driven, open-ended, interdisciplinary approach. We hope that departmental response to the Task Force will be to develop a range of subjects that have strong interdisciplinary focus and are not explicit parts of the hard-pressed departmental curricula. In our opinion, it would be a mistake to have the new generation of classes focus more on pedagogy than the message that big problems require a true interdisciplinary approach.

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courses in the first year can help bridge the gap between the profession a student eventually wants to practice and the necessary preparation for that profession. For the hundreds of MIT students whose future lies in product development, an engineering design experience in the first year provides a cornerstone that will solidify and integrate their education. Therefore, I strongly support the Task Force recommendation to offer more flexibility including a General Institute Requirement dedicated to project-based subjects.

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Foundational Electives and the First Year Experience in the first four semesters would make significant study of a foreign language extremely difficult before junior year.

Advice wanted

The current advising system could be greatly improved by encouraging more meaningful student-advisor interaction. Because each meeting is focused on the upcoming semester, less emphasis is placed on students' overall plan. Midterm meetings would allow more discussion of the long term, and would connect students with their advisors when students are struggling the most. We would like to see advising made a part of the tenure and promotion process, much as teaching is, and we would like suggestions about how to be better advisees.

Conclusion

We value the intellectual energy and intensity of an MIT undergraduate education. The Task Force strove for a Commons that "ignite a persistent passion for learning," and we believe this to be the most important goal. However, we would like to recall the words of former MIT President Jerome Wiesner, that "getting an MIT education is like taking a drink from a fire hose." If indeed, in the words of Yeats, "education is not the filling of a bucket, but the lighting of a fire," we must be careful that the experience of the Commons does not inadvertently extinguish the very flame we are trying to fuel.

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lems," "applying intelligence and analytic skills" to such problems. Such courses also "contribute to a student's professional identity."

More subtly, project-based subjects can play a critical role in laying a *pedagogic foundation for further learning.* This is far more than just motivation. "If properly designed, students will be involved in authentic experiences." They will learn to "connect theory, principles, and equations to something that works." Such concrete learning can have an important role in learning retention – " It can be a lasting experience when learning hands on." Such learning experience can cater to the variety of learning styles among our students – "a 'C' student in a lecture course can be an 'A' student in one of these courses."

The learning cycle proposed by Kolb [Kolb, D.A. *Experiential Learning*. Prentice-Hall, NJ, 1984] – concrete experiences, reflective observation, abstract generalization, and active experimentation (and then back to concrete experiences in a loop) – may better serve many of our students, who tend to learn from the concrete to the abstract [Qualters, D. *Learning Styles*. All About learning/Aero-Astro Learning White Paper Series. Massachusetts Institute of Technology, Dept. of Aeronautics and Astronautics, 2001]. This would give them the personal cognitive structure onto which the abstractions they learn in many of our other theory-based subjects could be mapped. The result is deeper learning of the abstractions, and better long-term retention.

Detriments and Other Issues

Picking up again on the theme of *pedagogic impact,* there is a concern that freshmen are not prepared for project-based experiences – "Freshmen don't know much, don't know all the principles yet; would these courses go better if we waited a year?" Others reflect the learning style variety as a concern: "It is possible that not everyone has an aptitude for this type of thing, but it can't be that bad to learn it for one semester."

Many faculty expressed concerns over *curricular tensions.* The most critical is simply the scarcity of time, that project-based courses "should not replace a GIR – should not be at the expense of a fundamental course." A more applied curricular concern is for the structure of the project-based subject in the Task Force proposal, indicating that there "seems that there are symmetrically more intelligent ways to do this," and that "interdisciplinary or inter-School courses would be better."

A widespread concern was of the *quality* of these offerings. At an intellectual level, there is a "concern that we'd be teaching merely surface behaviors that mimic authentic processes and students will think they then know something that they really don't." Said another way, "Will students think this is something 'Mickey Mouse' that was cooked up for freshmen, unlike the core courses they know are serious?" It is "very different to do these courses with freshmen – you cannot take an upper course and just use it for freshmen." In addition there were general quality concerns that such subjects need to be done carefully, and that there is "very little evidence (from the old Lab requirement) that there is effective monitoring and oversight of these courses."

Finally, almost everyone interviewed spoke in some way about a concern about resources. The "enormous preparation time for instructors," the "equipment for each student – must we share?" and the scalability to hundreds of students were prime concerns. The scarcity of interested and qualified faculty was evident in comments like "How many profs are good at this?" and that the interested "faculty submit pilots, but that may change in the future." Space, sustainability, and scalability were all issues.

There were also a number of comments made that did not identify project-based courses as clearly beneficial or detrimental, but which nevertheless highlighted important issues. These issues fell into the categories Fit Within Curriculum/Coordination, Value of Choice vs. Fundamentals vs. Improving GIRs, Evaluation and Assessment, Faculty Issues, and Ownership.

Summary

The benefits identified by the qualitative responses of the faculty generally support the propositions of the Task Force, and the experience with project-based subjects at MIT and elsewhere. The pedagogic value of helping construct a cognitive scaffold to support deeper learning of further, more abstract fundamentals, is not as well recognized as its value might suggest.

The detriments identified by the stakeholders are all legitimate. Some are more matters of priority of investment or resources, but must be considered in the implementation of the Task Force recommendations. Others call for quality in a sustained and scalable manner, and the development of adequate resources to ensure the job is done "MIT well."

The faculty responses for expected proficiency in nine skill areas – Problem Solving, Inquiry-Based Knowledge Discovery, System Thinking, Personal Skills, Attitudes, Conceiving/Designing/Building, Teamwork, Communication, and External and Societal Context – did not reflect a strong consensus that any one skill be emphasized. There was broad consensus that all of the skills should be learned near the level of "To be able to participate in and contribute to," which is a high expectation for a first-year subject. As an indication of hope, those who currently teach freshmen and sophomores were the most optimistic about what could be accomplished. The student input was also hopeful, and perhaps indicated a potential emphasis on teamwork. The vast majority of prospective MIT students indicated they would be interested taking such a subject.

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Those who have argued that these changes are not radical enough are correct: they aren't radical enough – as many in the Task Force were well aware. However, the proposed changes represent what seems achievable (and indeed the very least we should aim to achieve) in an intellectual culture still far too strongly wedded, in my view, to the existing educational structure, and to an understanding of the first year as serving primarily a pre-requisite function (for which the production of homogeneity is central). It is this culture that the Task Force seeks to change, and such an alteration, through steps that are small but cumulative, has never been so necessary. Students come in different sizes, students grow to different sizes. The first year at MIT needs to acknowledge these variations and to encourage them.

Variety in what one learns, and in how one learns what one learns, has been further squelched in our recent past by another regulation, one the Task Force does not address: the imposition of credit limits throughout the freshman year. To convey my sense of how pernicious this development has been, I need to turn briefly to my own experience as an MIT freshman in the pre-limit days. Being able to take and to handle five subjects meant that I was able to continue studying a foreign language, to do philosophy and to explore circuits (thereby testing my own original intention to major in Course 6). Having completed a greater number of subjects in my freshman year had a knock-on effect, making it easier for me to pursue interests in other fields in later years, and complete a double degree. Indeed, it was my second degree – then thought of as secondary – that later became primary. People grow and learn differently – and often unpredictably. Education needs to make room for that. Consequently, and more concretely, we need at the very minimum to consider lifting the credit limit for the second semester where students are now already on grades, and where their choices make a more public difference (on their transcripts and for their careers). Rather than strait-jacketing those in the freshman class capable of and itching to do more, we need to let them explore other areas of interest, or pursue in greater depth an area they have already decided upon. We need to free them not only to do so, but to "learn by doing" the consequences of their own decisions.

By opening choices and risks in the ways described above, we not only involve students more actively in their own learning, but render necessary a different kind of advising. Such advising would truly call for faculty who can help students reach decisions of more import than the choice between two excellent varieties of introductory chemistry, faculty who can engage students more fully as individuals choosing and finding their own trajectories in a new place – and faculty who have indeed the power to decide, for instance, whether a student has shown the drive and ability sufficient to allow him or her to break out of the one-lowest-common-denominator size that our first year currently imposes. Advising needs more faculty participation, but in an educational environment where advising means more than making sure that students check the right boxes.

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that demanded inspired diagnoses and debugging – good life experience that is important to get sooner rather than later.

There are tremendous challenges in offering such courses on a large scale. What does it take to go from 26 students to 100 or more? Faculty availability and commitment are often identified as issues, but I think there are enough among our ranks who enjoy this form of teaching and will make time for it. More of a barrier is the need for flexible, well-equipped and attractive teaching space that will provide the tools, lab equipment, and work space needed for relatively large groups of students to work. Faculty should not have to squeeze into already crowded rooms or be forced to raise their own funds for equipment and supplies.

There have been discussions about incentives for freshmen to take project-based classes. On their merits, these courses could successfully compete with whatever else freshmen consider taking as electives. However, freshmen are eager to fulfill Institute requirements. Further, the commitment at the personal and Institute level required to make project-based courses widely available is, realistically, not appropriate for electives. We think the courses can thrive and serve their intended purpose under many possible scenarios regarding the undergraduate commons. For example, they could replace the Institute lab requirement, be paired to courses in the science core, or team with an STS-style humanities class with integral freshman advising. Our strong preference is for project-based classes that supplement rather than replace a core body of knowledge.

Many of our competitors now offer freshman seminars to complement core classes, something we have done for at least 40 years. Other schools advertise these seminars as offering first-year students access to the wisdom and experience of learned faculty. Nothing wrong with that; we do it here as well! But that is not the same as hands-on grappling with design problems, in different fields and at different scales. We offer our undergraduates a unique education; our motto stipulates that they use their hands and their minds. We hope the current efforts sponsored by the d'Arbeloff Fund are just the beginning of an Institute-wide engagement of freshmen in the kind of active learning that many have done before they come here and that we look for in their applications.

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that the scheduling or goal-setting skills that they acquire will be good ones. For project courses to serve the objective of teaching skills, the faculty offering them must know enough to teach those skills and the course project must be a platform for learning them. Fortunately, there are faculty at MIT, and many faculty elsewhere, for whom the study of these skills is a focus of research. Unfortunately, few of us know the literature. Before we set out to address the learning of skills through a project-based first-year experience, we will have to identify and articulate the skills to be taught and then put in place the mechanisms for faculty to prepare themselves to teach those skills. MIT is no place for novices.

Inherent in the debate over what knowledge should be taught is the issue of who decides. Particularly, who will say how many of the "six choose five" a department can specify? Battle lines are being drawn. Engineering departments are seen as inflexible. Why is this issue so contentious? A look at the norms provides some insight [*Digest of Education Statistics – 1999*. National Center for Education Statistics, U.S. Department of Education, Office of Educational Research and Improvement. NCES 2000-031]. A U.S. student receiving a Bachelors degree in engineering will spend just shy of 75% of class units in classes on mathematics, natural sciences, engineering, and computer science. Students receiving degrees in the natural sciences will spend 55% of class units in these classes.

Why the spread? Schools of engineering are charged by the engineering community with the task of preparing their undergraduates to enter the engineering workforce. A large fraction of MIT's engineering undergraduates, hundreds per year, will not pursue advanced degrees. They're ready to work and they want to get to it. Students in the sciences, upon completion of their degree requirements, are not expected to become practicing scientists. A BS in engineering is a professional degree; a BS in science is not.

So where are we at MIT? Currently, for my department, things look like this:

math (24) + science (48) + {REST (24) + lab (12) + ME Department (138)} + HASS (96) + free electives (48) = Total (390)

(24 + 48 + 24+ 12+138) / 390 = 0.63 or 63%

Our current arrangement sets requirements for engineering that are essentially midway between the national norms for engineering and those for science. So it's not surprising that engineering faculty might feel they currently are unable to fulfill their educational responsibilities in a way that meets the expectations of their professional community, while faculty in other Schools see them as greedy.

Engineering curricula and science curricula are and should be different. Engineering and science students, in the aggregate, have different career goals. Both sets are noble and are central to the Institute's mission. And they are not the same. Several recent pronouncements by prominent MIT faculty, implying that engineering and science are two sides of the same slice, are, in my opinion, misguided. In the survey mentioned above, none of the 300 engineering alumni listed themselves as scientists. In a community that celebrates its respect for diversity, we should invest the time needed to understand and honor the differences among the missions, the methods, and the external forces that define the cultures within our Schools. These differences should be respected when we make the rules.

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grad has within her reach the ability to use her technology-centered education to deeply impact minds, hearts, bodies, and souls like never before.

In this new century, MIT has the unique opportunity to use their good ole "E to the U du dx" charm to make, as former President Vest once put it, "Engineering as the humanities of the twenty-first century." This is unlikely to happen with a business-as-usual approach to an MIT education, and I am optimistic that the next evolved step of the GIRs will gradually get us there. Because I now see a slew of MIT alums from Course II, III, VI, and VIII, to name a few, showing at prestigious venues from the Museum of Modern Art in New York to the Centre Pompidou in Paris as leaders of culture and distinction. An MIT education that prizes students' creative skills and gives them more tools to be able to "hack" their future life will broaden MIT's leadership beyond making great scientists and engineers, to inventing great artists and designers as well. Then perhaps our world can ultimately solve the biggest problem set of them all … without even pulling an all-nighter!

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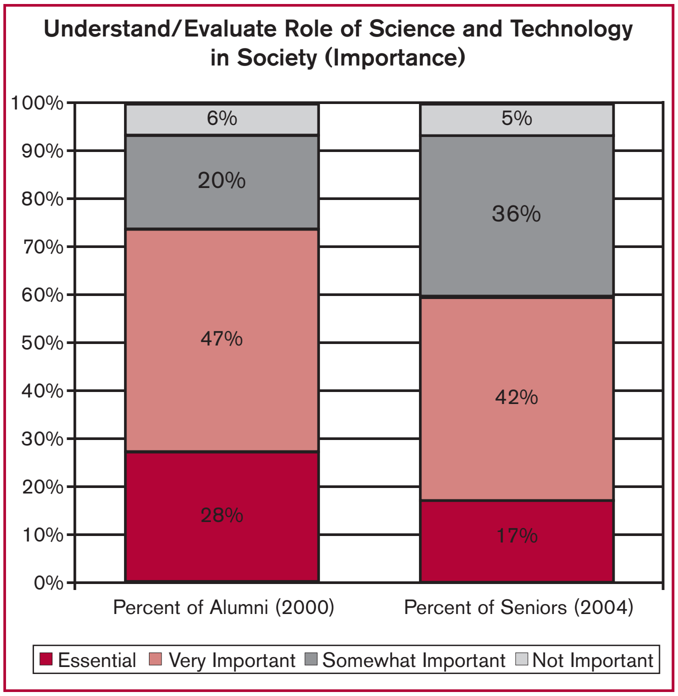
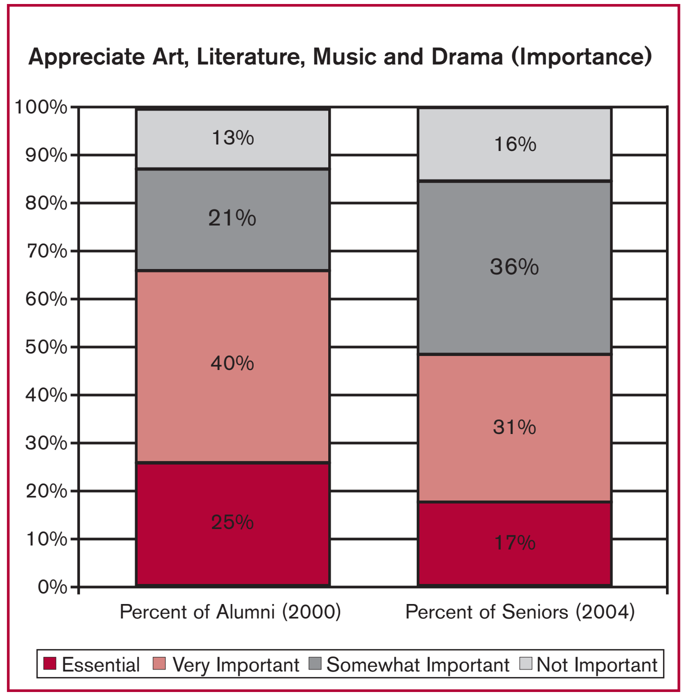
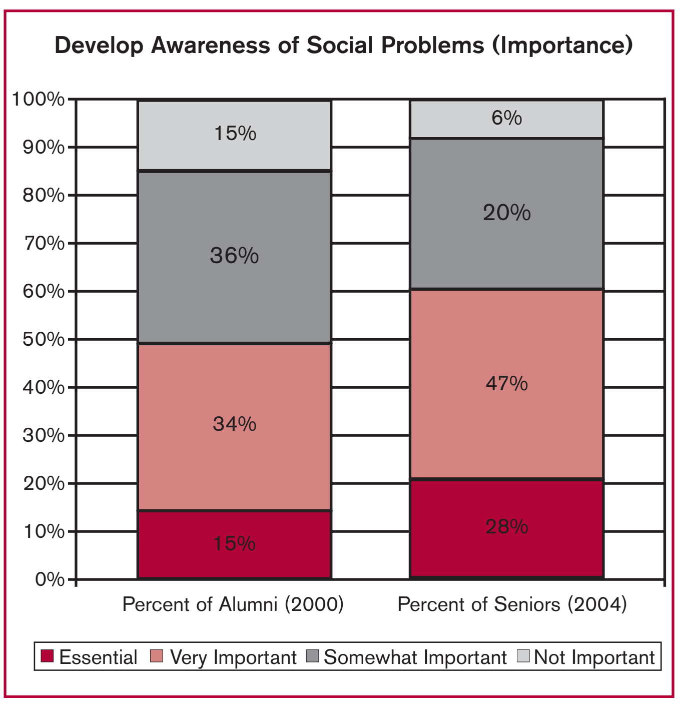
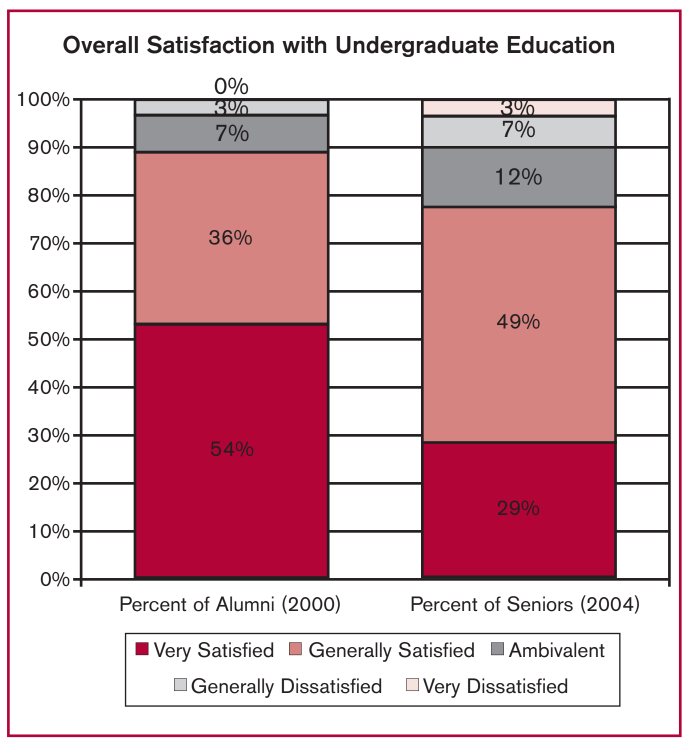
M.I.T. Numbers

Select Data Considered by the Task Force on the Undergraduate Educational Commons









From the 2000 Alumni Survey and the 2004 Senior Survey
Source: Office of the Provost/Institutional Research

M.I.T. Numbers

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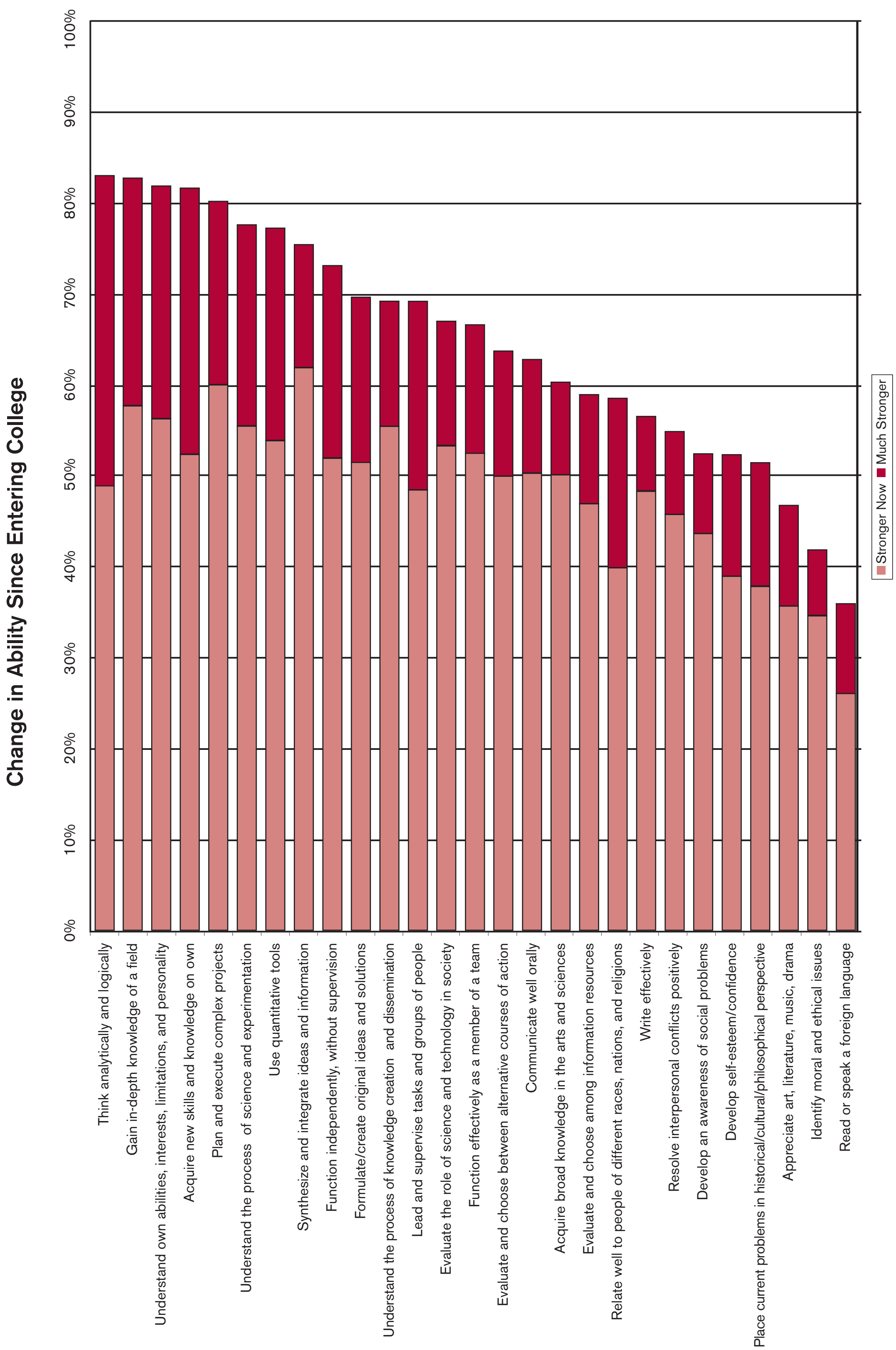

From the 2004 Senior Survey
Source: Office of the Provost/Institutional Research

M.I.T. Numbers

The General Institute Requirements (GIRs)

Science, Mathematics and Engineering Requirement

Current

Required:
- Calculus I (18.01)
- Calculus II (18.02)
- Physics I (8.01)

All 3 required:
- Physics II (8.02)
- Chemistry – Introduction to Solid-State Chemistry (3.091) or Principles of Chemical Science (5.11x)
- Introductory Biology (7.01x)

- 2 Restricted Electives in Science and Technology (RESTs)
- 1 Institute Lab

Proposed

Required:
- Calculus I (18.01)
- Calculus II (18.02)
- Physics I (8.01)

Choose 1 from each of 5 out of 6 categories:
- **Mathematics**
  e.g., Differential Equations (18.03), Probability and Statistics (6.041 and others).
- **Physical Sciences**
  e.g., Electricity and Magnetism (8.02).
- **Chemical Sciences**
  e.g., Introduction to Solid-State Chemistry (3.091), Principles of Chemical Science (5.11x).
- **Life Sciences**
  e.g., Introductory Biology (7.01), Introduction to Neuroscience (9.01).
- **Computation and Engineering**
  Subjects focused on modes of thought and problem-solving tools.
- **Project-Based First-Year Experiences**
  Subjects in engineering and science that involve design or creation, e.g., 2.000, 12.000, 16.000.

- No more REST or Institute Lab GIR; lab requirement to be subsumed into departmental requirements

Humanities, Arts, and Social Sciences Requirement

Current

HASS Distribution (HASS-D)
(Choose 1 subject from each of 3 out of 5 categories)
- Literary and Textual Studies
- Language, Thought, and Value
- Visual and Performing Arts
- Cultural and Social Studies
- Historical Studies

Advanced Subjects (5 classes)
- HASS Concentration
- HASS Electives

Proposed

Foundational Subjects (3 classes)
(Choose 1 class from each of 3 categories):
- Humanities
- Arts
- Social Sciences

One of the three foundational subjects must be part of the **First-Year Experience Program** to be taken by freshmen in the first or second semester of the first year.

Advanced Subjects (5 classes)
- HASS Concentration
- HASS Electives

Proposed changes to the requirements.

Adapted from *The Tech*, October 17, 2006