Report of
The Task Force on the Undergraduate Educational Commons

to the President of the Massachusetts Institute of Technology

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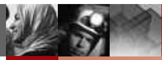

Report of
The Task Force on the Undergraduate Educational Commons

to the President of the Massachusetts Institute of Technology

October 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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2 October 2006

President Susan Hockfield
MIT Room 3-208

Dear Susan:

I am pleased to present you with the report and recommendations of the Task Force on the Undergraduate Educational Commons.

This report reflects the deliberations of a group of many dedicated faculty, staff, and students who worked together for two and a half years. Our discussions covered virtually every aspect of the common educational experience of our students. Although there were differences of opinion about certain of the recommendations in our report, we were uniform in our belief that the MIT undergraduate education is one of the best in the world because of the commitment to a true balance between general education and professional education.

In addition to the Task Force members themselves, we benefited from the many meetings and conversations with faculty in Task Force sessions, in our meetings with each department, and in public forums. We were fortunate to have students serving on the committee who provided excellent advice and welcome reality checks. In addition, the two reports of the Student Advisory Committee provided good guidance at crucial times.

I am deeply grateful for the hard work of my colleagues on the Task Force. In particular, I benefited from the advice and guidance of then Dean for Undergraduate Education Bob Redwine and from my associate chairs Heidi Nepf, Kip Hodges, Dava Newman, and Charles Stewart. Staff from the Office of the Dean for Undergraduate Education were immensely helpful in a variety of ways. A number of Task Force members contributed substantially to the content of this report, including Haynes Miller, Bob Redwine, Kip Hodges, and others. However, it was to Charles Stewart that we turned to transform our various recommendations into the thoughtful and coherent text that is this report. We owe Charles a great deal.

Finally, and most important, our work could not have been completed without the intellectual input and hard work of Peggy Enders and her colleagues including Mary Enterline, Anna Frazer, and, during our first year, Annie McLeod. MIT is truly fortunate to have such dedicated staff.

The work of the Task Force is done, and it is now up to the Faculty and its committees to take our work forward.

Sincerely,

Bob

Robert J. Silbey

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FOREWORD

The accompanying report presents a comprehensive accounting of the Task Force on the Undergraduate Educational Commons and its work for the past two and a half years. This effort has renewed our faith in the ingenuity of the faculty, staff, and student body, whose greatest desire is to sustain MIT as an incomparable community with a shared vision of creatively and powerfully tackling the most challenging tasks of humanity.

The report represents a collaborative effort of the Task Force and its colleagues to determine how best to perpetuate the delight of new discovery among future generations of the community's newest members. Each chapter is structured in three parts, beginning with a high-level summary of the arguments contained therein. An extensive discussion of the Task Force's deliberations then follows. Each chapter ends with a summary of the recommendations urged. By reviewing the summary that brackets each chapter, the reader can quickly scan the entire contents of the report.

The work of the Task Force has been assisted by the generous, earnest, and thoughtful insights of individuals across the entire MIT community who provided invaluable input to our efforts. We thank the members of every departmental faculty at the Institute for hosting delegations from the Task Force (some several times) and for exploring together the serious topics that surround our common curriculum. The appendix to the report acknowledges a smaller group of students, faculty, and staff members who participated, at some point, in the formal Task Force meetings. These individuals' contributions to our efforts vastly exceed the recognition we can give by publishing their names.

1. INTRODUCTION

In the winter of 2003–04, the Task Force was charged with reviewing MIT's undergraduate education and making recommendations on how the General Institute Requirements (GIRs) might be altered. Since then, we have conferred with numerous faculty members, students, staff members, and alumni.

The past fifty years of undergraduate education at MIT have been highly successful. Yet, while the curriculum remains robust, developments in the world and changing characteristics of students have brought important tensions to the curriculum. In particular, the Science Requirement has become overly prescriptive; the Humanities, Arts, and Social Sciences (HASS) Requirement has become extremely complicated and has not created an environment in which the study of culture and society is sufficiently valued; and the international environment demands that our undergraduates become comfortable with the culture, attitudes, and norms of other nations and peoples. As well, the past decade has witnessed considerable pedagogical innovation among the MIT faculty, which should be consolidated and incorporated in the mainstream.

We reaffirm the historic understanding of MIT's distinctive educational mission, which is devoted to the advancement of knowledge and the education of students in areas that contribute to, or prosper in, an environment of science and technology. Additionally, we reaffirm eleven specific principles that refine the mission as articulated by MIT's founders, the Lewis Committee, and the Task Force on Student Life and Learning. We distilled these historic principles into five major themes that are intended to capture the spirit of the education we intend to foster at MIT: (1) a persistent passion for learning, (2) intellectual diversity, (3) an innovative approach to core knowledge, (4) collaborative learning, and (5) education for responsible leadership.

In considering how to organize our undergraduate curriculum, we review changes in three major domains that constitute the raw material with which the faculty works: (1) science and technology, (2) culture and society, and (3) the prior preparation and aspirations of students. The proposed curriculum changes respond to developments in these domains and to commonly expressed concerns about the current curriculum. We bring the structure of the Science and HASS Requirements more closely into alignment, and suggest that the first year be regarded more as a unified whole.

Because it is impossible to provide a completely satisfactory professional preparation in four years, our most important task is to construct an educational infrastructure that prepares MIT graduates for a lifetime of learning. The approach to our deliberations has been guided by the words of William Butler Yeats: "Education is not the filling of a pail, but the lighting of a fire."

During the winter of 2003, MIT President Charles M. Vest charged the Task Force on the Undergraduate Educational Commons to address the goals, content, and structure of MIT's undergraduate education. In particular, we were asked to:

- review the statement of MIT's educational mission, including the reasoning and assumptions of the educational and societal contexts that support it, and then reaffirm or modify it as deemed appropriate;
- derive from the educational mission a specific set of *goals* for the education of all MIT undergraduate students;
- develop and articulate, at an appropriate level of definition, the *content* of the curriculum that should be common to the education of all MIT undergraduate students; and
- develop and recommend to the MIT faculty the formal *structure* of the MIT undergraduate curriculum, expressed in a set of GIRs or in an alternative formulation.[1]

In providing his charge to the Task Force on the Undergraduate Educational Commons, President Vest referenced the work of the Task Force on Student Life and Learning, which issued its report in 1998.[2] The charge of that earlier Task Force encompassed the complete undergraduate experience, both curricular and extracurricular. Although the Task Force on Student Life and Learning considered the formal curriculum and made many recommendations, its primary focus was on the larger community setting that framed the experience of MIT students. It articulated the view of an "educational triad" of education, research, and community that constitutes the core of MIT's educational experience. The Task Force on Student Life and Learning's report stimulated a decade-long effort to change student life, residential life, and the physical campus, so as to make MIT a vibrant meeting place well into the 21st century.

In effect, this report can be considered "Part II" of the 1998 report of the Task Force on Student Life and Learning, as it addresses more thoroughly the undergraduate classroom experience at MIT. Our work is a direct continuation of

1
The full charge to the Task Force is available at http://web.mit.edu/committees/edcommons/documents/charge.html.

2
Task Force on Student Life and Learning, *Report of the MIT Task Force on Student Life and Learning*, Cambridge, Massachusetts, Massachusetts Institute of Technology (September 1998). Available at http://web.mit.edu/committees/sll/tf.html.

that earlier effort; in many cases, we reiterate past proposals that were not ripe for implementation at the time, but whose execution is now essential to the renewal of our curriculum.

Because this report builds directly on the work of the Task Force of Student Life and Learning, the MIT community must understand that the work to be done in the coming years to renew the undergraduate curriculum must be seen as continuing the comprehensive educational reform begun here a decade ago. Strengthening the triad of education, research, and community remains the ultimate goal. The success of the Institute's efforts toward this renewal will rely on the continued close collaboration of the offices of the Dean for Undergraduate Education and the Dean of Student Life.

As upon previous occasions when the MIT faculty took a hard look at its educational practice, we stand at a critical juncture. The most exciting challenges in the worlds of science and technology require us to reassess whether the content of our scientific education is flexible enough to meet those demands. We also continue to live at a time in which undergraduates steeped in the fundamentals of science and technology can make a special contribution to a new array of social challenges and modes of cultural expression.

But the world is always changing. Why *now*? One answer draws us beyond the walls of MIT. The challenges we observe have been widely noted throughout the nation. America's continued prosperity and national security depend on the revitalization of its universities. The 2006 report by the National Academies, *Rising Above the Gathering Storm*, identifies strengthening basic research and increasing the number of undergraduates trained in the physical sciences, life sciences, engineering, and mathematics as two of the essential building blocks in assuring the continued prosperity and security of our nation.[3] The 2004 report by the National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, notes a historical tendency for the evolution of engineering education to lag behind developments in technology and society. The report questions whether this tendency best serves the nation, and sets out an agenda to allow engineering education to evolve so that it can anticipate societal and technological changes.[4] The recent report of the U.S. Secretary of Education's Commission on the Future of Higher Education not only acknowledges the great accomplishments of America's colleges and universities, but also catalogues serious shortcomings in America's system of higher education; it calls for the entire system to be held more clearly accountable to the nation for its performance.[5]

3
Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, D.C., National Academies Press, 2006).

4
Committee on the Engineer of 2020, Phase II, Committee on Engineering Education, National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* (National Academies Press, Washington, D.C., 2005).

5
U.S. Department of Education, *A Test of Leadership: Charting the Future of U.S. Higher Education* (Washington, D.C., 2006). Available at http://www.ed.gov/about/bdscomm/list/hiedfuture/index.html.

In recent years, thoughtful leaders in higher education, business, government, and civil society have expressed rising concerns about fundamental shifts in the foundations of America's prosperity, which has led to numerous calls to action for American higher education. All of these analyses identify the role of science and technology education as a critical link – sometimes *the* critical link – in the chain of actions needed to reinvigorate the American economy. Given these serious issues, MIT's broader mission demands that we examine the Institute's educational processes in light of these national concerns.

MIT and other American universities are examining, or have examined, their undergraduate educational systems. The educational renewal efforts of these colleague institutions are often in response to the same set of general developments and concerns that have drawn MIT's attention. We have collected many reports on these efforts and have included them in our online library. Each college and university has its own particular contribution to make to the advancement of education, so the reforms proposed by other universities in recent years are not all of a piece. We note one common trend that has affected our thinking, however. As other universities have examined their own curricula, many have concluded that they must strengthen and expand their attention to science and technology. This conclusion has been made manifest in many ways, from building new campuses to designing new curricula.

At many of these colleges and universities, the renewed emphasis on science and technology raises new challenges and opportunities for MIT, which has always specialized in these areas. To what degree should MIT "lead by example" as colleges and universities that have not historically emphasized these areas devote more attention to them? What about MIT's leadership among institutions that *have always* emphasized science and technology? If others seek to emulate MIT, should the Institute strive to be even more distinctive among American universities?

These are all large questions, and the Task Force is not all of one mind in answering them in the sweeping form in which they are posed. We *are* of a single mind, however, in our understanding of MIT's continued contribution to the betterment of the human condition in this nation and in the world. The MIT undergraduate curriculum must continue its traditional rigor while being adaptable to the new challenges that the Institute currently faces – and is likely to face in the future.

When we began our work, we recognized that MIT has been experiencing a decade-long period of exceptional educational innovation at the grass-roots level. This innovation has been responsive to a number of factors, including the national concerns that have already been noted. Others, however, have been responsive to the changing expectations of our undergraduates and the careful research into how best to improve the learning environment of the current generation of students.

These innovations – coupled with an appreciation for the changing expectations of MIT students and the development of important new intellectual approaches and fields of inquiry – convince us that the time has come to make changes to our curriculum that consolidate what we have learned from a decade of educational innovation. To some in our community, these changes – in the Science Requirement, the HASS Requirement, and the expansion of opportunities for international study – will be considered radical. However, each is firmly rooted in years of exploration and deliberation at the Institute. Therefore, the task for the Institute, as we see it, is to elevate innovation in undergraduate education to a new level, moving it from an activity championed by a dedicated cadre of reformers to one that informs all of what we do.

Process

We have deliberated for two and a half years. In the spring semester of 2004, we began with a series of meetings intended to inform ourselves about the current structure, process, and content of education at MIT. Our exploration into the curriculum continued in the summer of 2004, beginning with a weeklong retreat whose work was continued in three working groups that emerged from the retreat. We spent the fall of 2004 gathering input on the current state of MIT's undergraduate education from a wide variety of sources. The most extensive of these listening events was a series of meetings with the faculty in each academic unit of the Institute. Throughout calendar year 2005, we focused on better understanding and responding to the specific issues that were raised in these listening sessions, particularly the two major components of the GIRs, the Science Requirement[6] and the HASS Requirement. A pivotal public event in February 2005 was the devotion of MacVicar Day[7] to the preliminary findings of the Task Force, as well as a public forum on educational renewal at MIT. During the spring of 2006, we continued to hone our recommendations while beginning a new series of meetings with various configurations of MIT faculty members and students. This culminated in a campus-wide forum on the Task Force's deliberations, which was held in May 2006.

6
Strictly speaking, the Regulations of the Faculty do not define a single entity termed the "Science Requirement." Rather, the Regulations designate three requirements that fall under an umbrella that we refer to as *the* Science Requirement. These three requirements are the six-subject Science Core (consisting of two semesters of calculus, two semesters of physics, and one semester each of chemistry and biology), the two-subject Restrictive Electives in Science and Technology (REST), and the one-subject Laboratory Requirement.

7
MacVicar Day is an opportunity for the campus to focus on undergraduate education, and it coincides with the annual naming of new Margaret MacVicar Faculty Fellows. MacVicar Faculty Fellows are recognized for their profound influence on students through their sustained and significant contributions to teaching and curricular development.

These deliberations produced a considerable collection of written materials that describe current educational practices at the Institute, report on prior faculty deliberations, reflect the evolving thoughts of Task Force members on the key educational issues facing the Institute, and generally provide a bibliography in support of the Task Force's work. In an effort to leave a perpetual library documenting the process of educational innovation at MIT,[8] we will publish these collected materials online.

One component of the General Institute Requirements is the Physical Education (PE) Requirement. We met twice with faculty and staff members in the Department of Athletics, Physical Education, and Recreation (DAPER) to discuss the PE Requirement and DAPER's ongoing efforts to strengthen it. This report makes no recommendations concerning reforms to the PE Requirement, although we commend the thoughtful, creative, and ongoing efforts to better integrate physical education into the total educational experience of MIT undergraduates.

We were assisted by many groups at MIT that have a special interest in, and insight into, undergraduate education at the Institute. Two groups, in particular, deserve mention here as they were created at the behest of the Task Force. The first is the Student Advisory Committee, a group of ten self-selected student volunteers who collected student input on the MIT undergraduate experience and made two reports to the Task Force. These reports summarized the input that they received and distilled the recommendations for educational changes that arose from that input.[9] The second is an augmented HASS Overview Committee (termed the "HOC+"), which met intensively during the spring and summer of 2005. The HOC+ devoted its attention to a thorough review of the current HASS Requirement. Those deliberations were reported to the Task Force in the spring of 2006 and were used to structure the discussion and recommendations that are found in Chapter 3 of this report.

Summary of Findings and Recommendations

After reviewing MIT's educational mission and the underlying assumptions that support it, we embrace the vision articulated at the founding by the Committee on the Educational Survey of the Faculty of the Massachusetts Institute of Technology (the "Lewis Committee")[10] and reaffirmed by the Task Force on Student Life and Learning. We are also struck by the high degree of similarity between the

8
This online library will be available at http://web.mit.edu/committees/edcommons.

9
Student Advisory Committee to the Task Force on the Undergraduate Educational Commons, *Task Force on the Undergraduate Educational Commons Student Advisory Committee Preliminary Report: Advising, the Humanities, Arts, and Social Sciences Requirement, the Communication Requirement, and the Science GIR* (April 2005). Available at http://web.mit.edu/committees/edcommons/students/report.html; Student Advisory Committee to the Task Force on the Undergraduate Educational Commons, *MIT Task Force on the Undergraduate Educational Commons Student Advisory Committee Preliminary Report Addendum* (Spring 2005). Available at http://web.mit.edu/committees/edcommons/students/reportaddendum.pdf.

10
Warren K. Lewis *et al., Report of the Committee on the Educational Survey to the Faculty of the Massachusetts Institute of Technology*, Cambridge, Massachusetts, Massachusetts Institute of Technology (1949). [Hereafter referred to as the Lewis Report.] Available at http://libraries.mit.edu/archives/mithistory/histories-offices/lewis-com.html.

challenges that were addressed by the Committee on Curriculum Content Planning (the "Zacharias Committee")[11] in the mid-1960s and the current set of challenges we face forty years later. Among those are the rapid evolution of scientific knowledge, the increasing diversity of interests and backgrounds of entering MIT students, the sheer impossibility of fitting a satisfactory professional preparation within four years of a baccalaureate degree, tensions inherent in balancing a high-quality professional preparation with an equally high-quality liberal education, the critical need for scientists and engineers to engage with the wider public about the most pressing problems of the day and their possible solutions, as well as the ongoing need to renew individual subjects and the structure of the curriculum to address all of these challenges.

The past fifty years of undergraduate education at MIT have been highly successful. The blueprint for the curriculum that was laid out in 1950 has since been altered a handful of times on the margin, but has remained guided by a constant set of principles. It is a focused curriculum that not only gives special attention to science and technology, but also is inextricably linked to an aspiration to produce well-rounded graduates who are leaders in their private and public lives. The general educational blueprint that was described by the Lewis Committee preceded the upheaval spawned by the launch of *Sputnik* and provided a steady beacon as science, technology, and society changed in the following years. The curriculum continues to empower our undergraduates to become active participants in the research teams that confront the great scientific challenges that we face today – including challenges that Lewis and his committee could hardly have imagined.

We also note, with no small pride, that MIT's curriculum continues to prepare graduates for careers and lives that are varied and rewarding. MIT undergraduates go on to further graduate education at a much higher level than those of our peers, which is just one indicator of the extent to which students educated at MIT are being prepared to pursue their intellectual passions with even greater depth and rigor. Institute graduates pursue careers that take them far from their original majors, which are overwhelmingly in science and engineering. They naturally progress to become entrepreneurs, business leaders, engineers, physicians, and research scientists. Long after they have left MIT, alumni report that creativity and the ability to deal with new challenges were two of the greatest contributions that MIT made to their adult lives.[12]

In short, by maintaining an education grounded in the fundamentals of science, yet well seasoned with a sophisticated understanding of human culture, MIT has fostered an environment that educates students who are well rounded and well prepared to address a wide variety of challenges later in life. We have not disappointed William Barton Rogers.

11
Jerrold R. Zacharias *et al.*, *Report of the Committee on Curriculum Content Planning to the Faculty of the Massachusetts Institute of Technology*, Cambridge, Massachusetts, Massachusetts Institute of Technology (May 1964). [Hereafter referred to as the Zacharias Report.]

12
MIT undertakes an extensive program of educational research that, among other things, gauges the performance of our overall educational process and compares it with results at other universities. We thank the Provost's Office of Institutional Research for sharing the results of these studies with us, particularly Lydia Snover, Director of Institutional Research, and Gregory Harris, Senior Research Analyst. Elsewhere in our report, we make reference to enrollment statistics that were generously provided to us by Associate Registrar Ri Romano.

Being in the midst of an institution as complex as MIT – and one that is never satisfied with its accomplishments – it is often difficult to appreciate the strides made in MIT's education over the past half-century, and the altogether new stage on which MIT now acts. That is why the remarks made over a year ago by Alison Richard, the vice chancellor of the University of Cambridge, at the inauguration of our current president, Susan Hockfield, are so helpful in framing our current circumstances. Reflecting on the literal meaning of the words that form the initials, "MIT," Vice Chancellor Richard noted how inaccurately they characterized the institution we now inhabit:

> ***Massachusetts …*** *In the academic year 1864–65, the Institute had 72 students. Of those 72, just five were from outside the Commonwealth of Massachusetts. Today, the Institute has over 10,000 students, and less than 1,000 come from Massachusetts. By contrast, about a quarter of MIT's students are from outside the U.S. altogether. At the risk of stating the obvious, this is no longer a local school!*
>
> ***… Institute of …*** *Here, MIT has traveled just as far as it has traveled from Massachusetts. The world knows MIT to be a great university. It is an institution, rather than an institute, with a grand array of institutes within the institution, five schools, close to 1,000 faculty members, a great library system, 41 athletic teams, and almost 100,000 alumni. A great university, indeed.*
>
> ***… Technology …*** *In a speech in 1865, Dr. Jacob Bigelow, vice president of the Institute in that year, argued that the pursuit of raw, pure knowledge was pointless. There is simply too much to know. A classical education might be of value in disciplining the mind, he said, but other, useful subjects could fulfill the same function. To MIT's founders, the 'Arts' meant essentially the processes and techniques of applied science.*
>
> *Today, three-quarters of MIT undergraduates study literature, and the University celebrates its strength and achievements in the humanities, social sciences, and the literary, visual, and dramatic arts, alongside global distinction in fundamental science, engineering, and technology.*[13]

If the curriculum has taken us this far, why suggest changes? As successful as MIT's curriculum has been, a number of tensions pull at the fabric of its educational plan. MIT's general curriculum and the specific subjects that populate it are robust enough to withstand the momentary tensions that always buffet

13
Alison Richard, "Remarks on Behalf of the Academic Community on the Occasion of the Inauguration of Susan Hockfield, Sixteenth President of MIT," (speech, Massachusetts Institute of Technology, Cambridge, Massachusetts, May 6, 2005). Available at http://www.admin.cam.ac.uk/offices/v-c/speeches/20050506.html.

healthy universities. Looking ahead, however, many of the most challenging tensions we now face show no signs of abating. Consequently, while we do not believe that many radical changes are needed in MIT's curriculum, we do believe strongly that MIT will retain its leadership position among the world's universities only if it alters the curriculum to address those tensions, which arise out of changes in the nature of science, in culture and society, and in the student population. Far from radical, the changes we recommend have been debated at the Institute for many years before our own Task Force was charged.

Any thorough review of the current educational scene at MIT quickly comes upon a host of faculty and staff members who have been hard at work trying to understand the societal changes that affect MIT's mission, as well as to experiment with innovative responses to these challenges. Therefore, there is another answer to the question of "Why change *now*?" Over the past decade, a considerable number of MIT faculty members and staff have worked diligently to address the educational challenges that face the Institute anew. They have hit upon a variety of innovative approaches to education that should be generalized in order to reach a broader audience than is currently possible. Many of these efforts have reached the limits that even energetic entrepreneurial faculty members can surmount. To expand these efforts further and to foster new ones require efforts that are inherently more collective, such as changing graduation requirements, designing new teaching facilities, and generally rallying the entire educational community at MIT to this enterprise.

Consequently, the changes we recommend emerge directly from an ongoing educational conversation at MIT that spans many years. What separates past educational conversations from the present one is that we hope to combine all of these disparate efforts into a shared Institute-wide endeavor – one that rallies the entire faculty, administration, student body, Corporation, and alumni into a period of common educational renewal at the Institute.

Here are the concerns we wish to address and the common paths we wish to explore:

First, science and technology have advanced in such a way over the past fifty years that the Science Requirement has become overly prescriptive and too narrow in focus. Since the requirement no longer provides MIT students with the type of preparation in the fundamentals that they need, we recommend a new requirement that broadens the scope of subjects that are considered as part of the core.

We propose that all MIT undergraduates continue to complete two semesters of calculus and one semester of classical mechanics. To complete the core curriculum in science, mathematics, and engineering, a student will choose the remaining five subjects from among six categories. These categories will be populated with a small number of subjects that will provide a solid foundation for future study and a broad introduction into the nature of modern science and technology. These areas are chemical sciences, computation and engineering, life sciences, mathematics, physical sciences, and project-based first-year experiences. (However, we should also state at the outset that this more flexible Science, Mathematics, and Engineering (SME) Requirement will remain one of the most prescriptive and rigorous general science requirements in the United States.)

Second, the Humanities, Arts, and Social Sciences (HASS) Requirement has become overly complicated and fails to create an environment in which the study of the arts, culture, and society is widely valued. Therefore, we recommend that the HASS Requirement be restructured to provide a more common experience in the first and sophomore years and to solidify more advanced work in HASS fields, particularly in the junior and senior years.

Specifically, we propose that all first-year students complete a "first-year experience" subject that will introduce students to one of a limited number of important topics in the realm of human society, culture, and self-expression. These first-year experience subjects not only will introduce the class participants to important intellectual issues, but also will sponsor Institute-wide events – such as speakers, films, and symposia – to help enlarge the intellectual space that is occupied by these topics at the Institute. To complete the introductory phase of the HASS Requirement, undergraduates will take two other subjects that will introduce them to fundamental material in the humanities, arts, and social sciences, which may be of a more disciplinary nature. As well, these subjects will provide grounding in the skills necessary to pursue further work in these areas, such as giving special attention to writing, speaking, and using libraries. By having students take one class in each of the three HASS components (Humanities; Arts; Social Sciences) during this foundational phrase, the new requirement will ensure that every MIT graduate has pursued at least an introductory level of inquiry into the different methods and disciplines that structure the study of human organizations, achievements, and creativity, and has some awareness of the breadth and diversity of such study. Because the foundational phase will continue to include the demonstration of proficiency in written expression, it also will include expository writing. The remainder of the HASS Requirement will consist of a concentration component that is formally identical to the current system, but imbued with renewed energy and attention from the sponsoring units.

Third, the international environment is such that we must reduce the barriers that have prevented our undergraduates from becoming comfortable with the cultures, attitudes, and norms of other nations and peoples. If there is one major topic that competes with an overhaul of the GIRs for the attention of the faculty, it is the topic of global education. For many years, MIT's participation in solving problems of international import has been well recognized, but preparing undergraduates for the global involvement of their future lives has not been a high Institute priority. This must change. It is imperative that every MIT undergraduate understand the global context in which their future lives and careers will unfold. Students must also be comfortable working and living in settings in which they must adapt to differing values, traditions, assumptions, attitudes, and norms that will arise from cross-cultural contact within a new global economy. First, the Institute must devote more attention to nurturing the many excellent programs of international education that have already arisen through the largely grass-roots initiative of the faculty and staff; second, the Institute administration and faculty must find ways to ensure that any MIT undergraduate who wishes to include a serious international experience as part of his or her baccalaureate education may do so.

Fourth, the revamping of the common curriculum presents the ideal opportunity for the Institute to devote serious attention to rebuilding the infrastructure that supports its core undergraduate educational mission. Here, we mean both a physical infrastructure and human expertise. The past decade has witnessed a burgeoning of creative educational activity at the Institute that has led to new innovative subjects, new ways of teaching existing subjects, and pressures to change the curriculum to incorporate these innovations into standard practice. Yet, the physical infrastructure, especially classrooms, has not kept pace with these innovations and will be substantially inadequate to accommodate the changes we propose in the GIRs. MIT possesses a highly diverse student body, which is both a reflection of the changing demographic reach of our education and a source of educational strength for our undergraduate program. In the coming years of formal reform, we must intently monitor the effects of these reforms on the character of diversity on campus, while ensuring that they enhance educational opportunities. Finally, the past decade of educational innovation has also introduced many MIT faculty members and administrators to the value of working with a cadre of professional educational researchers, who can help design and implement assessments and then diffuse successful innovations throughout the Institute. This experience convinces us that a scientific approach to educational assessment and renewal should infuse all of MIT and that the stature of this activity should be raised at all levels.

MIT's Educational Mission

MIT was founded as the country was being drawn into its national tragedy of a civil war. The juxtaposition of the war and MIT's founding provides an apt illustration of why the idea of a new type of institution of higher education – dedicated to educating young men and women in a distinctive way – was so compelling at the time. The war itself was fought with modern weapons made possible only because science and technology had been harnessed in the industrial age to multiply many-fold the power of human agency. Although the weapons changed rapidly, human attitudes changed more slowly, leading to previously unimaginable battlefield horrors.

The plan for MIT developed over a number of years prior to its chartering in 1861. Central to that plan, however, was always a belief that the new industrial age required leaders to be educated in a new way – one radically different from the classical education of the day that greeted the select few men, and fewer women, who attended college. The MIT plan was shaped specifically for leaders of a new society who would lead in the forging of tangible goods, which would vastly extend the power of humans over the natural world. The plan celebrated practical education and eschewed dilettantism. Yet, MIT's primary founder, William Barton Rogers, hoped that the Institute's graduates would not only find new, efficient ways to manufacture the goods that stoked a new industrial order, but also would take the lead in helping society guide technology toward its more beneficial applications. This aspiration was summarized in MIT's motto, *mens et manus* – mind and hand. Consequently, a profound ethical imperative has been deeply imbedded in the identity of the Institute from its founding.

The need for an undergraduate education focused on science and technology – both in its practical applications and in its ethical implications – is at least as great now as it was at MIT's founding; while the need for an *expanded* vision of such an education is at least as great now as it was in the mid-1900s, when the Lewis Committee directly confronted problems that arose from the narrowing of MIT's undergraduate education as the twentieth century progressed.

In the ensuing half-century since the Institute faculty last took a comprehensive look at the entirety of MIT's undergraduate education, the impact of science and technology on the lives of all inhabitants on the planet has only grown. Scientific literacy and technological innovation are now universally recognized as part of a small set of necessary conditions for robust economic development. Today, 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 citizens.

The relevance of MIT's distinct approach to undergraduate education has also grown. MIT's special brand of education does not simply occupy a quirky niche of the higher education universe. Because of the tight interweaving of science, technology, culture, and society, MIT's undergraduate experience offers lessons about undergraduate education, in general, for all who are concerned about educating citizens of the modern world.

Still, we have a special concern for education that gives a privileged place to science and technology. Therefore, we must consider how science and technology have changed in recent years and what those changes imply for an undergraduate education that takes science and technology as its starting point. Science and technology are changing – and so must MIT's education, if it is to remain relevant.

In its comprehensive examination of the undergraduate experience less than a decade ago, the Task Force on Student Life and Learning undertook a serious study into the history of the Institute and how the Institute's mission had played out in practice. Following that study, the Task Force articulated what it considered to be the general educational mission of MIT as follows:

> The Massachusetts Institute of Technology is devoted to 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.[14]

Like any assemblage of MIT faculty convened to consider the lofty aspirations of our educational program and to articulate those goals to the world, we wrestled with this mission statement to understand whether it actually conveyed the essence of our educational task and whether it could be further improved. Though some might choose different ways of expressing the ideas conveyed herein, we concluded that this statement provides a very useful re-articulation of MIT's historical educational mission in a modern context.

14 Task Force on Student Life and Learning, p. 10.

The first two sentences of this mission statement set out a broad agenda, but one that nonetheless privileges science and technology as a touchstone. The final sentence, which may seem to be all things to all people, in fact makes a distinct statement about how we view undergraduate education in the context of a *research university*. Many research universities view undergraduate education uneasily, almost apologetically; MIT embraces the research enterprise as being central *even for our undergraduates*, since that is the best way for students to encounter the realms of the unknown and to experience firsthand the thrill of discovery. Certainly, the undergraduate years are a time of general exposure to a wide variety of intellectual traditions solely for the sake of developing one's mental capacities and enriching one's understanding of multiple perspectives and contexts. Nonetheless, we are driven to engage undergraduates in hands-on experiences with material, especially those on the frontiers of knowledge.

The Task Force on Student Life and Learning not only provided a statement of MIT's educational mission for the turn of the twenty-first century, but also reminded the community of a set of eight principles that have guided the development of MIT as an educational institution to this point. The task force also suggested that three new ones will join these, making eleven key principles in all.

The first four principles came directly from Rogers and the founding generation of MIT's leadership:[15]

1. ***The educational value of useful knowledge.*** In a clear dissent from the common view of higher education of his day, Rogers believed that science and technology were legitimate foundations of higher knowledge in an industrial society, and that students would benefit from the motivation of striving toward a useful goal.

2. ***Societal responsibility***. When Rogers founded MIT in 1861, one of his key principles was that "a place must be made for the young man {or woman} who wishes to apply the fruits of scientific discovery to the satisfaction of human wants." Employing "useful knowledge" to harness the power of technology was at the heart of MIT's important contribution to society in the latter half of the nineteenth century.

3. ***Learning by doing.*** Rogers believed that students should appreciate concrete conclusions drawn from factual data. He emphasized active learning through which students must seek out new

15 The description of the following principles is taken directly from Chapter 1 of the final report of the Task Force on Student Life and Learning.

information, thereby converting personal experience into knowledge. Since its founding, MIT has been a leader in the educational use of laboratories, shops, and computational resources, as well as the inclusion of undergraduates in research activities.

4. ***Combining a liberal and a professional education.*** From its founding, MIT has sought to provide a balanced education that combines professional education at the undergraduate level with components of a liberal education. Rogers believed that the development of technical proficiency was not enough, and that higher education ought to enable a person to participate effectively in "the humane culture of the community."

The next four principles were given voice in the Lewis Committee report and helped to enlarge the scope of MIT's impact on the larger society in the half-century following the second World War:

5. ***Education as a preparation for life.*** Education is more than intellectual development. To provide students with an education that better prepared engineers to function as professionals, the Lewis Committee recommended that MIT broaden the curriculum and create a School of Humanities and Social Sciences. The Lewis Committee recognized that the total environment in which a student's education takes place is important, and it remains so today.

6. ***The value of fundamentals.*** The Lewis Committee emphasized that a technical or professional education should be based on the fundamental principles in each field, quoting Rogers, who wrote, "The most truly practical education, even in an industrial point of view, is one founded on a thorough knowledge of scientific laws and principles." MIT has consistently striven to keep its educational programs focused on the fundamental principles that underlie the specific field of study.

7. ***Excellence and limited objectives.*** This principle was stated by the Lewis Committee in three parts: "First, in accordance with Rogers' belief in the dignity of useful knowledge, the educational program has been designed at all times to fit men {and women} for direct contribution to the needs of the society of their day. Second, effort has been limited to fields that could contribute to or profit from an

environment in which the predominant concern is with science and technology. Third, major activity has been confined at all times to those fields in which there appeared to be opportunity for the Institute to use its resources effectively."

8. ***The unity of the faculty.*** One attribute that distinguishes MIT is a single Institute-wide faculty. This unity of the faculty is based on mutual professional respect and a shared educational responsibility. As the Lewis Committee stated, "There is a common Faculty responsibility for educational policy and operations in all phases of educational work at the Institute."[16] The Committee affirmed that the entire MIT faculty was responsible for the education of undergraduate students. The reasons for this are twofold: first, to ensure that the undergraduate program is balanced; and, second, to ensure that the undergraduate program keeps pace with intellectual frontiers represented by the research activities of the entire faculty.

The final three principles emerged during the deliberations of the Task Force on Student Life and Learning, articulating factors that were particularly relevant to education in a residential environment. These were:

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9. ***An integrated "triad" of academics, research, and community***. Academics establish a place for rigorous study of the fundamentals of science, engineering, the social sciences, and the humanities, as well as a format for developing problem-solving skills, familiarity with quantitative and qualitative analysis, historical and literary insight, and an understanding of the scientific method. Participation in research develops both the foundation for professional competence and the opportunity for learning by doing. Through interaction with faculty and students within the community, students become familiar with the responsibilities of citizenship, hone communication and leadership skills, and gain self-mastery. Although each component of the triad is a distinct area of a student's education, the contribution of each reinforces and adds to that of the others. To provide a uniquely excellent education, MIT must bring students and faculty together to learn from one another through academics, research, and community.

16 The Lewis Report, p. 66.

10. ***Intensity, curiosity, and excitement.*** These define the ethos of the Institute and propagate into all of its educational activities. Intensity, curiosity, and excitement are integral parts of the MIT experience. More than anything else, they represent a shared rite of passage for its students and faculty. Although some aspects of the curriculum's pace and pressure should be examined and revised to ensure that student time is allocated wisely, MIT recognizes that the overall level of intensity, curiosity, and excitement represents a defining value of the Institute – and of an MIT education.

11. ***Diversity.*** The diversity of the Institute's students, faculty, and staff is critical to our educational mission. MIT has always been, and should remain, a meritocracy where intellectual achievement and capability are paramount. Within this context, diversity of the community will serve to enhance the educational experience through interaction with, and exposure to, people with different experiences, beliefs, and perspectives. This will become an increasingly important aspect of the educational experience as society and industry become more diverse and international. In striving to encourage diversity within its community, MIT must also endeavor to maintain an environment in which such diversity is appreciated and in which every student has a sense of place.

The first eight principles – those associated with MIT's founding and with the Lewis Committee – are so ingrained in the culture of MIT that they hardly need further articulation. The set of three new principles, which were enunciated by the Task Force on Student Life and Learning, has been embraced campus-wide over the past decade. These three new principles have been essential in guiding the Institute as it engaged in a program of significant structural and capital renovation, making the academic community in Cambridge more vibrant and interactive.

As an exercise to help us internalize the historic principles that have guided MIT's undergraduate education the past century and a half – and to begin a dialogue with the faculty on how we should steer the educational commons in the future – we ended our first deliberations by rearticulating these ideas in light of more contemporary sensibilities. We distilled these eleven historical principles into five major themes, which we brought to the faculty. By and large, they agreed that the following five principles capture the spirit of the education MIT intends to foster:

1. ***A persistent passion for learning.*** In their role as mentors and teachers, MIT faculty members share their love of learning with their undergraduates. They encourage students to be reflective individuals, understanding how the various elements of their undergraduate program fit together and what these elements mean in their own lives. They encourage students to develop and reflect upon their own educational visions, which will serve them here at MIT and beyond. Faculty members develop a culture that prepares these students for a lifetime of intellectual development. That culture emphasizes the value of creative thinking, critical thinking, and learning through problem solving, practices that will serve students well as they assume leadership roles in the society of tomorrow.

2. ***Intellectual diversity.*** MIT has a unified faculty that takes corporate responsibility for the general education and welfare of students. As a consequence of its own intellectual diversity, the faculty expects MIT students to develop diverse perspectives and the ability to combine multiple modes of inquiry to address fundamental questions and problems. Although science and engineering are fundamental components of our culture, they combine with the social sciences, the humanities, and the arts to form the core of modern higher education. By the time they graduate, MIT students will be at least familiar with each of these core areas.

3. ***An innovative approach to core knowledge.*** MIT students are expected to develop a mastery of the factual and conceptual underpinnings of their chosen field of specialization. However, the nature of these fields is constantly changing, and MIT students will be expected to be pioneers in this evolutionary process. To prepare them, the MIT faculty encourages students to venture off narrow educational pathways. Beyond exposure to a diverse set of ideas through the educational commons, students are expected to embrace the kind of interdisciplinary thinking that recognizes complexity and drives innovation.

4. ***Collaborative learning.*** Although MIT continues to value independent learning, there is an increasing emphasis here on collaborative research and design. Such initiatives underscore the

importance of developing diverse perspectives and working as part of a community to address important problems.

5. ***Education for responsible leadership.*** An MIT education should be designed to encourage students to assume leadership roles in a global society. To be successful in those roles, they must develop personal priorities and a code of ethics to guide their future actions. MIT's focus on science and technology provides special opportunities to encourage students to reflect on the impact of science and technology on modern society and to shape technological innovation responsibly.

In short, an MIT education 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. Collectively, such students can lead the world in developing technologies creatively and using their talents to improve the state of the natural world and humankind.

Our early consultations with our colleagues and students confirmed our strong initial sense that themes such as these are not sufficiently well communicated to MIT undergraduates. Ideally, the first year will begin with a dialogue between new students and faculty about this philosophy. More importantly, students must be encouraged – and given the time – to reflect on this philosophy and become active participants in the educational process throughout their tenure as undergraduates.

We consider our own report to stand directly on the shoulders of the report of the Task Force on Student Life and Learning. Having now rearranged much of MIT's administrative structure and made significant improvements to its physical environment in the service of creating a more robust community, we believe the Institute is in a position to complete and extend the work of the Task Force on Student Life and Learning. In particular, that task force drew the attention of the MIT community to the distinct gains that emerge when we are engaged in an educational setting that draws on the community itself as a resource. The changes that resulted mostly, but not entirely, affected education that occurs outside the classroom. Readers of this report will immediately recognize that we focus more on experiences that occur within the classroom and the formal curriculum. However, many of these proposals – such as encouraging the expansion of project-based subjects in the first year or engaging more thoroughly with the global nature of modern life – will have no chance of succeeding without the renewed attention to the quality of community life that the Task Force on Student Life and Learning inaugurated.

Educational Goals

President Vest's charge to the Task Force asked us to relate MIT's educational mission to a series of educational goals that apply to all of our undergraduates. These goals, stated at the most general level, are fairly simple. First, every MIT undergraduate will be equipped with a broad understanding of and easy facility with the most important concepts in modern science and technology. Second, every MIT undergraduate should be expert enough in the application of a subset of these concepts to be able to pursue successfully a challenging major in science or engineering. Third, every MIT undergraduate should be knowledgeable enough about the "humane culture of society" and adept enough in social interactions to participate as an effective citizen and innovator. Fourth, every MIT undergraduate will have participated in at least one instance of new discovery through research in a setting such as the Undergraduate Research Opportunity Program (UROP), writing a senior thesis, or serving an internship in an international laboratory.

For those of us who are deeply enmeshed in the culture of MIT, it is easy to view these general goals as being self-evident, just as it is possible to view the mission statement as unremarkable. Nonetheless, within the context of a wider universe of American higher education, these general goals are deeply consequential as they highlight one set of aspirations over another. For instance, the goal of new discovery signals that we regard research on the frontiers of knowledge as integral to the undergraduate experience, not something to be deferred to graduate school, which often is the case elsewhere. We expect all MIT students to be expert enough with the concepts of their general education to *use them* in creative ways. This almost immediately causes us to value more instrumental styles of education, compared to many other universities.

MIT has a set of goals that help guide the education provided for its students. Students who come to study at MIT have their own goals, which are more or less aligned with the Institute's. When we examine the early history of MIT, we see that the faculty largely took it for granted that the goals of its students were relatively constant, fitting well with a relatively homogeneous style of education. The great curricular reform efforts pursued by the MIT faculty in the twentieth century, launched by the Lewis Committee and the Zacharias Committee, were partially motivated by the desire to match a set of more heterogeneous goals and backgrounds that students were bringing to campus with a more varied curriculum and an array of learning environments.

We believe that the insights of these two great committees were correct. However, we recognize that our student body harbors diverse academic goals that are consistent with MIT's historical mission. Therefore, it is critical that students and faculty alike explicitly define how the aspirations of *each individual student* can best be achieved through the focused set of goals that MIT is best situated to accomplish.

As we propose adding more flexibility into MIT's core curriculum, we realize that it will become *even more important* for individual MIT students to be more explicit about their own particular educational goals. From the moment they step on campus, students must begin to develop these goals. The curricular changes we propose in later chapters, particularly to the Science Requirement, will offer students important academic choices upon their arrival at MIT; these choices will make the pursuit of some academic paths considerably easier than others.

Consequently, the faculty not only must better articulate the curriculum goals to students, but also must help students better articulate their own academic goals to themselves, their parents, and their advisors. The faculty bears the responsibility of ensuring that undergraduates begin considering their academic path from their earliest days at the Institute and that their advisors be proficient in providing appropriate advice as they discover what that path will be.

Educational Content and Structure

The pragmatic goal of all our deliberations has been to designate the content and structure of MIT's common undergraduate curriculum. In considering how best to do this, we find it necessary to think in terms of three large domains that constitute the raw material with which we work. The first domain is science and technology; the second is human history, culture, and society, broadly defined; and the third is the students who come to the Institute expecting their lives to be transformed by completing an undergraduate education at MIT. Each of these domains has been shifting under our feet, necessitating a reconsideration of our general education.

Changes in science

Our current general science and technology curriculum serves many students very well. While providing a solid foundation on which to build a satisfying education in the major programs, it has also provided a general education into many major currents of modern science and technology. Science is changing, however, and we must not let our general science education become a museum piece. The range of topics that now constitute what every “scientifically literate” individual should know has grown immensely, the specific tools required of majors has grown larger, and the most exciting developments in science and technology often fail to respect traditional disciplinary boundaries.

Throughout our deliberations, we have become especially concerned about two related developments in science and technology over the past fifty years that have added considerable strain to the structure of the Science Requirement. The first is the broadening scope of these domains and an expansion of what is considered to be “fundamental” in each. The second is the growing importance of discoveries that breach the barriers that separate the traditional academic disciplines and that make interdisciplinary approaches to science and engineering education more important from the outset.

The Science Requirement currently fulfills two needs within the larger curriculum of MIT. First, it supplies a large amount of prerequisite knowledge that the great majority of undergraduates will use in their majors. This is a direct consequence of the Lewis Committee’s principles of grounding the MIT education in “fundamental knowledge.” Students must master this prerequisite knowledge in order to rapidly accelerate into these programs once they become sophomores. Second, the Science Requirement educates all students on modern science, regardless of their major or career choice, equipping them with a unique perspective on the world as they become citizens of a democratic society.

The quantity of fundamental knowledge has grown well beyond the confines of the current Science Requirement. As we canvassed the faculty about the scientific fundamentals on which professional programs are based and about which all scientifically literate citizens should be conversant, we clearly heard a wider array of subjects than are currently included in our Science Requirement. In addition to the current subjects – which indisputably contribute to fundamental knowledge in science and technology – we have heard strong arguments that the list also should include subjects such as probability and statistics, neuroscience, and algorithmic reasoning and computation.

Not only have we heard that different subjects could be added to the fundamental core, but also that different approaches to scientific and technical questions belong at the base of a rigorous technical education. Many of these approaches are multidisciplinary, which is nearly impossible to consider in a core that is thoroughly disciplinary.

When knowledge grows, a natural temptation is to take the easy route by simply piling new requirements on top of the old. However, as we have heard time and again, the MIT curriculum is already bursting at the seams. Therefore, we are faced with the need to provide for a greater coverage of "fundamental science" within the core science curriculum without increasing the footprint of the Science Requirement within the four years at MIT. We can do this by first making it absolutely clear what *everyone* must master. Second, we must establish principles to guide students as they branch off to acquire fundamental scientific knowledge. We believe our proposal to replace the current Science Requirement with a new core curriculum in science, mathematics, and engineering accomplishes that goal.

Changes in culture and society

The previous discussion on the changing nature of science and technology proceeded as if these developments were divorced from a wider array of changes in culture and society. Yet, if we are to take our lead from the Lewis Committee report, we must always keep in mind that science and technology are closely involved with culture and society. MIT is uniquely positioned as a place where students and faculty can explore together the ground on which science, technology, culture, and society intersect.

When the Lewis Committee report was written, the world was awestruck by the devastating potential contained in the most notable contemporary achievement of science and technology: the atomic bomb. Harnessing the power of the atom for peaceful, constructive purposes was a project that manifestly required the cooperation of scientists and average citizens. Furthermore, although harnessing atomic power for peaceful purposes was the most urgent issue bringing scientists and average citizens into a close embrace, it was not the only one. The Lewis Committee recognized that many realms at the intersection of technology and human culture would have direct and massive consequences for the welfare of the planet. It was therefore important that scientists be mindful of their larger social and cultural context, even when doing basic research. Thus, the Lewis Committee called for MIT to take seriously the necessity of ensuring that each undergraduate received a "well-rounded" education.

The nuclear threat continues, even if it is now cast in a new geopolitical context. Supplanting anxieties about "the Bomb" in the minds of many Americans have been other concerns that also map directly onto developments in science and technology. These newer anxieties have real consequences, both for society in general and, through a number of feedback loops, for science and engineering in particular. The anxieties that arise over the threat of global terrorism are fueled by the knowledge that terror networks often seek to harness a wide range of high-tech weapons to meet their ends and to use techniques made possible by advances in electronics, transportation, and biology to deliver them. In an entirely different realm, the moral dilemmas that arise from biology now being more amenable to scientific and technological manipulation have presented challenges for scientists who wish to push further in advancing biology for the benefit of humankind. We witness this in the debates across the country on the content of high-school biology curricula in the question of whether stem cell research should be encouraged or banned, and in the controversy over the genetic modification of crops.

Even social concerns that are not obviously scientific and technological at their core have essential technological roots. For instance, in an age when unemployment and interest rates are historically low, Americans continue to tell pollsters that the state of the economy is the most important problem facing the nation. Why is this? The correct answer has many components, an important one being the rise of globalization, which has raised the specter of competition against economies with low wages and lax environmental laws. But what makes this sort of globalization possible? Among other things, the Internet has created an infrastructure that allows information to flow anywhere in the world almost instantly; advances in transportation and logistics have made it possible to move physical goods between any two points on earth in a matter of hours. (And, of course, many critics have argued that technology has largely encouraged the economic exploitation of the developing world, to the benefit of the West.)

These examples suggest how politics and economics are inextricably linked with science and technology, but there are numerous examples where advances in science and technology have transformed creative expression and made a significant impact on culture. Cultural collaborations are more common and occur more quickly in a world of fast, reliable transportation and ubiquitous electronics. The differing roles of artist and audience have changed, as well.

MIT is a place where the consideration of topics like these has a natural home. Indeed, the expansion of the humanities, arts, and social sciences at MIT over the past half-century, in scope and in stature, has made the Institute an international magnet for scholars interested in understanding the ground on which science, technology, culture, and society intersect. Although this meeting ground is most robust in the areas of faculty research and the education of graduate students, it is uneven at the undergraduate level – which is an opportunity awaiting greater exploitation.

Changes in MIT students

As we have deliberated on how best to craft a new set of GIRs, we have tried to be mindful of the fact that our education does not happen among a generic group of students who remain unmoved by the context in which they were raised. We have an obligation to make technologically oriented problems compelling to the current generation of high-school graduates and to the generations yet to come. If we are to engage the brightest minds of future generations, MIT's education must change to reflect their prior preparation and concerns.

By virtually any measure, MIT undergraduates have changed substantially over the past four decades. Some of this change is readily apparent when walking around campus. In 1960, 99 percent of MIT's undergraduates were white and 97 percent were men. Now, half of MIT's undergraduates are non-white, and almost half are women. Other changes are just as substantial, even if they are not so obvious to the casual observer. Students now coming to MIT have had a broader experience in secondary education, a larger range of life experiences, and a wider array of career ambitions. These changes present us with a collection of challenges and opportunities as we remake MIT's common undergraduate experience.

The types of majors that entering MIT undergraduates wish to pursue and the precise demographic mix of students have always fluctuated from year to year. These changes go beyond simple short-term fluctuations; rather, they relate to long-term secular trends in society and in MIT's conception of itself, which must be factored into any consideration of MIT's undergraduate curriculum.

The societal changes that have affected MIT's undergraduate experience since the 1960s are profound, including the following: the greater fraction of women going to college and the larger fraction of students interested in science and technology who are women; expanded opportunities for minority students as a consequence of the civil rights movement; a greater fraction of students' parents who went to college; a decline (and nascent rebound) in the quality of public-school education, including science and mathematics; a continuing decline in interest among high-school students in engineering careers; a growing nationalization (and possible internationalization) of the market for undergraduate education; as well as a growing interest in "hands-on" learning, integrated learning, and "making a difference" through one's education.

MIT has responded to these trends on the margin as its educational offerings have evolved. The question before us now is whether we will consider changes that are more than marginal.

Since the 1960s, the environment in which high-school students choose where to attend college has changed dramatically. The proliferation of college guidebooks and highly publicized college rankings is both a cause and a consequence of a trend by which students and their parents treat the choice of college as they do any other major consumer purchase. What is most relevant to this discussion, however, is the fact that the "consumerist approach" to choosing a college has led the market for higher education to become national. In turn, this has caused the number of applications to MIT to mushroom, thereby creating a more diverse pool of applicants. The fraction of students coming to MIT from the Northeast has dropped, while the share of students from the West and South has risen considerably.

In the past half-century, the number of completed undergraduate applications to MIT has more than doubled, while the geographic spread of the applicant pool has distributed more evenly throughout the country. The number of first-year students who eventually register from this pool has crept up modestly, from roughly 900 to 1,050. Not surprisingly, with the size of the undergraduate student body virtually constant and the application pool more than doubling, MIT has become significantly more selective than ever before. In 1960, 40 percent of applicants to MIT were admitted; in 2006, 13 percent were accepted.

Over the past half-century, the admissions "yield" (i.e., the percentage of admitted students who choose to come to MIT) has grown from roughly 55 percent to 65 percent, rapidly accelerating in the past few years. The high yield suggests that the growth in applications is not simply a consequence of more students "playing admissions lottery," but rather is testimony to the work of the admissions process in identifying a cohort of applicants who belong (and believe they belong) at MIT. As a result, students are better prepared for the rigors of MIT than in the past, and have probably more carefully considered why they want to attend MIT. Therefore, MIT students are in a better position to take full advantage of all the educational resources that the Institute has to offer.

As the number of applications has grown, the intellectual breadth of the application pool has also increased. The simplest metric of the growth in that breadth is average standardized test scores on the verbal and quantitative portions of the SAT. It is not surprising that the average quantitative SAT score of entering MIT students is exceptionally high. What may be surprising is the fact that entering MIT students now have among the highest average *verbal* SAT scores in the country.

The breadth of the prior preparation and abilities of entering students is measurable in other ways, as well. Nowadays, more than 60 percent of MIT's entering class arrives with Advanced Placement (AP) credit in at least one examination area of the humanities, arts, and social sciences, compared to 40 percent twenty years ago – which is even more impressive when we consider that the bar was raised in the intervening years for receiving AP credit at MIT. In the class that entered in 2002, more students received a "5" on their AP exams in English Literature/Composition (361) and in American History (296) than in Biology (233).

Students coming to MIT who express a preference for a major field on their application still mostly choose engineering, but the number overall has fallen. Within engineering, fewer students apply to MIT with one specific engineering field in mind; more are indicating a general engineering interest than before. As the number of entering students expressing an interest in engineering has fallen, the number of students expressing an interest in studying management, the humanities, and the social sciences has grown.

Finally, we must acknowledge the changes in American secondary education that affect the prior preparation of MIT students and their expectations. Significant levels of public concern were expressed in the 1980s about the quality of public-school education, which has led virtually all school districts in the United States to attempt to strengthen their curricula. This, in turn, has led to a general increase in the quality of secondary education nationwide, especially in the sciences and mathematics. One indicator of this improvement is the rise in the prevalence of AP courses in high schools. This national trend has led to an increase in the number of AP subjects with which MIT students enter and, in general, to a stronger background for many students in fundamental subjects like calculus. However, as the mean preparation level in certain fundamental subjects has increased, the variance has also grown. Consequently, although many more students are well prepared for the academic rigors of MIT upon arrival, a substantial number of students will still need time to overcome deficiencies in their high-school backgrounds.

Primary and secondary schools have also changed how they teach. Education at this level continues to undergo a transition in teaching methods, increasingly emphasizing a range of techniques – including project-based learning, peer instruction, internships, and service learning – which William Barton Rogers would have called "learning by doing" and which we call "hands-on learning." At their best, these approaches seek to leverage a robust finding in social psychology: Children and adolescents learn much more efficiently from peers than from adult authority figures. These teaching methods are also increasingly prevalent at MIT and other universities.

Hands-on approaches to education have a powerful impact in setting expectations among students, both in how they learn and in how they perceive the importance of what they learn. High-school students who have feasted on a steady diet of group projects, peer learning, service learning, and problem-based exercises will naturally gravitate toward such modes in college. They may be more adept in learning how to operate in groups and work in teams, but may be less skilled at activities that require individual initiative. Students who expect to approach learning through peer instruction and projects may also more easily gravitate toward activities that have immediate real-world payoff, while chafing at activities that are less immediately applicable.

One final long-term change among entering MIT students must be kept in mind: High-school students are increasingly busy. Children and adolescents spend more time in structured activities, like school clubs and organized sports, and have less free time. One indicator of this shift in "structured vs. free time" is simply in the most frequently mentioned extracurricular activities of today's entering MIT students. In the 1960s and 1970s, our entering students were mostly interested in music, ham radio, and tinkering; in the 2000s, they were mainly occupied with volunteering, music, leadership activities, and athletics.

The sources and implications of these changes are many and controversial, but the consequences for MIT's curriculum are the same regardless of the causes. For one thing, MIT students come to college expecting to devote a significant portion of their energies to activities that may only tangentially relate to their academic pursuits. There is considerable evidence that once they are at MIT, students follow through on these expectations. For instance, the number of extracurricular activities has exploded at MIT over the past four decades, from 60 groups recognized by the Association of Student Activities (ASA) in 1960 to 356 ASA-recognized groups in 2000.

A long series of studies of our undergraduates shows that they continue to be as heavily involved in their coursework as in the past, but have added a variety of additional commitments. These new undertakings have allowed MIT undergraduates to acquire real-world work and research experience, and to make an individual difference in society. By and large, these new obligations (e.g., internships) complement coursework, and often occupy times of the year {e.g., the Independent Activities Period (IAP) and the summer} that used to be devoted to less structured activities. Viewed another way, the MIT undergraduate academic experience is now year-round for many students.

In reviewing how the expectations and prior experiences of MIT students have changed over the past decades, we do not mean to suggest that the Institute should simply capitulate to trends that may, in some instances, be incongruent with MIT's academic mission. At a minimum, these developments present us with a set of challenges and opportunities that we have attempted to address in this report. Some of these opportunities and challenges include the following.

First, more first-year students arrive on campus having already experienced high-quality preparation in the natural sciences and mathematics. Most MIT first-year students arrive with at least one of their Science Requirement subjects satisfied through Advanced Placement. These students are able to approach the first year more flexibly than the minority of students who have no AP credit. However, this also makes it difficult to create a truly common first-year experience in the sciences. It also challenges us to create many different ways for students to fulfill the Science Requirement.

Second, first-year students are also arriving on campus having already experienced high-quality preparation in the humanities, arts, and social sciences. MIT has always prided itself in successfully combining a rigorous scientific and technical preparation with a firm grounding in the liberal arts. In past generations, the typical prior preparation of our entering students in the humanities, arts, and social sciences was not nearly as strong as the technical and scientific preparation. That is no longer the case, however. This suggests that we must devote considerable energy to rethinking how we engage students with the humanities, arts, and social sciences.

Third, all first-year students now arrive on campus with extensive experience in hands-on modes of learning – for many, it is the predominant mode. The emphasis on projects, hands-on learning, and internships is a two-edged sword in thinking about MIT's undergraduate education. On the one hand, it suggests that we should continue examining ways to bring these techniques more completely into the MIT curriculum, as the Institute has already done with diverse educational innovations such as TEAL, service learning, and the MISTI study/work-abroad program. On the other hand, excellence in many subjects requires self-reliance, which may need to be developed more explicitly at MIT than in years past. The increasing dominance of group-based approaches to learning in primary and secondary education suggests that the transition to more solitary activities in college may be more difficult to achieve than in the past.

Fourth, young people increasingly expect that their actions will "make a difference" in the world. On the whole, the movement toward students wanting to "be in the world" is a positive one for the type of education at which MIT has always excelled. Yet, this also presents new challenges for important parts of the curriculum that are inherently theoretical or abstract, as well as for the humanities, arts, and social sciences curriculum, which is valuable precisely because it defies justification by a reliance on instrumentalism.

Fifth, MIT first-year students increasingly seek to explore professional paths that do not neatly map onto the traditional disciplines and major programs that we have long offered. This is a challenge because MIT has long regarded the majors as a long-term investment by a student in a solidly established body of knowledge that will pay off many years into the future. These new interests among recent generations of MIT students suggest that we should revisit the question of how prescriptive our majors should be, encourage the development of more flexible versions of existing majors, and lower the considerable barriers that currently exist to acquiring a second major.

Finally, adolescents come to college having been over-programmed throughout life. MIT first-year students frequently arrive on campus having followed a driven path in which busy-ness has been rewarded. The aphorism that "being at MIT is like drinking from a fire hose" was coined before young people were expected to excel in so many different arenas. What do MIT students "drink from" now? One of the worries about the social pressures put upon high-achieving adolescents is that they are not taught how to make choices. By expanding the range of opportunities that are available to MIT undergraduates, we also must be mindful that we are offering these choices to adolescents who have been encouraged to "do it all."

Greater Balance and Symmetry in the Core Curriculum

The following chapters, particularly Chapters 2 and 3, discuss the General Institute Requirements and how we propose that they be changed. From the introduction that preceded and the more detailed discussions that follow, the reader will see that we propose two major changes in the core curriculum that are abstracted from the content of the curriculum itself. First, we bring the general structure of the Science Requirement (which we term the Science, Mathematics, and Engineering (SME) Requirement), on the one hand, and the HASS Requirement, on the other, into greater alignment. While the two requirements will continue to be structured differently in the details, each will be organized so that most students start at roughly the same place. However, each requirement will provide ways for students to quickly branch off into different directions in order to satisfy their own curiosity, account for their different backgrounds, and prepare themselves for different careers.

Second, we suggest that the first year be considered more of a unified whole, from the perspective of both the SME and the HASS Requirements. On the SME Requirement side, we predict that the first year for each student will gain greater coherence – particularly for those who seek to consolidate knowledge learned in their introductory science subjects – by taking a project-based "first-year experience" subject in the spring semester. On the HASS Requirement side, we predict that the small number of first-year experience subjects – which will mostly be taught in the fall – will set the stage for a series of campus-wide conversations throughout the year, providing students with greater guidance as they choose disciplinary HASS subjects in the spring term. We also hope that, over time, faculty from across all Schools at the Institute will see the value of closely coordinating some fall-term HASS first-year experience subjects with some spring-term science/engineering design subjects. This will prompt students to begin thinking immediately about the truly trans-disciplinary context in which virtually all the important problems facing humankind – now and in the future – are situated.

The accompanying figure schematically sketches out the new GIRs as we currently see them. As drawn, the figure emphasizes the structural parallels between the Humanities, Arts, and Social Sciences (HASS) Requirement and the Science, Mathematics, and Engineering (SME) Requirement. Each is composed of a small set of required subjects – a thematic first-year experience class and expository writing (if needed) for HASS, and two semesters of calculus and a class in classical mechanics in SME. Each requirement has a distributional component. For the

HASS Requirement, the distributional areas are labeled by the three major intellectual domains that compose the requirement's name; for the SME Requirement, students will choose among the following distributional areas: chemical sciences, computation and engineering, life sciences, mathematics, physical sciences, and a project-based "first-year experience" class (choose five out of six).

We propose a set of General Institute Requirements (GIRs) that consists of sixteen subjects, or roughly half of a student's undergraduate education. We firmly embrace continuing the MIT practice of allocating half of the undergraduate experience to general education. Many faculty members have advocated strongly that the role of general education be reduced at MIT, in most cases to accommodate the growth in important topics covered by the majors. We respect and often sympathize with these arguments. Even so, long experience at MIT has demonstrated that our great strength in educating students to pursue lives devoted to science and technology comes from insisting that students be broadly and flexibly prepared. Every university makes a choice about where to reside along the specialization-generalization continuum; a distinctive mark of MIT is its commitment to a *balance* between general and professional education. Deviating from that path in the past did not serve us well; we do not believe it will serve us well in the future.

Showing a commitment to the value of balancing general and professional education by specifying a sixteen-subject set of GIRs could, in some cases, present new challenges to students who pursue particular majors. Some gaps remain between the principle of adhering to MIT's tradition of balancing general and professional education and the practice of allowing all students to graduate in four years without enduring chronic overloading. There is still important detailed work to be done to ensure that some students are not unduly disadvantaged, or that specific departmental programs are not placed in untenable situations.

Conclusion

Because of particular changes in the nature of science and technology and in the characteristics of high-school graduates, we must consider, and recommend, changes to MIT's common experience. Furthermore, MIT has an opportunity to improve students' experiences during their first year and to address other areas of MIT's culture where change might strengthen the quality of undergraduate education.

In doing so, however, we also must make clear that MIT currently does many things excellently; indeed, many of the recommendations we make are consistent with the best educational practices that have emerged at the Institute in recent years.

We embrace the fact that science, human culture, and young people have changed in important ways over the past half-century, and are confident that responding to these developments presents the type of challenge that MIT is well positioned to tackle. To a large degree, the most promising responses to the educational challenges facing MIT have grown up right under our noses – the product of the initiative of individual faculty members in some cases or the result of collaborative efforts in departments, centers, and laboratories in other instances. The task ahead is to nurture the creative impulses that already flourish abundantly at MIT so that these fledgling initiatives, as well as others that might be incubated in the future, will become a part of the MIT education for all students in the years to come.

Our task, reflected in our name, has been to consider the *common* educational experience of our undergraduate students. This is not an exercise that faculty members in research universities take to naturally, yet it is a critical one if we are to foster an environment that values *education* as much as it does *training*. Given where we are in our own lives and what we do as researchers, it is easy to forget the days when most of us were unclear about how to sort through the multiple opportunities presented to us while on the verge of adulthood, how to piece together the individual elements offered in a college experience, and how to ensure that our college experience prepares us for life. Each of us on the task force is an accomplished researcher who has succeeded because the Institute provided a wealth of opportunities for us to extend the frontiers of knowledge in our own specialized areas. We are long past the time when our experience at a university was one that focused on making us good and responsible people, regardless of our vocations.

And yet, the task that we face requires us to consider the experience at MIT that *precedes* the fully formed career or even the declared major. It is an experience that has direct implications for majors and chosen professions, to be sure. But more than that, an MIT education should prepare a student for life, in all its aspects, wherever the path may lead.

In the words of William Butler Yeats, “Education is not the filling of a pail, but the lighting of a fire.”

Summary of Recommendations

1. ***The Science Core, Restrictive Electives in Science and Technology (REST), and Laboratory requirements will be replaced with a single eight-subject Science, Mathematics, and Engineering Requirement.*** The key feature of this requirement is requiring mastery in foundational material by combining a small set of subjects required of all students (single-variable calculus, multi-variable calculus, and classical mechanics) with a limited set of foundational subjects that will be organized into six categories: chemical sciences, computation and engineering, life sciences, mathematics, physical sciences, and project-based first-year experiences.

2. ***The Humanities, Arts, and Social Sciences (HASS) Requirement will be changed to an eight-subject requirement that is divided into two major parts, the* foundational phase *and the* concentration phase.** The foundational phase will consist of four subjects – expository writing and three "foundational electives" distributed across the categories of the arts, the humanities, and the social sciences. (Expository writing may be converted into a free HASS elective by passing an MIT-administered exam.) The concentration phase will consist of four subjects taken from a concentration that was sponsored by a department or an interdisciplinary field. (Concentration fields will have the option of allowing students one free HASS elective.) A HASS First-year Experience Program will be created to support a small set of foundational electives that will be designed specifically for the first year; all first-year students will take one of these subjects.

3. ***MIT will make it clear that acquiring experience in living and working with people from other countries is an essential feature of an undergraduate education, work to expand current international education programs that have proven successful in the MIT environment, and develop strategies to create other opportunities that are especially relevant to an environment that emphasizes science and technology.*** We must aim to allow every MIT student who wishes to undertake a meaningful study, work, or internship experience abroad to do so without financial or academic penalty.

4. ***MIT will use this period of curricular renewal to enhance the infrastructure that supports excellent undergraduate teaching.*** These efforts include increasing coordinated planning of the first-year curriculum; improving orientation and first-year advising; upgrading the quality of classrooms and aligning the mix of classrooms with our teaching needs; gaining control over

counterproductive class-scheduling practices; documenting more completely the contributions our educational efforts make in enhancing the meaningful interactions among students of diverse backgrounds; further extending and professionalizing our efforts to engender educational excellence; and adapting the faculty governance structure to the needs of curricular renewal.

The New General Institute Requirements

Humanities, Arts, and Social Sciences Requirement (Eight Subjects)

Foundational Subjects

one subject from each of three categories,
one of which must be from the First-Year Experience Program

HUMANITIES	ARTS	SOCIAL SCIENCES

Expository Writing (if neccessary) or HASS Elective

Concentration Subjects

four subjects specified for each Concentration;
Concentrations may allow HASS Elective as fourth subject

Science, Mathematics, and Engineering Requirement (Eight Subjects)

Required Subjects

MECHANICS	SINGLE-VARIABLE CALCULUS	MULTI-VARIABLE CALCULUS

Foundational Subjects

one subject from five of six categories

CHEMICAL SCIENCES	COMPUTATION & ENGINEERING	LIFE SCIENCES	MATHEMATICS	PHYSICAL SCIENCES	PROJECT-BASED EXPERIENCE

2. SCIENTIFIC AND ENGINGEERING PREPARATION FOR THE 21ST CENTURY

Three elements of the General Institute Requirements (GIRs) provide an essential education in science and engineering – the Science Core, the Laboratory Requirement, and the Restrictive Electives in Science and Technology (REST) Requirement. Even with these strengths, the set of subjects that is absolutely central to careers at the forefront of science and technology is broader than the set embraced by these requirements. The current approach to the GIRs also causes students to defer for too long a direct experience with the type of creative research and design that produces the most spectacular advances in science and engineering. As a result, a significant number of MIT students graduate without an exposure to the principles and methods of engineering.

Given the size of many major programs, the desire to preserve a reasonable number of free electives, and the constraint of an eight-semester undergraduate program, we cannot require every MIT student to take all of the background subjects identified as essential to an ideal preparation of twenty-first century careers in science and engineering.

Instead, we recommend a new, two-tiered Science, Mathematics, and Engineering (SME) Requirement that defines the scope of the ideal preparation in science and engineering, but recognizes the practical limits of the GIRs in the context of a four-year undergraduate degree. We propose that all students be required to take three subjects: two semesters of calculus and one semester of physics. Students also will be required to take one subject from five of six foundational categories: chemical sciences, computation and engineering, life sciences, mathematics, physical sciences, and project-based first-year experiences.

We further recommend that, with the exception of calculus, MIT students not be allowed to satisfy elements of the new Science, Mathematics, and Engineering Requirement through Advanced Placement (AP) or International Baccalaureate (IB) examinations, that departments be allowed to prescribe a limited number of foundational subjects in the requirement, that a new oversight committee be developed for the implementation of the requirement, and that the faculty and administration work to ensure the continued success of the special first-year programs.

At MIT, a strong preparation in mathematics and the natural sciences is a major part of the intellectual foundation on which students build their educations. This preparation includes exposure to the basic principles that underlie new discoveries in science and engineering, as well as an introduction to the modes of quantitative inquiry that lie at the heart of science and engineering. The Science Requirement[1] currently accounts for nine of the seventeen General Institute Requirement subjects needed to graduate. To many members of the faculty, this requirement – comprised of the Science Core, the REST Requirement, and the Laboratory Requirement – represents the cornerstone of an MIT education.

For many years, these requirements have provided an essential foundation for students in science and technology. This is especially true of the Science Core subjects, which sustain the largest enrollments and closely resemble a common educational experience. Departments involved in providing Science Core subjects have been responsive to the evolving educational needs of students. Pedagogical advances, such as the Technology-Enhanced Active Learning (TEAL) initiative in physics, have resulted in documented improvements in the quality of core science education. The alternative Science Core subjects offered by the Concourse and the Experimental Studies Group (ESG) first-year programs have played positive roles in the lives of many first-year students. In recent years, Science Core instructors and the instructors of "downstream" subjects have collaborated to develop online resources that enable the review of core material throughout a student's MIT experience.

Despite the quality and effectiveness of the current Science Requirement, the Task Force heard persuasive arguments from faculty, students, and alumni that the set of subjects that is absolutely central to careers at the forefront of science and technology is broader than the set currently embraced by the Science Requirement; therefore, the GIRs will be changed to reflect this development. Furthermore, we have encountered a commonly expressed belief that the canonical sequencing of subjects in the Science Core defers for too long a direct experience with the type of creative research and design that produces the most spectacular advances in science and engineering. With increasing frequency, such efforts are trans-disciplinary. The discipline-based foundational knowledge that has been the hallmark of the Science Core is necessary but not sufficient to do the kind of world-changing science and engineering that we expect from MIT graduates. Opportunities for project-based learning – an educational strategy that is well suited for encouraging creativity while bridging disciplinary boundaries – will be available to all students as early as the first year.

1
Strictly speaking, the Regulations of the faculty do not define a single entity termed the "Science Requirement." We use this single term as a shorthand phase to refer simultaneously to three related requirements: the six-subject Science Core, the two-subject Restrictive Electives in Science and Technology (REST), and the one-subject Laboratory Requirement.

Finally, despite MIT's preeminence in engineering education, a significant number of students graduate without being exposed to the principles and methods of engineering. Although we were persuaded that there is no single "engineering method," just as there is no single "scientific method," all students will be well served by an introduction to at least some of the modes of inquiry central to engineering. Therefore, keeping firmly in mind the notable successes of MIT's Science Requirement over the past half-century, we conclude that it is time to add greater flexibility to the requirement, considered as a whole.

History of the Science Core and Other Science-Technology Requirements

Although the general infrastructure of the Science Requirement has been stable for a generation, its particular history is marked by a punctuated evolution that has responded to the changing imperatives to provide both a general education in science and technology *and* a preparation for majors that build on knowledge acquired in GIR classes. In the years immediately prior to 1962, the Science Requirement was a highly prescribed Science Core that consisted of four semesters of physics, four semesters of mathematics, and two semesters of chemistry. Faced with rapid changes in high-school science curricula and an increasing heterogeneity of student backgrounds and goals, a faculty committee was established in 1962 to take a comprehensive look at the undergraduate curriculum, particularly the Science Requirement. Two years later, the committee – chaired by Jerrold Zacharias of the Physics Department – proposed changes to the science curriculum that were intended to encourage continued renewal in MIT's fundamental science offerings and better respond to the varied interests of undergraduates. These proposed changes led to a major restructuring of the Science Requirement in 1965, which is described below.

In reviewing the report of the Zacharias Committee, we are struck with a sense of *déjà vu*, both in terms of the concerns that the faculty thought important to tackle at the time and the character of the curricular changes they proposed. The Zacharias Committee recognized a fundamental problem that still faces the Institute today: Despite a desire to provide students with a comprehensive foundation in science and mathematics, there are more "essential" subjects in these fields than can be packed into a four-year curriculum that aims to provide both a general and a professional education. The committee debated whether "pure science" was the best way to inaugurate undergraduates to MIT, particularly asking whether emphasizing reading- and lecture-based science subjects undermined the "resourcefulness" and efficacy of students. Additionally, they wrestled with the tensions between professional and general education, weighing the pressures to jump right into one's major with the need to educate students about the broader view of their future lives and professions.

The committee's report responded by providing a framework for a more diverse and flexible Science Requirement. The plan still included a Science Core, but the number of prescribed subjects was reduced by half to two semesters of physics, two semesters of mathematics, and one semester of chemistry. The subjects that were consequently freed up were allocated to a single elective laboratory subject and three elective classes from a short list of Science Distribution subjects.

The proposed elective laboratory subjects were implemented as the current Institute Laboratory Requirement. The goal of these subjects was not simply to provide students with experiences in formulaic laboratory procedures or with a set of skills that would be particularly useful in completing their majors. Rather, the goal was twofold: (1) to create practical, project-based experiences that would allow students to exercise the basic concepts learned in science classrooms; and (2) to provide students with early-on practice in conceptualizing ill-defined problems, designing experiments to address those problems, implementing the experiments, adapting to the unexpected that occurred in the course of the experiments, and then drawing conclusions from the empirical observations that the experiments produced. The following words, some of which remain in the MIT *Bulletin* to this day, captured the essence of the newly proposed "elective laboratories":

> These laboratory electives would not be designed to teach specific subject matter or to provide broad coverage of a particular field; rather, they would be intended to give the students some real idea as to what laboratories are and what is meant by solving experimental problems in science and engineering. The laboratories should be essentially professional in flavor. The students should get the feeling that they are working on a problem as a professional would work on it . . . .[2]

These subjects might have no prerequisites, or perhaps one prerequisite from among the common core Science Requirement, but they were expected to be taken either in the first or sophomore year.

2 The Zacharias Report, p. 36.

The second new feature of the Science Requirement, the "science area electives," was a compromise between the desire to expose all students to a common core of fundamental science subjects and the reality that the interests, aptitudes, and prior preparation of students varied. It was clear to the Zacharias Committee that all students should be exposed to a common set of general intellectual domains within science and technology, but the committee explicitly rejected the idea that this should be accomplished by exposing all MIT students to the same set of subjects throughout. Rather, they proposed that the science elective subjects be divided into six categories (life sciences; chemistry; mathematics; physics; earth sciences; and applied science), and that students be required to take one subject from among three of these categories. They also recommended that every student who was not in ROTC be required to take a six-unit engineering elective.

When the Institute faculty got around to implementing this proposal from the Zacharias Committee, it was changed to a simpler structure – three subjects chosen from a single list of science-area electives (not six sub-lists), which eventually became the Science Distribution requirement. To maintain the idea of distribution, students were required to take these subjects from three different departments and three different fields. The engineering requirement was not pursued. Some of the subjects taken in the Science Distribution would be chosen to gain further preparation for a major, others would be chosen to help fill in holes in students' prior experience, and still others would be chosen simply because students were curious about the subject.

The Zacharias Committee recognized that some of the subjects included among the laboratory and science-area electives would require prerequisites from among other Science Requirement subjects. Thus, the committee recognized that laboratory and science-area electives would often serve as an explicit bridge between the general preparation in science represented by the math, physics, and chemistry requirements and the majors that undergraduates might eventually choose. The resulting overlap of subjects, which was intended to provide a general education *and* function as the integral part of a major, was seen as a mixed blessing. On the one hand, a more flexible Science Requirement allowed students to pursue subjects whose topics interested them and whose intellectual styles were more congruent with their own. On the other hand, since many of these subjects would be taught by departments as pathways to their own majors, once a student had made a choice of a laboratory or science-area elective, she or he might be locked into a path leading toward one major, to the exclusion of others. Stated more directly, departments might start requiring that their majors take classes that counted toward the Laboratory or Science Distribution Requirements, which could lock students into majors as first-year students or sophomores, before having the opportunity to explore the intellectual landscape at MIT and make a fully informed choice of major. A compromise was worked out, which allowed departments to prescribe only two of the four elective subjects in the Science Requirement.

Over the past forty years, the tension between the general educational experience offered by these elective subjects and their roles as providing prerequisite knowledge for particular majors increased. As their disciplines evolved, the faculty teaching in the departmental programs felt it necessary to include more and more subject material, which produced substantial pressure to shift some of the subject material into the Science Requirement or, at least, to expect the Science Requirement more explicitly to prepare students for major programs. Since departments were already allowed some overlap between their major programs and the GIRs, it was a natural next step for them to begin developing new subjects of their own to populate the lists of Institute Lab and Science Distribution subjects.

The number of Science Distribution subjects eventually increased from forty-six to seventy-three, as each science and engineering department argued for having at least one subject on the list. In effect, the Science Distribution Requirement (now termed the REST Requirement and reduced to two subjects) evolved into the required sophomore subjects in each engineering and science major. A parallel change in the Laboratory Requirement also occurred. An initial small set of options (twenty-two in 1966) became the long list of departmentally required subjects (forty-nine) that we have today – often subjects taken in the junior year, instead of in the first two years as was originally envisioned and still formally prescribed by the Rules of the Faculty.

The Science Distribution and Laboratory components of the GIRs that emerged in the 1960s were flexible structures that represented a compromise between a narrowly prescribed core and elective choice. Over time, flexibility was also added at the level of individual subjects within the Science Core itself. During the 1970s and 1980s, for example, the chemistry requirement could be satisfied by one of a number of subjects: Introduction to Structure, Bonding, and Mechanism (5.41); Chemical Thermodynamics (5.60); General Chemistry (5.40); Introduction to Solid State Chemistry (3.091); and General Biology (7.01). Different flavors of essential physics subjects have been offered (standard, laboratory-based, theoretical, and bio-physical), and students have been able to take accelerated, standard, applied, and theoretical versions of calculus as part of the Mathematics Requirement. Moreover, students in the Concourse and Experimental Study Group first-year programs have been allowed to elect to take some of the Science Core subjects in small-group settings, which encourage greater student-student and student-faculty interactions.

Thus, while a casual perusal of the Science Requirement suggests that MIT undergraduates all march in lock step through a core science and engineering curriculum, the actual experience of students within the curriculum has been something quite different. In fact, only a handful of students actually take the exact same subjects in order to satisfy the Science Requirement.[3] Students who graduated in 2004 took a total of 118 different subjects to satisfy the Science Core, REST, and Laboratory Requirements.[4] It is a testimony to the spirit in which these subjects are offered that faculty, students, and alumni almost uniformly regard this plethora of classes as constituting a coherent whole, united in purpose.

The addition of biology to the Science Core in the early 1990s is a significant example of how the structure of the General Institute Requirements has evolved incrementally in response to the changing nature of "fundamental" science since the 1960s. By the early 1990s, it had become apparent that the essential modes of inquiry of biology were fundamentally different from those of chemistry or physics, and it was clear that a revolution in molecular biology was to have a profound impact on the modern world. Our faculty was faced with the problem of finding space in its packed curriculum for a new General Institute Requirement. In order to accommodate the change, the Science Distribution requirements were reduced to two subjects and renamed the "Restricted Electives in Science and Technology (REST) Requirement." This reform has effected a significant, salutary change in the substance of undergraduate education at MIT. However, the change also has underscored how the desire of the faculty to ensure that students all receive a common grounding in natural science and mathematics always involves trading off three values that we all hold dear – breadth in the Science Requirement itself *vs.* subject choice for students *vs.* the substantial demands facing the majors.

For most MIT students, the three subjects that now combine to constitute the Laboratory and REST Requirements are fully incorporated into their departmental major programs. Although this situation has arisen as a consequence of pressures to increase the technical content of the major programs, the result has imposed many of the educational costs that the Zacharias Committee foresaw when it encouraged all departments to develop subjects that would participate in our general undergraduate education. Primary among these is a tendency toward overspecialization, which is antithetical to the current evolution of science and engineering toward trans-disciplinary and "systems" thinking. Of secondary concern, but still serious, is the pressure exerted on many students to commit to a major before they have sampled the wide variety of options available at MIT.

3
For instance, the 946 undergraduates who entered MIT in the fall of 2000 and graduated in the spring of 2004 pursued 384 unique combinations of Science Core subjects on the way to completing the requirement. The most common way to complete the science core was to receive AP or Advanced Standing credit for all physics, calculus, and chemistry subjects, only taking 7.012 at MIT. (This was accomplished by 27 students.) The second-most common path through the Science Core was to receive AP credit for 18.01 and then take 3.091, 7.012, 8.01, 8.02, and 18.02 at MIT. This was done by only 24 students. Only 16 students took the most common version of the stereotypical sequence of common core subjects at MIT – 3.091, 7.012, 8.01, 8.02, 18.01, and 18.02.

4
The breakdown is as follows: Students satisfied the Biology Requirement with three different subjects, the Calculus I Requirement with four different subjects, the Calculus II Requirement with six different subjects, Chemistry with three different subjects, the Laboratory Requirement with 41 different subjects, Physics I with four different subjects, Physics II with five different subjects, and the REST Requirement with 52 different subjects.

Toward an Improved Science, Mathematics, and Engineering Requirement

We have reviewed the efficacy and content of the Science Core, REST, and Laboratory Requirements, seeking the opinions of faculty, students, and alumni. The findings of this exercise were congruent with other reviews of the MIT science curriculum undertaken in recent years, particularly those of the Educational Design Project carried out by the Committee on the Undergraduate Program in the late 1990s, which surveyed an even broader spectrum of the MIT community, including employers of MIT graduates.[5] We heard that MIT graduates are increasingly being called on to bridge the gaps between traditional disciplines in their careers after graduation. In addition to the deep, specialized training that is the hallmark of an MIT education, we heard that we should better prepare students to take leadership roles in driving innovations in science and engineering, especially the design of new hybrid disciplines. Such roles require both a strong foundation in current knowledge and the creative capacity to develop new knowledge. In brief, the message received by the Task Force was that the current requirements have well served students by providing an exceptional entrée into the traditional disciplines of science and engineering. However, these requirements might not provide a sufficiently comprehensive background in the full spectrum of science and engineering needed for the future – and they might not demand of students the type of creativity and resourcefulness necessary to innovate in the coming years.

Having received that message, our challenge was to design an even more effective core experience that includes a broader introduction to different scientific and analytical perspectives. For example, many in the MIT community have argued that a basic introduction to computation, specifically data abstraction and algorithmic thinking, is essential preparation for many engineering and science careers. Probability and statistics are fundamental subjects required across the sciences and engineering, as well as topics that are critical for the general citizenry to be conversant with as we face societal issues fraught with uncertainty and imprecise evidence. Many other important disciplines or sub-disciplines – such as earth science, complex systems, neuroscience, and engineering practice – were mentioned by members of the MIT community as foundational subjects that should be included in the portfolio of any MIT graduate.

We spent much time discussing how to maintain an introduction to fundamental science and engineering given the constraints of a four-year undergraduate program and the increasing pressure on departments to expand their undergraduate major

5
Educational Design Project, *Preliminary Findings and Recommendations of the Educational Design Project*, Cambridge, Massachusetts, Massachusetts Institute of Technology (August 1999). Available at http://web.mit.edu/faculty/reports/edp.html.

programs. This problem is neither unique nor new to MIT. One answer to the problem, and only one part of the solution, is to resist the pressures to replace general education with pre-professional subjects required of majors. This is consistent with the comments of the 2005 National Academy of Engineering report which noted that "the exploding body of science and engineering knowledge cannot be accommodated within the traditional four-year baccalaureate degree," and that engineering education is evolving toward a condition in which the baccalaureate degree should be "recognized as the 'pre-engineering' degree or bachelor of arts in engineering degree." As a consequence, the authors of that report concluded that "engineering schools must teach engineering students how to learn and must play a continuing role … in facilitating lifelong learning."[6]

The National Academy of Engineering statement helps to frame our own thinking about how to approach more generally the common MIT curriculum. While our task is certainly to specify a set of particular subjects that students should master, our greater responsibility is to create an environment in which students develop a sense of ownership of their education, the creative instincts to go beyond what we can hope to teach them in four years, and the ability to be lifelong learners after they earn their bachelor of science degrees.

Our proposed solution to the constrained optimization problem we face is quite similar to the one offered by the Zacharias Committee nearly forty years ago. It differs primarily in the weight given to classes required of all students, compared to "branching options" that are available to students as they are allowed to choose the precise ways they will travel through the Science, Mathematics, and Engineering (SME) Requirement.

Another strong message received by the Task Force was that the first year needed to excite students about learning. Many in the wider MIT community believe that the first-year curriculum will benefit greatly from the wider availability of project-based experiences that are especially effective at infusing excitement, developing greater creative capacity, and establishing the importance of self-directed learning. A well-designed project experience in science and engineering motivates the acquisition of disciplinary knowledge and serves as a context for that knowledge. It can illuminate connections among different disciplines, help develop transferable skills, and – depending on the design of the experience – foster the development of teamwork and communication skills. Many successful models exist today at MIT for such subjects – some involve integrative, team-based learning, while others entail discipline-specific, individual work; yet, all feature the essential element of discovery that pervades research activities at MIT. Because innovation, contextual

6
Committee on the Engineer of 2020, Phase II, Committee on Engineering Education, National Academy of Engineering, pp. 52, 55.

reasoning, and transferable skills are hallmarks of the Institute, we believe that each student must have the opportunity for such an experience as part of his or her MIT undergraduate education. To some extent, the Undergraduate Research Opportunities (UROP) program addresses this need. Since most students become involved in UROP after the first year, however, many UROP experiences do not give students substantial latitude in defining and tackling research problems. Ideally, research experience will begin in the first year, before the vast majority of students are prepared to contribute to substantial independent work in a science or engineering laboratory.

Specific Recommendations

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 improve the entrée of students into exciting new areas of science and technology. This change will require students to be more active in their choice of pathways through the core, introduce new modes of analysis that we consider to be fundamental, and provide new opportunities for students to become involved in project-based experiences that imbue excitement into the first-year experience.

Replacing the current requirements will be a single eight-subject Science, Mathematics, and Engineering Requirement that is comprised of two tiers of classes, required subjects and foundational subjects. Three subjects will be required of all students. The second tier will be comprised of subjects divided thematically into six areas, representing other foundational subjects in science and technology that are appropriately chosen by students, depending on their educational goals, including their intended majors; students will be required to take one subject from five of the six foundational areas.

Because calculus of multiple variables is indispensable in the vast majority of majors at the Institute, MIT will continue to require that all students receive credit for calculus of single and multiple variables, which are currently 18.01 and 18.02, along with their variants (18.01A, 18.014, etc.). Classical mechanics is also appropriate to include among the required subjects, but for a different reason.

Mechanics (8.01 and variants) is a prerequisite for many majors at MIT; in addition, Mechanics is ideal for exposing students to how mathematics and the natural sciences are intellectually intertwined and how reductive science can best be approached. In other words, Mechanics is both practically useful for many students' professional goals *and* provides a clear window into the basic methods of problem solving that are so characteristic of an MIT education.

In effect, this will require that all students complete 18.01, 18.02, and 8.01 (or their variants). These three subjects already have many natural affinities; classifying them together as required subjects will, we hope, encourage continued and enriched opportunities for active coordination among these subjects.

The foundational subjects are designed to provide students with some flexibility in their general education in science and engineering disciplines, while also encouraging students to have a broad range of experience with different modes of learning. There will be six foundational subject areas:

1. ***Chemical sciences.*** These subjects expose students to the basic ideas of modern chemistry. Topics include the electronic and geometric structure of molecules, chemical reactions, the states of matter, and the chemical processes essential to life. Of our current curricular offerings, 3.091 (Introduction to Solid State Chemistry) and 5.111/5.112 (Principles of Chemical Science) fit naturally into this category.

2. ***Computation and engineering.*** Subjects in this category focus on the modes of thought and problem-solving tools associated with the computational modes of analysis and the engineering method. In developing this category, the Task Force was strongly influenced by the recent report from the Engineering Council on Undergraduate Education entitled ***From Useful Abstractions to Useful Designs – Thoughts on the Foundations of the Engineering Method***. The authors of that document argued that "conceptual and practical understanding of 'engineering thinking' is a critical foundation for human knowledge" and that all MIT undergraduates should have a subject on this topic as part of their MIT experience.[7]

   The computation subjects will explore the role of algorithmic and data abstractions, as well as the use of imperative knowledge in designing computational solutions to theoretical and practical

7
Dick K. P. Yue *et al., From Useful Abstractions to Useful Designs – Thoughts on the Foundations of the Engineering Method*, Cambridge, Massachusetts, Massachusetts Institute of Technology (2005), p. 2. Available at http://web.mit.edu/engineering/ecue/core_abilities/index.html.

problems. These subjects will not simply be introductions to programming languages, but rather will provide a computational paradigm for reasoning and problem solving. Although current subjects, such as 6.001 (Structure and Interpretation of Computer Programs), serve as potential models for appropriate computation subjects, this category invites the development of new subjects that, for example, may involve collaborations among departments and other academic units.

By taking engineering subjects in this category, students will gain an appreciation of the trans-disciplinary principles of engineering and their use in problem solving. In these subjects, particular emphasis will be placed on the use of abstraction, the processes of design and synthesis, and the complexities of large systems in the context of modern technological society.

3. ***Life sciences.*** These subjects examine the fundamentals of the processes of biology at the molecular, cellular, and systems levels. They will expose students to the basic ideas of molecular biology and genetics, biological evolution, the functioning of cells, and the integration of cells into biological systems. Life sciences classes include subjects such as 7.012/7.013/7.014 (Introductory Biology) from the current Biology Requirement of the Science Core. Other subjects that serve as basic introductions to aspects of the life sciences (i.e., an introduction to neuroscience that satisfies the above criteria) also can be included in this category.

4. ***Mathematics.*** These subjects introduce students to fundamental structures of formal, quantitative reasoning and analysis used throughout science and engineering. Subjects in this category will provide basic experience with specific mathematical methods and modes of thought, such as the quantitative and qualitative relationships between incremental change and long-term behavior (e.g., 18.03, Differential Equations); the geometry and numerical representation of systems with many degrees of freedom (e.g., 18.06, Linear Algebra); and the analysis of uncertainty and expectation (e.g., 18.05, Introduction to Probability and Statistics; 6.041, Probabilistic Systems Analysis).

5. ***Physical sciences.*** The realm of the physical sciences extends from the smallest structures in the universe (quarks, nuclei, and atoms)

to the largest (galaxies). Studying the principles of the physical sciences leads to a deep understanding of the physical world and provides the fundamentals necessary for innovation in many areas of science and engineering. Subjects in this category broaden a student's knowledge of the physical sciences beyond introductory classical mechanics. Options will certainly include 8.02 (Physics II and Electricity and Magnetism), but other subjects that might be added to the list could provide an introduction to geophysics, or a fundamental treatment of vibrations and waves.

6. ***Project-based first-year experiences.*** These subjects will be learning opportunities that involve either design or creation. They will emphasize the synthesis of ideas and techniques, especially leveraging the use of real-world problems to motivate the acquisition of disciplinary knowledge, and stress the cross-disciplinary interactions needed to address all aspects of a design problem. The outcome of a project-based subject will not be narrowly prescribed in advance; part of the project process is defining the goal through informed decisions. Examples of existing subjects that provide useful models for classes in this area include 2.000 (How and Why Machines Work), 12.000 (Solving Complex Problems), and 16.00 (Introduction to Aerospace and Design). This category is particularly ripe for the inclusion of new, interdisciplinary subjects that focus on the use of science and engineering concepts to address emerging societal issues.

   The d'Arbeloff Fund for Excellence in Education is currently funding pilots for six new subjects that might naturally fit into this category. Especially exciting is the possibility that some project-based experiences may include appropriate content that will make them capable of serving as foundational subjects in other categories (e.g., Computation and Engineering).

In order to graduate, each student will take at least one subject from five of these six categories. We envision all foundational subjects to be truly introductory, allowing no prerequisites beyond the three required subjects.

In proposing the six foundational subject areas, we caution against allowing the number of these subjects to proliferate, such that they become *de facto* equivalents of the current REST or Laboratory Requirements. Consequently, we recommend that none of these areas – except the project-based first-year experience – include more than three carefully designed subjects apiece. During the transitional period for the new requirement, we anticipate a great deal of experimentation to take place under the umbrella of the project-based first-year experience. Thus, it seems inappropriate to restrict the number of these subjects.

The accompanying table *(on page 58)* compares the current set of GIRs in science, mathematics, and engineering with the proposed new requirement.

An alternative organization of the Science, Mathematics, and Engineering Requirement

A majority of Task Force members endorse the proposed new structure of the two-tiered Science, Mathematics, and Engineering Requirement outlined above, but a significant minority favored an alternative that identified five, not six, foundational areas and that required students to take one class from each area. In the interest of continuing this discussion within the entire MIT community, we describe this alternative view.

There are a few ways to construct a new Science, Mathematics, and Engineering Requirement around five, rather than six, category areas. One proposal that we gave serious consideration to was the elimination of the Mathematics elective area, leaving the remaining five categories. In the end, the most effective alternative seemed to be combining computation and engineering and the project-based first-year experience into a single category. This will make the five foundational areas: (1) chemical sciences; (2) computation, engineering, and project-based first-year experiences; (3) life sciences; (4) mathematics; and (5) physical sciences.

Task Force members who favor this alternative recognize that combining these two categories raises questions about the goals and coherence of such a combined elective area. Yet, the combination responds directly, and substantively, to nation-wide concerns about the "pipeline" of students from the United States into science, technology, engineering, and mathematics (STEM) fields in college. The current curricular practices at MIT may have inadvertently contributed to this problem in two ways. First, students who come to MIT to study engineering are presently told that they must wait until the sophomore year or later to engage the fields that brought them to MIT. Second, many students find that the traditional ways of teaching core subjects lack excitement and stimulation. Project-based engineering experiences are intended to be engaging and will get students started in the fields of study that attracted them to MIT. Creating a foundational area that combines project-based learning with engineering complements proposals in the K–12 arena, which attempt to address the pipeline concerns at an earlier point in time. Many believe that one way of attracting more students into the STEM pipeline is to introduce them to interesting and exciting applications of technology and engineering in both middle school and high school.

Currently, the computation and engineering and the project-based first-year experience categories are less developed than the other four areas. Most likely, it will take some years of development to create enough subjects in these areas to serve all the students who wish to take them. In any event, the questions of goals and coherence will need to be revisited several years from now.

Taking the broad view, why propose to reduce the number of foundational subject areas to five and require students to take one subject from each category (i.e., requiring “five-out-of-five” rather than “five-out-of-six”)? Consider the first argument in favor of this proposal: If the faculty believes a disciplinary area is essential for all students to understand in order to be effective scholars and citizens, then *not requiring* it will be a disservice to students and will send the wrong message both inside and outside MIT. A five-out-of-five scheme will continue to require that *all* MIT students graduate having taken two semesters of physical science, two semesters of calculus, and one each of chemical science and biological science. It will provide greater flexibility about the flavor of each category, along with considerable flexibility in choosing how to approach the computation, engineering, and project-based first-year experience area.

Here is a second, complementary argument: The real gain in the new structure is increasing choice *within* categories, thus requiring students to engage with the important question of how to further explore basic topics in areas such as the biological sciences and physical sciences. Allowing the further choice of which foundational area can be avoided, as is done in the five-out-of-six scheme, needlessly adds complexity to this intellectual exploration.

A third argument is this: By allowing students to skip one of the foundational areas, the five-out-of-six plan will box them out of possible majors earlier than is appropriate. This is also a potential problem in the five-out-of-five proposal. However, students will have more flexible major options down the road if they are required to explore all of the core scientific disciplines, rather than being allowed to forego one of them at the outset. Clearly, as we discuss elsewhere in this report, we will need to provide excellent first-year advising to reduce the incidence and impact of bad academic choices in the first year. Inevitably, some students will (appropriately) decide to change directions during their time at MIT. With certain GIR choices made in the five-out-of-six structure, it is easy to see how they could find some majors impossible to complete in four years.

The Task Force members discussed and debated at length the structure of a new Science, Mathematics, and Engineering Requirement and, in the end, most favored the five-out-of-six structure. However, we all recognize that this issue will continue to be discussed as the faculty moves toward formally adopting curricular changes. Therefore, we consider it important to describe the most prominent alternative and outline its justification. In closing, however, it is important to note the following: After two years of considering this matter, what is *not* in serious widespread dispute is whether we will move toward greater flexibility in our common science and engineering requirement or whether we will open up the requirement to include new areas such as computation, engineering, and complex systems. The real question is how to do this in the best interests of MIT students, considered as a whole.

Accompanying Issues

As we examined the current status of the Science Requirement, we encountered a series of issues that impinge upon its current success or that arise in thinking through the implications of a new, more flexible core. We highlight these issues here, anticipating that they will be incorporated into the details of the curricular reforms that finally emerge.

Advanced credit

A significant issue that arose in our deliberations was whether to require that all of the subjects taken to satisfy the Science, Mathematics, and Engineering Requirement be taken while at MIT or, in limited cases, through transfer. MIT currently allows departments a "local option" in establishing policies about the use of Advanced Placement (AP) and International Baccalaureate (IB) credit in Science Core, REST, and Laboratory Requirement subjects. Should this continue?

Arguing in favor of continuing the current practice is MIT's long tradition of encouraging students to tackle challenging material, often accelerating at a rapid pace. Discouraging well-prepared students from moving ahead will have a stultifying effect on our education and therefore should be resisted. Arguing against the current practice was a growing body of 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 one exception to this generalization is calculus, where the Mathematics Department has established clear regularities between AP exam performance and mastery of material as taught at MIT.) In some cases, notably biology, the content covered on the AP exam overlaps very little with the content of the subjects as taught at MIT. Finally, there was the belief that there is no substitute for tackling this fundamental material with MIT students as one's peers.

After much discussion, we concluded that, with the exception of calculus, the argument against awarding credit for required science subjects through the AP and IB exams was compelling. These exams may be appropriately used as placement instruments or as evidence that a student might want to stand for an MIT-administered Advanced Standing exam. As a general matter, MIT faculty members must not accept outside examinations as evidence that students have met our basic requirements in science and engineering.

Mandates and size of departmental programs

Departments must have some predictability regarding the preparation of students for their major programs. Therefore, departments will be allowed to stipulate some, but not all, of the foundational subjects that their majors must take within the Science, Mathematics, and Engineering Requirement. Under the new requirement, we might discover, for instance, subjects as diverse as Electricity and Magnetism and Geophysics in the same elective area of the physical sciences. It would be inappropriate to mandate that *each* of these subjects serve as a prerequisite for Circuits and Electronics (6.002) and for Physics and Chemistry of the Solar System (12.420), which is what the current Regulations of the Faculty require.

Allowing departments to specify subjects within the Science, Mathematics, and Engineering Requirement raises the danger, however, that departmental expectations could cause the first year to be highly prescribed, as first-year students launch out immediately to fulfill departmental requirements. In implementing the new requirement, we must resist the temptation among MIT students to overspecialize.

This is not a new concern. Nearly forty years ago, the Zacharias Committee highlighted this point as being a natural consequence of allowing a liberal arts education to overlap considerably with early professional preparation in the core curriculum.

Preserving desired flexibility for students, both at the level of choosing individual subjects and choosing a major, will require a portfolio of responses. Key among these is the development of advising structures and information portals that encourage first-year students to understand the curricular implications of majoring in a particular program and to make informed decisions about foundational subjects. As well, MIT will need to reverse the recent decline in the involvement of faculty members in first-year advising. Concern about flexibility is also one key reason for departments to maintain more flexible versions of their majors, in order to accommodate the certainty that some students each year will make a choice of elective science subjects that will, in the end, interfere with their ability to complete a major in four years.

A related concern is the number of required subjects in the majors under this proposal. Many departments at MIT rely on beginning majors having been exposed to all of the current Science Core subjects by the end of the first year. With greater flexibility in the SME Requirement, majors may no longer be able to count on this. If so, then major departments may feel it necessary to specify explicitly a set of foundational subjects that in the past were simply assumed. To the degree that departments will find it necessary to designate SME Requirement subjects within their own major, they could potentially grow too large to be accomplished in four years without chronic overloading by students.

How the faculty will regulate the growth of departmental programs as a consequence of these reforms is a difficult issue that must be resolved in the coming months. We are in agreement, however, that part of the solution must involve requiring departments whose majors must grow larger than the constraints currently embodied in the Regulations of the Faculty to offer more flexible majors that require fewer subjects. Some departments currently support such majors, including physics and mechanical engineering. Many students will benefit if similar options are available across the board.

Oversight

Formally, the faculty Committee on the Undergraduate Program is responsible for overseeing the Science Core, but practical, day-to-day oversight of Science Core subjects has fallen to the departments that offer them. This has been a largely successful, practical approach that reinforces MIT's long tradition of firmly embedding the responsibility for teaching the content of subjects with the faculty members who are the experts in those subjects. At the same time, as the name implies, the General Institute Requirements are mandated by the entire faculty because they accomplish a set of goals that transcends the desire of any one department's faculty. Thus, the entire faculty must regard themselves as stakeholders in the content and pedagogy of GIR subjects, regardless of their departments or schools. This is especially important for the new Science, Mathematics, and Engineering Requirement, which will naturally include subjects offered by faculty from both the School of Science and the School of Engineering, and perhaps from other academic units as well.

Therefore, we recommend that a new oversight committee be developed for the Science, Mathematics, and Engineering Requirement that will both enable management of the SME Requirement and inspire departments and schools to populate it with exciting and inspiring subjects that are distinct to MIT. Moreover, this committee must provide encouragement for individual faculty members to participate in the general education enterprise and work creatively with schools and departments to design an appropriate recognition scheme for those faculty members who contribute.

Formally, we envision this committee as a standing subcommittee of the Faculty Committee on the Undergraduate Program that includes faculty representatives from all five Schools at MIT, the active participation of all five School Deans, as well as the Dean for Undergraduate Education. The committee will review and approve subjects proposed to populate the Science, Mathematics, and Engineering foundational areas. In addition, the committee will be expected to take a proactive role in encouraging the development of new subjects and approaches to teaching, as well as new educational collaborations among faculty across departments and Schools.

The special first-year programs

MIT's special first-year programs – Concourse, the Experimental Study Group, the Media Arts and Sciences Freshman Program, and Terrascope – play an important role in providing MIT's newest students with effective learning environments. In some cases, these programs have developed special offerings of Science Core subjects for their participants, and the new Science, Mathematics, and Engineering structure will create significant challenges for these programs. That is because the structure of the new requirement will increase substantially the number of subjects that could fulfill the basic SME Requirement, and the special first-year programs are simply too small to offer parallel versions of each subject in the new requirement.

At the same time, the new Science, Mathematics, and Engineering Requirement provides the opportunity to serve as a test bed for experimental subjects, which was the original intention behind starting these programs nearly forty years ago. In recent years, the Terrascope program has been an incubator for the development of 12.000 (Solving Complex Problems), which is a proof-of-concept model for integrative, hands-on, project-based first-year experiences and a prime example of how such experiments might be done. Moreover, some of the special first-year programs may evolve toward communities that serve groups of students interested in pursuing specific disciplinary paths, or that provide special opportunities to explore career alternatives. In any event, the Task Force encourages the Institute to continue to support these programs and to take special pains to ensure that they are strengthened, not undermined, by the new requirements.

Conclusion

MIT has a special responsibility to articulate the fundamental knowledge base on which the next generation's scientists and engineers will build their careers and the content of technical education with which all "scientifically literate" citizens should have some facility. When the MIT faculty last visited this question, in the midst of the Space Race, it concluded that the nature of technological progress and the diverse interests of the nation's most capable young people who choose to attend MIT argue against a "one-size-fits-all" approach to this task. After forty years of experience with that basic approach, we see every reason to continue embracing this view.

But the world has changed in the past forty years, and the right mix of prescription and flexibility for MIT students has changed, as well. The new Science, Mathematics, and Engineering Requirement will continue MIT's tradition of focused excellence in the general education of students, while allowing them more immediate access to the compelling questions that bring young people to study at MIT in the first place.

Summary of Recommendations

1. ***The Science Core, Restrictive Electives in Science and Technology (REST), and Laboratory Requirements should be replaced with a single eight-subject Science, Mathematics, and Engineering (SME) Requirement that retains the rigorous character of the current Science Requirement, while providing greater flexibility to better represent the disciplinary breadth of MIT and improve the entrée of students into exciting new areas of science and technology***. The key feature of this requirement is insisting that students master *foundational material* by combining a small set of subjects required of all students (e.g., univariate calculus, multivariate calculus, and classical mechanics) with a limited set of foundational subjects that will be organized into six foundational categories: chemical sciences, computation and engineering, life sciences, mathematics, physical sciences, and project-based first-year experiences.

2. ***Formal mechanisms should be established to limit the subjects contained in the six foundational categories to classes that address matters of a foundational nature and limit the number of subjects in each category to three.*** The exception to this numerical limitation is the Project-Based First-Year Experience category.

3. ***Students generally should not be allowed to satisfy the new SME Requirement through examination, except through Advanced Standing examinations administered by MIT.*** Exceptions can be imagined, such as for Calculus, but they must be grounded in a set of findings that: (1) map the content of the outside exams onto the content of classes as taught at MIT, and (2) document that students who satisfy the requirement through these exams perform well in subjects that require mastery of the foundational material.

4. ***Departments may designate a limited number of named subjects to be used to jointly satisfy the SME Requirement and serve as a prerequisite for required subjects in the major.*** However, departments should not be allowed to designate *all* of the SME electives. Departments with large major programs should offer a more flexible degree option that requires fewer subjects.

5. ***A subcommittee of the Committee on the Undergraduate Program should be constituted to oversee the SME Requirement.*** The subcommittee should include representation from all Schools of the Institute and active participation from the Deans for Undergraduate Education, Science, and Engineering.

6. ***The Institute should continue to support the special first-year programs as they adjust to the flexibility required of the new SME Requirement and to allow these programs to continue to serve as a testing bed for experimental approaches to foundational material.***

Table 1

Comparison of Current and Proposed Science, Mathematics, and Engineering Requirements

Current Requirements *

1) Six core science subjects, one subject from each of the following groups: 3.091, 5.111, or 5.112; 7.011, 7.012, 7.013, or 7.014; 8.01, 8.01X, 8.01L, or 8.012; 8.02, 8.02T, 8.02X, or 8.022; 18.01, 18.01A, 18.012, 18.013, or 18.014; and 18.02, 18.02A, 18.023, or 18.024. The available choices shall be equivalent as prerequisites for departmental programs.

2) Two Restricted Electives in Science and Technology, at least one of which is not in a student's own department.

3) One Laboratory subject of 12 units, or two Laboratory courses of at least six units each, so that the Laboratory work will call for a major commitment of the student's attention; it is suggested that students satisfy at least a portion of the Laboratory Requirement during the first two years.

Proposed Requirement

1) Differentiation and integration of functions of one variable (18.01 and variants).

2) Calculus of several variables (18.02 and variants).

3) Classical mechanics (8.01 and variants).

4) One subject from five of the following six areas:

i) *Chemical Sciences* [3.091, 5.111, or 5.112, as examples].

ii) *Computation and Engineering* [new subjects in development].

iii) *Life Sciences* [7.01 and variants, and 9.01, as examples].

iv) *Mathematics* [18.03, 18.05, 18.06, or 6.041 as examples].

v) *Physical Sciences* [8.02 and variants, as examples].

vi) *Project-Based First-Year Experiences* [2.000, 12.000, or 16.00, as examples].

* *Rules and Regulations of the Faculty* (April 2006), Section 2.84a., available at http://web.mit.edu/faculty/rules/rules.pdf.


3

3. STUDYING CULTURE AND SOCIETY AT MIT IN THE 21ST CENTURY

A rigorous curriculum in the humanities, arts, and social sciences is a distinctive feature of MIT's undergraduate program, distinguishing it from most other universities primarily devoted to science and technology. The current HASS Requirement was last changed in 1989, but draws its ultimate inspiration from the 1950 Lewis Committee report, which provided a blueprint for highlighting the understanding of culture and society in the context of a technical education. That blueprint has guided the development of a flourishing faculty in the humanities, arts, and social sciences with a rich legacy of teaching and research.

As a result, MIT undergraduates are challenged by superb teaching and research collaborations in these fields. However, the requirement is overly complex and inadequately structured to achieve its goals. We must also find new ways to encourage the active collaboration of faculties in science and engineering with faculties in the humanities, arts, and social sciences in designing classes that more explicitly bridge these areas.

We propose the establishment of a new requirement in the humanities, arts, and social sciences. This new requirement will explicitly create intellectual communities organized around the exploration of major issues in culture and society, while providing a focused introduction to the intellectual traditions and practices associated with these disciplines. It is organized around four subjects in a "foundational phase" and four subjects in a "concentration phase." One of the foundational phase subjects will be taken from among classes associated with the new HASS First-Year Experience Program, which will encourage innovation in first-year education and oversee developments of distinct first-year opportunities. We also recommend a portfolio of strategies that is intended to facilitate greater collaborations among HASS departments and between HASS and non-HASS faculties.

In the words of William Barton Rogers, one of the main principles of an MIT undergraduate education is the preparation of individuals to participate in the "humane culture of the community." Each generation of MIT faculty has had to interpret the meaning of this principle in light of changes within human culture and the interaction of science and technology with it. Fifty years ago, responding to considerable evidence that MIT had drifted in preparing its graduates to become engaged citizens, the Lewis Committee provided a compelling blueprint for broadening MIT's educational mission and for guarding against the reoccurrence of this drift. Invoking the vision articulated by Rogers, the success of MIT's undergraduate education could no longer be judged solely by the technical proficiency of its graduates, but had to respond to the imperative that they understand and help shape modern culture and society. The spirit of the Lewis Committee report was repeated by the Zacharias Committee when it stated in its conclusion that the most important purpose of the then-humanities requirement was to guarantee "that our future citizens of the technological community have substantial knowledge and experience within the areas of humanities and social science."

The Task Force reaffirms this expanded vision of MIT, especially in light of the critical need for scientists and engineers to be engaged with society as professionals and citizens – a need as great today as it was in the mid-twentieth century (not to mention the mid-nineteenth century). Leaders in science and engineering must understand the larger context in which they act, just as society faces decisions of great consequence that must be framed in light of technical understanding. These leaders must be confident as they face multiple, competing perspectives about what constitutes enhancements to cherished human values, such as prosperity, security, freedom, self-worth, community, and beauty. They must have minds that are capable of thriving in the face of contradictory perspectives, nuanced interpretive skills to assist in understanding these perspectives, and verbal fluency to communicate persuasively with others who do not share their assumptions.

Each day, the front pages of the newspapers record the importance of scientific and technological developments as engines of economic growth, as well as the uses of science and technology for the destruction of humankind. These same newspapers record evidence that the United States may soon lose its preeminence as the world's leader in scientific and engineering innovation. And finally, the daily news brings renewed evidence that the historic preeminence of the United States in science and technology rests on decisions made by elected officials, from school boards to legislatures, on how science will be taught in the public schools, how public research-and-development funds will be invested, and how emerging technologies will be regulated.

In response to the social setting of science and technology, the Institute has maintained, for over half a century, a common requirement for all its undergraduates, now called the Humanities, Arts, and Social Sciences (HASS) Requirement. The goals of the HASS Requirement, reflected in the most recent MIT *Bulletin*, are to develop:

- skills in communication, both oral and written;
- knowledge of human cultures, past and present, and of the ways in which they have influenced one another;
- awareness of concepts, ideas, and systems of thought that underlie human activities;
- understanding of the social, political, and economic framework of different societies; and, finally,
- sensitivity to modes of communication and self-expression in the arts.

With the help of an augmented HASS Overview Committee (HOC+), along with input from faculty, students, and alumni, we have assessed the current HASS Requirement in view of these goals. In addition, we have more broadly evaluated the requirement in light of the needs of future generations, who will take the lead in applying technologies to human desires and in judging how these technologies meet human needs. We note the gains made over the past fifty years in raising the intellectual quality of classes in the humanities, arts, and social sciences, as well as the distinction of the faculty members who teach these subjects. MIT has avoided the trap, which has ensnared many research universities, of relying heavily on para-faculty to teach all but the most specialized of subjects. The HASS curriculum has largely avoided most of the distractions that have weighed down liberal arts curricula in other universities. Although we have heard complaints that the HASS Requirement has become overly complex, it still remains one of the most focused and prescribed liberal arts curricula in the United States.

That does not mean that the structure of the HASS Requirement is beyond reproach. Indeed, we conclude that the HASS Requirement should be changed, to provide greater coherence and clarity. Such a change will be a vehicle to stimulate an infusion of creative energy dedicated to the design and implementation of classes that are crafted for the particular needs of MIT students – classes that provide a compelling transition from high school to college – and provide inspiring examples of how students educated in culture and society systematically approach the world.

Finally, MIT must do better at helping faculties in the humanities, arts, and social sciences, on the one hand, and faculties in engineering, on the other, integrate the professional and personal education of MIT undergraduates. We highlight the engineering programs here because they are the largest at MIT, as well as the most time constrained and the most professionally oriented. Faculty members in these programs understand acutely that the professional success of their graduates relies on their being equipped to be contributing citizens. In constructing effective curricula that pass accreditation muster, these programs face constraints that often create friction when they interact with what HASS faculty members regard as best practices in approaching their own subjects. This tension lies deep inside MIT's DNA and will not be relieved unless we acknowledge and directly approach it. We can creatively harness this tension, however, through a combination of strategies that will change the curriculum to reflect the larger intellectual context of the Institute *and* that will make other institutional changes to help foster greater collaboration across all Schools and departments.

Background and History of MIT's HASS Requirement

MIT's founders sought to establish an institute of technology that would do more than simply train young people to be the employees who designed the products, populated the factories, and built the railroads that were increasingly common features of the American landscape. The founders sought to integrate the study of culture and society into MIT's technical education so that its graduates could aspire to rise to positions of societal leadership. This vision challenged directly the dominant view of how the nation's future leaders should be prepared, which was through a classical curriculum that excluded modern science. MIT's founders understood that the power of emerging technologies was so great that society would be ill served if its leaders were not educated in modern science. A major task of the Lewis Committee, therefore, was plotting a way back to an undergraduate curriculum that equipped excellently trained technical experts to embrace their roles as citizens.

The plan for the elevation of the humanities, arts, and social sciences at MIT built upon efforts already under way to improve the role of general education at the Institute, particularly the 1944 faculty decision to increase the rigor of the humanities, arts, and social sciences offerings and to raise the academic caliber of humanities, arts, and social sciences faculty recruited to teach here. The Lewis Committee pushed this development forward in an important way, by advocating the creation of a new School of Humanities and Social Sciences.[1] A separate school would allow the humanities and social sciences to develop "in its own right,"[2] and thus acquire an academic status comparable to that of Engineering and Science. It would encompass new doctoral programs, thus advancing knowledge in those areas of the humanities and social sciences that benefited most from a close proximity to science and technology.

The Lewis Committee did not confine itself solely to advocating for the elevation of the humanities, arts, and social sciences through the creation of a school; rather, it assessed the humanities curriculum and found it wanting. The primary defect identified was the lack of integration, in the sense that the later years of instruction did not build upon the earlier ones. The reforms advocated by the Lewis Committee led to the creation of a humanities curriculum in 1951, which now represents, for some, the halcyon days of liberal arts education at the Institute. Set within a highly prescribed eight-subject requirement, its base was a required four-subject sequence – one subject per semester in the first and sophomore years – that introduced students to the great works of western civilization. These subjects then gave way to a "concentration" in the junior and senior years, chosen by the student from among seven areas,[3] in which the student would take one subject for each of the next three semesters. In the final semester, a graduating senior would take a "light elective" in any field.

This neat sequencing and tight structure lasted for about a decade before it began to unravel.[4] It is important to understand what led to this unraveling, because many of the factors persist to this day and would make a similarly prescribed curriculum impractical, if not impossible, to maintain.

MIT's unified humanities core came undone at the same time that other universities saw their own highly prescribed graduation requirements attacked during the campus unrest of the mid-to-late 1960s. During the "troubles," MIT faculty members certainly responded to student demands to loosen up the overall curriculum. However, it is important to recognize that pressures on the 1951 humanities requirement had already resulted in curriculum reform prior to the student revolts. An analysis of these changes places the pressures for greater

1
The School's name was changed to the Humanities, *Arts*, and Social Sciences in 2000.

2
The Lewis Report, p. 42. This identical phrase was used on the immediately preceding page, where the Lewis Committee advocated freeing the natural science faculties from "harassing pressures toward the achievement of practical goals."

3
Economics, History, Political Science, Literature, Philosophy, Music, and Fine Arts.

4
This account relies heavily on Travis R. Merritt *et al., Report of the Committee on the History and Current Status of MIT's Programs and Requirements in Humanities, Arts, and Social Sciences and on Related Developments in American Education* (May 1985).

flexibility at the feet of both the needs of a changing student body and the evolving profile of the faculty in the humanities, arts, and social sciences. In that sense, the changes in the humanities requirement paralleled, in structure and inspiration, changes in the Science Requirement advocated by the Zacharias Committee and detailed in Chapter 2.

On the one hand, having signaled that it was more interested in educating well-rounded students in the Lewis Committee report, MIT began admitting more of them. MIT was one of the first universities to participate in the College Board's Advanced Placement (AP) program, which brought to the campus students who believed they had already experienced basic college-level humanities classes while in high school; they were ready to move quickly past the western civilization core. On the other hand, the growing strength of doctorate-granting social science faculties also helped to put pressure on the subject offerings designed for first-year and sophomore students, which were mostly taught by faculties that lacked graduate programs. MIT had succeeded in attracting distinguished social science faculty members, who were working on some of the most pressing problems of the day. Therefore, it seemed very much contrary to MIT's culture to discourage MIT's first-year and sophomore students from taking classes with them.

As a consequence, the HASS Requirement was changed in 1964, to lend greater flexibility in the choice of offerings for sophomores, among what was still a limited number of subjects designed specifically for them. The number of fields in which students could concentrate was also expanded. In the minds of both students and faculty, this modest increase in flexibility was insufficient. The strains were particularly great in the first two years of the curriculum, where the subject choices were very limited. Within a decade of the 1964 reforms, the Dean of Humanities and Social Sciences was approving hundreds of petitions per year from first-year and sophomore students requesting exceptions to the "humanities core."

This, in turn, led to a much more radical reform of the HASS Requirement in 1974, which produced a superstructure that in many respects remains to this day. The "lower division" subjects – which had introduced first-year and sophomore students to the broad, enduring themes in the humanities, arts, and social sciences – were replaced by a "distribution requirement" that could be completed any time during the four years at MIT; the distribution requirement was populated with scores of classes allocated into fifteen categories. Students were required to take Humanities Distribution subjects ("Hum-Ds") in three of these categories. The concept of concentration remained, with students allowed to explore in depth one of the subjects they had taken as a Hum-D by adding three more classes in that area. (There were by now twenty concentration fields.) Continuing with the theme of student choice, the 1974 HASS Requirement reforms increased by one the number of HASS subjects that were tied neither to distribution nor concentration, but could be considered purely elective.

The 1974 HASS curriculum was recognized almost immediately as a mistake. Once it became clear that there were no clear intellectual or mechanical criteria to distinguish distribution subjects from regular electives, the faculty committee that was charged with vetting new Hum-D subjects went out of existence. Advisors in major departments began to sense that their advisees were wandering aimlessly through their HASS subjects, often choosing classes based on their lack of intellectual challenge or light workload. As a result, it was widely agreed that the HASS curriculum needed greater structure and rigor.

Precisely how to achieve this was a difficult issue to resolve, but two important changes emerged to produce the current HASS Requirement. The most far-reaching was a major tightening up of the distribution requirement. For the class entering in 1988–89, the faculty reduced the number of distribution categories from 23 to 5, lowered the number of individual subjects that fulfilled the distribution requirement from 156 to 58, and increased the mechanical criteria (e.g., a minimum amount of writing, caps on section sizes, and a final exam requirement) of the distribution subjects. These distribution subjects were relabeled "HASS-D" (Humanities, Arts, and Social Sciences – Distribution), clarifying that this was not merely a humanities requirement. The concentration requirement remained virtually unchanged, as did the allowance of either two or three HASS subjects outside the confines of either the distribution or concentration portions of the requirement.

Undergraduate minors in HASS fields were also introduced at roughly the same time. Although minors are formally outside the HASS Requirement, they have had a significant impact on the experience of students in learning about culture and society. The proposal for HASS minors came from a working group of faculty drawn from all Schools across the Institute. Although the success of this reform has never been assessed systematically and directly, students have voted with their feet in declaring minors. Among the graduating class of 2006, over 200 completed a minor in the humanities, arts, and social sciences.

The Communication Requirement was passed in 2000 and made effective for the class that entered in the fall of 2001. Like minors, the Communication Requirement is not formally part of the HASS Requirement, but has important implications for it. The Communication Requirement was designed to address a concern, expressed by alumni and employers, that MIT graduates were often inadequate writers and speakers. Four structural deficiencies with the curriculum were identified and addressed in the reform. The first was the fact that students who entered MIT with writing inadequacies were not caught early enough and given help to improve their writing; second was the fact that students wrote infrequently, causing even those who entered MIT as superb writers to lose their fluency through disuse; third was the tendency of students not to learn how to write in the context of their professions; and fourth was the absence of widespread opportunities to improve in oral communication.

The Communication Requirement has implications for the HASS Requirement because it was structured, in part, to overlap with the HASS Requirement. In particular, since 2001 all students have been required to take two HASS subjects that are designated "communication-intensive," usually one in the first year and one in the sophomore year. Depending on the results of a writing diagnostic test, the first-year class might be an expository writing subject. The set of communication-intensive subjects intersects significantly with the set of HASS-Ds, but neither is a subset of the other.

The decision to imbed part of the Communication Requirement within the HASS Requirement arose from the laudatory desire not to add more subjects to either the GIRs or the majors, but rather to transform how existing subjects were taught. However, this blending of subjects has had the unintended consequence of making the HASS Requirement much more difficult to navigate for students and their advisors.[5] In addition, whenever a HASS-D subject carries a Communication-Intensive HASS CI-H designation, the educational goals of students who are attracted to the HASS-D aspect of the class often conflict with those who are attracted to the CI-H attribute.

Assessment of the Current HASS Requirement

If serious engagement with culture and society is a hallmark of an MIT undergraduate education, we must ask whether the current plan of how MIT undergraduates are exposed to the humanities, arts, and social sciences is optimally configured to meet its goals. Our conclusion is mixed.

5 As we began our study of the MIT undergraduate educational commons, the Subcommittee on the Communication Requirement began a comprehensive assessment of the requirement. We have not undertaken an independent comprehensive review of the requirement, focusing instead on the issues of overlap with the HASS Requirement.

There are many positive features of the current HASS Requirement. Individual HASS subjects receive student evaluations that are, on average, among the highest at the Institute. Because of their small size, HASS classes are among the most intimate at the Institute, which is a characteristic highly valued by both faculty and students. Finally, both students and faculty members value highly the choice that is available in the HASS curriculum, which at its best allows students to engage with questions of history and art, culture and society according to their passions.

The most serious concerns that have been raised about the current HASS Requirement pertain to the structure of the requirement itself and the larger social context in which the requirement is imbedded. In particular, we have heard three major complaints about the current status of the HASS Requirement that must be addressed by the Institute:

1. ***The HASS Requirement leaves only a slight cumulative impression on most students, despite the fact that individual HASS subjects generally provide a very high level of academic challenge and are taught very well.*** While there are many reasons why this may be, we are convinced that the primary reason is structural. The wide range of choices available in the HASS-D system causes entering students to be confronted with an incoherent academic arcade that is difficult to comprehend as a whole. First-year students choose from more than fifty HASS-D subjects when they enter and then are assigned into disjointed academic communities that are too small to have any significant impact on the cultural landscape of undergraduates beyond the classes themselves. Stated another way, no subject in the humanities, arts, and social sciences is shared by first-year students to the same extent as basic science and engineering subjects are, either numerically or in the creative imagination of the community. Based on recent enrollment patterns, if we were to choose at random two members of the first-year class, there would only be a 5 percent probability that each had taken the same HASS-D subject.

   Furthermore, there are often serious contradictions in matching the goals of HASS-D subjects with the intellectual development of students who take them. HASS-D subjects are intended to introduce students to fundamental methods of scholarship and areas of knowledge, but they must also be accessible both to first-year students and seniors. This tension has grown as HASS-D subjects have increasingly acquired the status of communication-intensive subjects that first-year and sophomore students must take. The diversity of educational goals undercuts the ability of HASS-D subjects to focus on fundamentals and to provide a firm foundation for students to undertake more sophisticated work later on. HASS-D subjects often struggle in trying to be too much to too many.

2. ***The HASS Requirement is overly complex, which encourages students to approach it as a bureaucratic challenge to surmount rather than as an intellectual opportunity to explore.*** This complaint is related to the first. It starts with the existence of five distribution categories whose content is remembered by few and appears constructed for the benefit of the faculty rather than the students.[6] Each student is required to take one class from three of these five categories. Because departments are allowed to place classes in any category, it is easy for a student to elude intellectual diversity by taking a single department's subjects across three different HASS-D categories. On top of the five distribution categories, students are allowed to substitute a "foreign language option" for one of the five. Finally, most, but not all, of the HASS-D subjects also function as CI-H subjects.

The complexity of the entire HASS Requirement permeates each aspect of the requirement, not just the HASS-D system, to the point that the HASS Education Office has its hands full auditing students to make sure everyone is following the rules. Consequently, little time is left to ensure that classes fit the needs of students or that faculty members who wish to teach exciting new classes are given the support they need to innovate.

Managing the complexity of the HASS Requirement has diverted the creative attention of the HASS faculty and those who administer the requirement. The requirement perplexes the advisors of upperclass students, who are mostly outside the fields of the humanities, arts, and social sciences. Therefore, in designing and communicating a new curriculum to students and advisors, simplicity will be an intrinsic virtue.

3. ***It is difficult for faculty members in Engineering and Science to work with HASS faculty to develop subjects and other educational offerings that are more fully integrated into the major programs.***

6
The categories are as follows: Category 1, Literary and Textual Studies; Category 2, Language, Thought, and Value; Category 3, Visual and Performing Arts; Category 4, Cultural and Social Studies; and Category 5, Historical Studies.

> Faculty members in the Engineering School particularly express frustration at their inability to work with faculty in the humanities, arts, and social sciences to develop classes, or class components, that speak to the larger social and cultural implications of their professions. Within the great flexibility of the current HASS Requirement, only a small number of students actually take classes that are focused on issues of science, technology, and society. For instance, only about 20 percent of undergraduates take even one class offered by the Program in Science, Technology, and Society (STS). Other departments do offer classes that are directly relevant to these issues, but these classes are comparatively few in number and their enrollments are small.

A recent alumni survey inquired into the undergraduate educational experience of the MIT class of 1995 and compared the responses of MIT graduates to a group of science and engineering majors at a set of seventeen peer institutions. MIT alumni came in last in the degree to which their undergraduate education allowed them to place current problems in historical perspective and to identify moral and ethical issues, and second-to-last in helping them to understand social problems. In light of the mission of the Institute and the hopes of the Lewis Committee, these sorts of results are distressing.

Examining the curriculum of the peer institutions whose engineering and science students report a better preparation in understanding the societal role of science and technology, we note that some have an explicit "science, technology, and society" requirement, but most do not. What seems to distinguish the universities whose science and engineering graduates report the greatest gains in understanding the role of science and technology in society is the fact that the science and engineering student bodies in those schools are relatively small. We take this as evidence that what matters most in inculcating students in the understanding of the important cultural and social problems of the day is the existence of a robust environment in which historical, social, and cultural issues are the target of intensive study and discussion, not a list of classes students are required to take.

The evidence all suggests that one hope of the Lewis Committee has been fulfilled: By raising the intellectual stature of the humanities, arts, and social sciences, we have attracted a world-class faculty in these fields whose contributions to undergraduate education tremendously enrich the education of MIT students.

Those excellent classroom experiences are not yet structured to complement fully the educational practices and expectations of students and Institute faculty, however. We succeed at the retail aspects of the curriculum (i.e., individual classes), but not so much at the wholesale (i.e., the requirement as a whole). It is this structural problem, more so than the content of individual subjects, with which we wrestled.

New HASS Requirement

The HASS Requirement must be reconfigured to create a greater sense of shared mission and intellectual urgency surrounding the intersections of culture and society, and science and technology. The new HASS Requirement will:

- have a greater perceived impact on the undergraduate educational landscape;
- allow students to engage confidently with important topics at an increasing degree of sophistication;
- foster creativity and verbal fluency, and the understanding of multiple perspectives and modes of interpretation;
- allow students to pursue their passionate interests without lapsing into solipsism;
- be simple to communicate and follow; and
- provide more opportunities for direct collaborations within and across all Schools to allow for the better professional development of students.

We must start with the first year. First-year students entering MIT must be met with a strong and unambiguous message that MIT's undergraduate education aims first to make them effective citizens and creative, thoughtful human beings.

The rhetoric must meet a curriculum that is consistent with it. Therefore, all entering first-year students will encounter classes that introduce them to the compelling social and cultural issues of the past, present, and future, and that are taught in an environment that will have an impact on the intellectual culture of the Institute beyond the classroom.

In addition, we must work aggressively to ensure that each student continues to be engaged with pressing social and cultural issues beyond his or her first year, and that each undergraduate becomes imbedded in at least one vibrant intellectual community whose primary passion revolves around these issues.

Finally, we must give greater attention to ensuring that MIT undergraduates are equipped with the intellectual tools necessary to engage with these issues in an increasingly sophisticated and perceptive fashion. The most important of these include critical reading, clear written and oral expression, and the use of research resources, particularly libraries.

In considering how the HASS Requirement should be reformed, we have relied heavily on the work conducted by the expanded HASS Overview Committee (HOC+), at our request, to re-imagine how the HASS Requirement might be reconceived along these lines. The HOC+ has done serious work grappling with these issues, and we recommend their report.[7] Here, building on that report, we describe our proposal to change the HASS Requirement, framing the recommendations in light of the issues we have previously raised.

Design challenge

The design challenge starts with achieving the goals of the HASS Requirement, which were enumerated above, within the footprint of eight subjects. Added to this challenge are two major considerations of the first order that guide how we understand this problem *at MIT*. The first is that MIT students have highly diverse backgrounds and highly diverse professional and personal goals. The second is that MIT is committed to teaching the common curriculum primarily with regular faculty members, rather than with a collection of teaching fellows and temporary instructors, which is the practice in so many research universities.

Faculty members in the humanities, arts, and social sciences who have taught at the Institute for more than a decade can easily discern that MIT's current students are much more sophisticated about cultural and social matters than they were

7
Deborah Fitzgerald *et al.*, *Final Report of the HOC+ to the Task Force on the Undergraduate Educational Commons: The HASS Requirement at MIT*, Cambridge, Massachusetts, Massachusetts Institute of Technology (January 2006). Available at https://web.mit.edu/committees/edcommons/mitonly/hocplus/reports/hocplusfinalreport3806.pdf.

before – a state of affairs confirmed by statistics from the Admissions Office. A vast number of students are highly skilled musically, their average verbal SAT scores equal or surpass those of Ivy League institutions, more receive a "five" on the AP American History and English Literature exams than on the Biology exam, and they are much more likely than their professors to have had cross-cultural experiences and friendships from birth.

This heterogeneity bears directly on our desire to bring greater order to the first-year experience in the humanities, arts, and social sciences, which is a priority of the highest order. From across the wider MIT community, we have heard the opinion expressed many times that the best approach to the humanities, arts, and social sciences would be the establishment of a single-path "humanities core." Yet, we are convinced that just as most MIT first-year students are ready to skip the required first calculus subject and a large number skip Physics I, a great many students would be ready to jump over a "HASS I" subject if it were required. Because MIT students are a heterogeneous lot, we suspect that a great number would appreciate precisely such a subject. Therefore, we need a curriculum that will serve a wide variety of students.

These problems of heterogeneous tastes and prior preparation put great strains on the old humanities core as soon as it was created in the post-World War II years, leading to its undoing in the 1960s and 1970s. We are convinced that a unified first-year humanities core – one akin to the formal requirement from 1944 to 1974 – would immediately confront the same strains and last only long enough to convene another faculty task force that, in turn, would recommend ways to engender greater flexibility. There are some costs to the current degree of flexibility of the HASS Requirement in the first year, but there are also great strengths. We seek a middle course.

The question of who teaches "core" subjects in the humanities, arts, and social sciences is also of great concern. MIT is committed to having its faculty actually teach undergraduates. In addition, MIT insists that the classes intended to fulfill a distributional mission, whether they be in the old first-year core or the HASS-D system, be high caliber, involve a heavy use of primary sources for teaching, eschew textbooks, and involve a significant amount of time in small sections. With the current trends in "hands-on" education and "active learning," and the knowledge that interaction with their professors is important to student success and happiness, one should be wary of moving in a direction that risks fewer direct student-faculty interactions.

This teaching commitment creates tensions, for precisely the same reasons they arise in other research universities and in the other Schools at the Institute. While teaching undergraduates is an important job for MIT faculty members, it is not the only job. Teaching undergraduates is an integral part of the Institute's educational mission, which also includes teaching graduate students (now the largest student constituent in every school of the Institute), conducting path-breaking research, and providing service to the nation and the world.

We have heard many passionate defenses of "great books" humanities curricula; many, though not most, MIT faculty members would prefer that we establish such a curriculum here. It is important to remember that when MIT last had a curriculum that was akin to a great books plan, the HASS faculty was not a research faculty and the cultural hierarchies of Europe were still in the ascendant; it was an undergraduate teaching faculty working in fewer disciplines and using fewer research methods, whose members were expected to spend their time in the classroom or prepare themselves to be in the classroom. MIT made a commitment a half-century ago to encourage the humanities, arts, and social sciences to develop "on their own terms" within the context of a great, modern research university. If regular faculty members, rather than an army of teaching assistants (TAs) or teaching fellows, are to be the normative teaching staff for distribution subjects, and if undergraduate teaching is to be coordinated with the research aims of the Institute, then MIT must have flexibility in core class offerings.

A major reason the old first-year/sophomore core broke apart is that many faculty members who taught within it regarded the classes as intellectually stagnant and alien to the spirit of MIT undergraduate education overall, which is to highlight the excitement of new discovery. The world has changed and the humanities, arts, and social sciences have changed with it. There are costs to offering narrowly drawn distribution subjects. However, there are also benefits to aligning the principle of core education in the humanities, arts, and social sciences with the research activity at the Institute, particularly if we value the ability of students to move rapidly to the frontiers of knowledge in these fields, too.

We are designing a humanities, arts, and social sciences curriculum at MIT– not at another university – and in 2006, not in 1986, 1966, or 1946. MIT's particular setting and particular time in that setting make it appropriate for us to establish greater coherence to the HASS curriculum, while honoring the diversity of the student body, MIT's status as a research university, and its commitment to meaningful student-faculty interactions. The following pages lay out the changes that we propose.

The plan

It is useful to think about the new requirement in two phases, which will largely coincide with the first two years (foundational phase) and the last two years (concentration phase) of a student's time at MIT.

The foundational phase will be aimed at providing a transition from high school to college, by ensuring that all students are able to write in a college environment and by introducing students to how the big issues facing humankind can be understood through the disciplinary lenses of the humanities, arts, and social sciences. It will also be structured to ensure that all students achieve a basic proficiency in the intellectual tools – such as critical reading and independent research – that are necessary to conduct further analysis of culture and society at a sophisticated level. And, it will be the portion of the curriculum to which the Institute and the Schools will devote the most intense concern and greatest resources. This will ensure not only that they sustain the high quality of these classes, but also that they together help create a greater sense of shared intellectual engagement with important social and cultural concerns.

In the concentration phase, each student will enter an academic community defined by one of the disciplines in the humanities, arts, or social sciences and will begin to acquire a sophisticated sense of the empirical puzzles and intellectual tools that draw people to the study of these fields. Furthermore, each student will be in a position to take on the more focused task of becoming acquainted with the social and cultural implications of science and technology, if that is his or her interest or an explicit requirement of a major.

Let us now turn our attention to the details of how MIT will achieve these reforms. To aid in this discussion, Table 1 provides a schematic view of a typical student's path through the revised HASS Requirement, depending on whether she or he is required to take an expository writing subject as a first-year student.

The foundational phase

All MIT undergraduates will continue to show that they are capable of writing expository prose at a college level and demonstrate this proficiency at the end of the first year. As is currently the case, we anticipate that the vast majority of students will demonstrate this proficiency through MIT's own placement examination when they matriculate, but that roughly a quarter of entering students will want or require an expository writing class in the first year.

In addition, all MIT undergraduates will be required to take *three* designated HASS subjects – one each in the area of humanities, arts, and social sciences – in their first two years at the Institute. The goals of these specially designated subjects, termed "foundational electives," are the following:

1. introduce each student to major issues of culture and society and to the major approaches used in the humanities, arts, and social sciences to address them;

2. impart to each student a confident facility in critical reading, writing, and oral expression;

3. develop in each student an ability to understand and interpret primary materials, such as original texts, interviews, performances, and survey results; and

4. instill in each student confidence in working alone and collaboratively to understand culture and society at a more sophisticated level.

To ensure that the first goal is achieved, each foundational elective will be allocated into one of three categories:

1. the humanities (History, Literature, Foreign Languages and Literatures, Philosophy);

2. the arts (Music, Theater Arts, Writing, History of Art and Architecture, Visual Studies); and

3. the social sciences (Anthropology; Economics; Linguistics; Political Science; Science, Technology, and Society (STS); Urban Studies and Planning).

Students will be required to take one class from each category in the first two years. The mechanical and qualitative criteria governing the vetting of these classes will ensure that the other three goals are met.

Within each of these three categories, a limited number of subjects will be designed to meet a set of *additional educational needs that are distinct to the first year*.

These classes, which we will collect together into a HASS First-Year Experience Program, will be distinct in their commitment to do the following:

1. ignite the interest of first-year students in "big ideas" concerning culture and society that have endured over time, such as ending poverty, the city, modernity, war and revolutions, creativity, understanding the self, and democracy;

2. provide both a large-scale "common" learning experience as well as a small-scale seminar-style experience in each class;

3. emphasize independent and critical thinking and analysis;

4. introduce students to the process of developing a cogent and complex argument; and

5. help students understand ambiguity and the role of interpretation by using open-ended class materials.

Students will normally be expected to take a foundational elective that is in the First-Year Experience Program during the first semester of the first year, except for those who instead decide to take expository writing in the first semester. These students will then take a first-year experience class in the second semester. Below, we discuss how to foster this expectation, which we consider to be a focal point for rethinking the complete HASS experience at MIT.

The first two characteristics of these classes in the HASS First-Year Experience Program, considered together, are the starting points for structuring the initial encounter that MIT undergraduates have with college-level humanities, arts, and social sciences. It is imperative that entering first-year students immediately experience a large and vibrant community of learners who agree to share, for at least a short time, a set of intellectual concerns. To that end, it is also imperative that the HASS First-Year Experience Program be closely monitored and diligently encouraged by a group of dedicated faculty that is overseen by the Dean of Humanities, Arts, and Social Sciences. By collecting these classes together into a highly visible program, we aim to foster a special *esprit* among those who teach them; provide a focused avenue in which to describe the experience to prospective and current first-year students; provide an infrastructure for continual innovation in first-year HASS subjects; provide an advising system that is easily accessible to students and advisors; and provide administrative support so that the teaching staff can focus on education. We also hope that by establishing a program with strong connections to the Dean of Humanities, Arts, and Social Sciences, it will be easier to foster greater interdisciplinary and interdepartmental collaboration in the development of these special classes.

Classes in the HASS First-Year Experience Program also will be responsible for reaching out to the larger MIT community to support events – including plays, speakers, films, and conferences – that will cause the intellectual space occupied by these classes to claim greater ground in the campus environment.

The number of first-year experience classes must be considerably smaller than the current number of HASS-D subjects, although they must each be structured so that a significant amount of teaching is done in small groups. We anticipate that, in any given semester, no more than a dozen of these classes will be offered. To accommodate the vicissitudes of scheduling and leaves, however, we may need to develop a few more. The classes offered must show a sufficient diversity of material. In that way, all faculties in the humanities, arts, and social sciences will be able to participate at some level, and the range of concerns will be representative of the issues of culture and society that MIT graduates will face throughout their lives. The HASS First-Year Experience Program will not work if particular departments come to consider it their right to offer a subject, nor will it work without the participation of all faculties in the humanities, arts, and social sciences at MIT. But most of all, this program cannot succeed without the willingness of faculty members to come forward with compelling ideas.

The foundational phase of the HASS Requirement will be satisfied for most students by taking one foundational elective in the HASS First-Year Experience Program and two outside the program. These three subjects will be distributed across the area categories of the humanities, arts, and social sciences. The first-year experience class will be taken in the first semester, while the other two foundational electives will be taken any time before the end of the sophomore year. For most, that will leave at least one HASS class during the first two years which can be chosen with entire freedom by the student, depending on his or her prior interests, recently ignited curiosity, or future career goals.

If current trends hold, roughly one-fourth of MIT students will need or want to take an expository writing class. Students who choose to take expository writing in the first semester will then take a first-year experience class in their second semester, completing the foundational elective requirement in the sophomore year. Thus, students will have less flexibility in the categories of HASS subjects they will take early on at MIT, but will still have considerable flexibility within subject categories. For all students, the paths through the first two years of the requirement are limited enough to assist in advising, yet flexible enough to account for varying student interests.

The foundational elective element of the new HASS Requirement reflects our continued commitment to ensure breadth in the liberal arts education of all students. We continue to believe that many of the ideas articulated when the HASS-D system was created serve us well, with one important exception, which is the idea that HASS-D subjects should generally not be intended to introduce students to disciplines. We believe that such a criterion is inappropriate in a research university, particularly at MIT. Obviously, most students who take the first-year/sophomore foundational elective classes will never again take another class at MIT in these subjects. However, we want students to leave these classes yearning to know more and capable of delving deeper into the same subject matter, if they so choose.

At the same time, these foundational electives should not be narrow introductions to particular disciplines, just as they should not be retreaded HASS-D subjects. They must serve the goals of the *common* curriculum in the humanities, arts, and social sciences. These common goals include critical reading, written and oral communication, dealing with "raw data," and grappling with indeterminacies. As a practical matter, these classes must all be "communication-intensive" as defined under the current requirement. The licensing of these classes should continue to be handled by a faculty committee similar to the current HASS Overview Committee (HOC), although we also believe that membership on the committee should be opened up somewhat and its organizational residence located clearly within the regular Institute faculty governance system. (Currently, the complete HASS Requirement is governed by the Dean of the School of Humanities, Arts, and Social Sciences. Formally, the HOC acts at the discretion of the Dean, which is distinct at MIT.) Practically speaking, this suggests that the oversight of the HASS Requirement should closely parallel that outlined in Chapter 2 for the Science, Mathematics, and Engineering Requirement, with the flavor of the faculty and decanal involvement oriented toward faculty members who teach across the disciplines covered by the HASS Requirement.

We consider fusing the HASS Requirement and the CI-H portion of the Communication Requirement into a seamless whole to be a critical idea of our proposal, if we are to simplify the HASS Requirement. After five years of experience with the Communication Requirement and trying to enable it to coexist with the HASS Requirement, we believe that the wisest course is to incorporate the first portion of the Communication Requirement fully into the HASS Foundational Requirement, so that its architecture is essentially invisible to students and advisors. All foundational elective subjects will be CI-H, and all CI-H subjects will fulfill the foundational elective requirement. Expository writing classes will continue to exist and serve two audiences: (1) students who are required to take such a class in their first year because of their performance on the writing placement test, and (2) students who are not required to take the class, but believe it would provide a firm foundation for later college work. The structure we are proposing will continue to allow students to take these classes in either the first or second semester of the first year.

Scheduling

One of the most nagging practical problems associated with the HASS Requirement that we have heard about, time and again, is scheduling. Because the reforms we propose will serve to streamline the HASS Requirement, we will be in a good position to address this problem.

Faculty and students commonly complain that HASS-D subjects conflict with too many subjects in the Science Requirement and in the majors. We regard the current practice – whereby students select HASS-D subjects because they fit within one's schedule, not because of intellectual interests – as anti-intellectual. It has no place within the GIRs. With a smaller set of subjects that serve the purpose of distribution, it should be easier to dedicate a limited number of class times, unimpeded by conflicts with introductory classes in science and engineering, to first-year experience and foundational elective subjects.

Pace

The foundational phase requirements as outlined make two assumptions about the pace with which the HASS Requirement is completed. First, one class in the HASS First-Year Experience Program must be taken in the first year. Second, all foundational electives must be completed by the end of the second year. A student who fails to satisfy either expectation will be considered to be making inadequate academic progress.

MIT has not had a strong history of such pace requirements. This sequencing may interject a new set of tensions into the continued support for the requirement among the faculty and students. However, we should remember that, although the current Science Requirement is couched as a graduation requirement, not a first-year requirement, the Committee on Academic Performance (CAP) has long judged the academic progress of first-year students in terms of how much of the Science Requirement was completed in the first year; and so, we have had an informal pace requirement for Science for many decades. The Communication Requirement has a more formal pace option, which is often a source of complaint among students and their advisors. (The new HASS Requirement will fully enfold the existing CI-H portion of the Communication Requirement. Therefore, if we do not transfer the pace requirement into the foundational phase of the HASS Requirement, we will lose an important feature of the Communication Requirement.)

The experience with the pace feature of the Communication Requirement has taught us, however, that if there is a good reason for such a feature, then it is worthwhile to insist upon it, even in the face of the natural tensions it brings. We believe that there are sound educational reasons to insist that first-year and sophomore students attend to the foundational aspects of the HASS Requirement before they launch full speed into the HASS concentration. At the end of their fourth semester at MIT, students will be free to focus on their concentrations, minors, and majors. (Of course, students who wish to take more than one foundational elective in a semester, in order to accelerate through the HASS Requirement, or who wish to take an additional HASS elective in a favorite or new field of interest, will be allowed to do so.) This plan will ensure that students have a solid foundation in communication skills and a basic familiarity with three analytical modes of thought by the end of their fourth semester. This, in turn, will give students a more solid basis for selecting their concentrations and minors.

It is also true that MIT has mastered the art and science of directing students through the foundational phase of the Science Requirement, using a combination of devices, some positive and some negative. For instance, although the Science Core requirement is not a first-year requirement, first-year students experience it that way. The advising literature published by the Academic Resource Center and used by first-year students and their advisors treats the canonical path through the Science Core (i.e., first term – calculus, physics, and chemistry; second term – calculus, physics, and biology) as completely normative; deviations from that path are just variations on the theme. The "Core Blitz" program highlights almost exclusively the Science Core, HASS-D, CI-H, expository writing, and Physical Education subjects. As mentioned previously, the CAP judges academic progress in the first year, in part, by the number of Science Core subjects completed. This is all done because the collective experience of the faculty has judged that attending to the Science Core early on opens up the greatest number of exciting intellectual avenues for students.

As well, this could be true of the HASS Requirement. MIT already treats taking a HASS-D subject during the first semester as normative; the great majority of first-year students do so already. We do not anticipate that encouraging first-year students to take subjects in the HASS First-Year Experience Program will be any more difficult. Indeed, it should be even easier to describe clearly the compelling features of these subjects and to generate great anticipation about the opportunities they present even before classes begin.

The concentration phase

After the first two years, students should devote their efforts primarily to becoming comfortable with one of the disciplines, or interdisciplinary fields, in the humanities, arts, and social sciences. To accomplish this, they will complete a HASS concentration, much in the same way MIT students currently pursue concentrations.

In considering the comments we received about concentrations, most constituents at MIT believe the requirement overall is working well, though it clearly should be strengthened and given more attention. A few concentrations are no more than a loosely connected group of three classes taken entirely at the discretion of the student, with no input from a faculty member about the plan's intellectual coherence.[8] Therefore, all concentrations should revisit their requirements and ensure that they are not overly loose. Furthermore, all concentrations in fields that are not associated with established departments that offer majors should be asked to demonstrate that they have sufficient faculty commitment and staffing resources to make the concentration an actual intellectual community.

Fostering Greater Collaboration Across Schools

The discussion to this point has centered on reinvigorating the HASS Requirement. However, we must address a further concern that is somewhat oblique to the requirement itself. This problem, most strongly expressed by faculty in the School

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A number of these concentrations were created at a time when the MIT-Wellesley exchange program was more active. At that time, some concentrations were handled entirely by Wellesley faculty members. As the exchange has fallen into a state of disuse, these concentrations have been left behind as orphans.

of Engineering, is that the HASS Requirement does not respond to the needs associated with professional education within those majors.

An initial response to these concerns is that the HASS Requirement is not intended for professional preparation, nor should it be. The requirement intends that students become more knowledgeable, creative, and well rounded by gaining comfort with the approaches to understanding culture and society that are fundamental in the disciplines of the humanities, arts, and social sciences. The payoff to the requirement certainly includes helping to prepare students for their professional lives, but the larger payoff concerns preparing them for the rest of their lives. It will be a great mistake and a huge step backwards to cast the HASS Requirement primarily in terms of professional development.

Nonetheless, we understand one of the strengths of MIT's relatively small size and the principle of "unity of the faculty" to be that it provides opportunities for greater collaboration among faculty members who teach subjects in different schools. Productive collaborations are proceeding right now, involving faculty members in humanities, arts, and social sciences and in science and engineering. However, there are not enough collaborations, nor is there currently an institutional arrangement for them to grow much beyond where they are today.

To help further these collaborations, we offer the following three recommendations. First, although the HASS Requirement cannot be cast solely in terms of professional development, one important goal is professional development. It is certainly appropriate for departments in engineering and science to include HASS subjects within their own major programs, either as requirements or restrictive electives. This is already being done on a limited basis by some departments, and we will encourage departments to explore with each other the appropriateness of expanding this practice.

Second, within each science and engineering discipline, there is a body of knowledge whose substance and approach draw on elements that combine science, engineering, culture, and society. Classes in this category might include those that touch on the history of a discipline or the ethical issues it raises. As well, many engineering capstone classes require students to consider and report on the social implications of a particular design or product. MIT does not currently have a very robust platform for interdisciplinary collaborations to help develop classes that respond to this need. The Program on Science, Technology, and Society (STS) fills part of this need, by developing and teaching many classes that explicitly address the interaction of science and technology with society. However, the STS faculty is small and already scrambles to keep up with the demand to help think about these issues. Moreover, these issues transcend the exclusive domain of STS as a field of inquiry, and provide an opportunity for many types of productive interdisciplinary collaboration. We believe it is appropriate for the Institute to consider the establishment of a center at MIT that will be responsible for developing links between HASS faculty and departments in the Schools of Science and Engineering. Its purpose will be to develop classes and class sections that will respond more directly to the professional development needs of undergraduates, as well as to the intellectual challenges and responsibility that accompany the practice of modern science and engineering.

Third, the Institute has already been successful in developing internship programs that are designed for allowing students to encounter the nontechnical aspects of their chosen technical professions. These programs are both domestic, such as the Washington Summer Internship Program, and international, such as the MIT International Science and Technology Initiatives (MISTI). As these programs are small, however, they currently are unable to meet the demand expressed by undergraduates. We recommend that these programs be allowed to grow to meet the current demand and that the Institute dedicate funds to ensure that these programs become permanent features on the MIT landscape.

Conclusion

The MIT education succeeds best when its students grasp the larger social and cultural context in which technological advances are pursued and applied. The roots of this vision can be traced to MIT's founding. Each generation of MIT faculty has had to re-imagine how best to awaken in students a passion for the ethical and aesthetic implications of the scientific and technological pursuits that they are preparing to follow.

Summary of Recommendations

1. *The Humanities, Arts, and Social Sciences (HASS) Requirement should be changed to an eight-subject requirement that is divided into two major parts, the* foundational phase *and the* concentration phase. The foundational phase would consist of four subjects – expository writing and three "foundational electives" distributed across the categories of the arts, the humanities, and the social sciences. (Expository writing could be converted into a free HASS elective by passing an MIT-administered exam.) The concentration phase would consist of four subjects taken from a concentration that was sponsored by a department or an interdisciplinary field. (Concentration fields would have the option of allowing students one free HASS elective.)

2. *A HASS First-Year Experience Program should be created to support a small set of foundational electives that would be designed specifically for the first year.* All first-year students would be required to take one of these subjects.

3. *A subcommittee of the Committee on the Undergraduate Program should be constituted to oversee the implementation of the HASS Requirement.* The subcommittee should include representation from all Schools of the Institute and active participation from the Deans of Humanities, Arts, and Social Sciences; Architecture and Planning; and the Sloan School of Management; and Undergraduate Education.

4. *The Dean of the School of Humanities, Arts, and Social Sciences should immediately issue a call to academic units and interdisciplinary committees of faculty to propose HASS concentrations.* These proposals shall specify the structure of the requirement and its academic strengths, show evidence that the concentration will have sufficient budgetary and staff support, provide plans for the establishment of intellectual activities outside the formal curriculum, and demonstrate the long-term commitment of regular faculty to ensure the continued coherence and rigor of the program.

5. *The Registrar should work with the academic deans to develop a plan to ensure that foundational elective subjects have a dedicated time in the schedule that is coordinated with the major lectures in the SME Requirement.*

6. *We recommend that study be given to the establishment of a center to be responsible for developing links between HASS faculty and departments in*

the Schools of Science and Engineering, for the purpose of developing classes and class sections that will respond more directly to the professional development needs of undergraduates, as well as to the intellectual challenges and responsibility that accompany the practice of modern science and engineering.

Table 2

Three Paths Through the HASS Requirement

a. No Expository Writing class taken

Year	Fall	Spring
First	First-Year Experience Program Foundational Elective	Foundational Elective
Second	Foundational Elective	Concentration Subject or HASS Elective
Third	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective
Fourth	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective

b. Expository Writing class taken in the first semester, first year

Year	Fall	Spring
First	Expository Writing	First-Year Experience Program Foundational Elective
Second	Foundational Elective	Foundational Elective
Third	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective
Fourth	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective

c. Expository Writing class taken in the second semester, first year

Year	Fall	Spring
First	First-Year Experience Program Foundational Elective	Expository Writing
Second	Foundational Elective	Foundational Elective
Third	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective
Fourth	Concentration Subject or HASS Elective	Concentration Subject or HASS Elective


4

4. INTERNATIONAL EXPERIENCES AND AN MIT EDUCATION

The rising global character of the economy and culture is one of the most compelling developments in the world today. It is made possible largely through scientific and technological changes that MIT has fostered and has a great interest in continuing to affect. Being able to understand and to work with people from diverse nations and cultures are indispensable abilities that will characterize successful leaders in the coming century. We must encourage students, while they are undergraduates at MIT, to encounter the cultures, educational systems, research enterprises, and manufacturing concerns of other countries, as well as to understand the role of the United States within this global framework.

The past decade has seen the development of several highly successful models for accomplishing this goal, which have been adapted to the distinct environment of MIT. These programs allow students with diverse experiences to acquire meaningful encounters with the international system and specific cultures. We encourage the Institute to consolidate these developments and nurture their growth to sustainable size. Institute faculty members are brimming with further ideas on enlivening the encounter of students with other countries; therefore, we must support and fully implement these ideas at all stages of the process. Finally, we must create a prominent information portal that clearly communicates the value of these programs, as well as how to pursue them.

We are confident that these efforts will help us achieve our final goal: to allow any MIT undergraduate who wishes to participate in a meaningful experience abroad to do so without financial or academic penalty.

MIT students will graduate into a world in which knowledge, jobs, and culture will be less contained within national boundaries than even a decade ago. Responding to this phenomenon, which falls under the catchword of "globalization," is one of the most critical challenges facing higher education in the United States today – and it is one to which MIT must devote new energy and attention.

MIT's education specializes in science and technology, which are subjects that readily defy national boundaries. Because of this specialization, MIT is particularly exposed to the rise of cultural and economic globalization. The Institute has gained notice around the world for its major international initiatives, such as the Cambridge-MIT Institute and the Singapore-MIT Alliance. Even our Open CourseWare (OCW) initiative has had as much impact abroad as at home. A high percentage of MIT faculty were born abroad, and 40 percent of the Institute's graduate students come from foreign countries.

At the same time, encouraging a majority of MIT undergraduates to encounter the cultures, educational systems, research enterprises, and manufacturing concerns of other countries has not been a top priority of the Institute. However, in this regard, MIT is no different from other American universities that have a large engineering component to their undergraduate education. The study- and internship-abroad rates among MIT engineering graduates appear to be nearly identical to those of engineering graduates at peer institutions, which is generally below that of students who major in most other areas.[1]

This is not to say that MIT faculty members have been inactive in creating opportunities that have a special resonance with undergraduates who wish to gain international experience while at MIT – quite the contrary. MIT faculty and staff members have developed innovative programs of international education, tailored to the distinct environment of the Institute. These programs have become prominent models for guiding other technologically oriented universities as they have expanded their international presence. The following is just a sample of international educational initiatives, developed at MIT, that have already proved effective:

- ***The MIT International Science and Technology Initiatives (MISTI).*** A generalization of the MIT Japan Program that was founded in the early 1980s, MISTI has provided high-quality, professional experiences to MIT students – graduates and undergraduates alike – in universities, research laboratories, and factories throughout the world since 1994. There are currently eight country-specific programs, in China, France, Germany, India, Italy,

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Depending on how one defines "study abroad" and measures it, the fraction of MIT students who go abroad sometime during their undergraduate years is in the 15%–20% range. Taking one common benchmark for comparison, in 2006 MIT conducted a survey of its graduating seniors, in conjunction with nine other peer research universities that did the same among their graduating students. In this survey, 19% of MIT graduating seniors reported studying or interning abroad sometime during their four years at MIT, compared to 38% among the graduating seniors who attended peer institutions. The difference between MIT and the peer institutions is accounted for entirely by differences *outside of engineering*. At MIT, students with engineering majors went abroad to study or intern at a rate of 20%, compared to a 19% rate among peer engineering graduates. Natural science majors at MIT reported studying or interning abroad at a 17% rate, compared to 31% at the peer institutions. Among the remaining students – those studying humanities, social sciences, and business – MIT's study/intern-abroad rate was 34%, compared to 43% among graduates of the peer institutions.

Japan, Mexico, and Singapore. Over the past decade, MISTI has sent more than 1,700 students overseas as interns.

- ***Hyperstudio.*** A platform developed at MIT that provides the infrastructure and support for the development of media applications within the humanities, Hyperstudio is jointly sponsored by foreign languages and literatures, literature, and comparative media studies. Nationally prominent examples of Hyperstudio activities have included projects that have helped make learning foreign languages and encountering foreign cultures much more interactive and compelling. Among these are *Cultura*, which provides virtual daily exchanges between French polytechnical university students and MIT students; *Berliner Sehen*, which is a collaborative learning environment on the cultural, social, and political life of Berlin; and *España de cerca*, which provides video interviews that reveal contemporary Spaniards' perspectives on a variety of social questions, and which is updated annually.

- ***The Cambridge-MIT Exchange (CME).*** Created in 2000 as a part of the Cambridge-MIT Institute, CME is a strategic alliance between MIT and the University of Cambridge, England. Centered on a junior-year exchange program between the two universities, CME has already sent nearly 200 students from MIT to study at Cambridge, and a similar number from Cambridge to study at MIT, enriching the cultures of both universities. A distinct feature of this program is the explicit working out of the educational plans of the participants, which allow MIT students, in most cases, to be fully integrated into the regular Tripos programs at Cambridge while remaining on schedule to graduate from MIT.

- ***The minor in Applied International Studies (AIS).*** Sponsored by the Political Science department and administered by MISTI, AIS provides an integrated curricular framework for students who wish to enhance their study-abroad experiences with further foreign language training and classes on foreign cultures. Within three years of implementation, AIS has already become the second-largest HASS (humanities, arts, and social sciences) minor at the Institute, second only to economics.

- ***The Development Lab (D-Lab).*** Sponsored by the Edgerton Center, the D-Lab enables students to work with communities in developing countries to design and implement creative solutions to the economic, environmental, and health challenges faced by those communities. Through a series of subjects taught at MIT and field trips arranged by the program, students have worked on projects as diverse as making charcoal from sugar cane, developing low-cost methods of water purification, and bringing electricity to local schools.

Vital communities have evolved around these and other programs, which have involved students and faculty from every school at the Institute. Yet, MIT's international undergraduate opportunities remain some of our "hidden treasures" when viewed from the perspective of most faculty and students, as well as high-school students who might consider attending MIT. One of the reasons why these (and other) programs remain hidden treasures is that MIT simply has not trumpeted its successes to the degree that other institutions have for their programs. Even so, many of the existing MIT programs are operating at capacity, which naturally suggests that keeping a low profile in international education at MIT may have been wise in the short run.

Another reason why international educational opportunities have not been more thoroughly encouraged at MIT, however, is rooted in the context in which these opportunities have developed here. International experiences have been considered one of many salutary adventures that students might pursue, but are no more helpful than many other programs. Faculty and staff members have been encouraged to deploy their entrepreneurial energies to create and sustain these programs, and students have been allowed to participate within the constraints of MIT's educational plan.

This largely decentralized model of educational development was appropriate a decade ago, but the world has changed. Nearly all graduates will leave MIT and immediately encounter a world in which they must cooperate with teams of individuals – in universities, laboratories, and companies – many of whom were neither raised nor educated in the United States. These teams will often be working on projects that will be valued for their transportability to multiple cultural and national settings. This new context is true not only for students who will be employed by multinational corporations, but also for students whose lives and careers will be confined to these shores.

In responding to the challenges and opportunities of the new global environment, MIT can build on a robust array of successful educational models that most likely will continue to thrive – the sole question now is one of scalability. If MIT immediately moves to build on its successes, the Institute will be well positioned to consider new initiatives that might flourish in the distinct MIT environment. Most important for this endeavor is the clear signal that an expansive embrace of international education for undergraduates is an Institute priority – one that is shared at all levels.

Conceptualizing International Education for MIT

Because study abroad is currently far from the well-trodden path at MIT, we believe it is important to articulate a set of goals that will guide expanding study-abroad opportunities at MIT. These four goals are to provide students the following:

1. a better awareness of problems on a global scale, including but not limited to problems that relate to their individual field of study;

2. the opportunity to understand professional problems within their cultural context, illustrating that other cultures may attach different priorities to these problems and their solutions;

3. explicit exposure to different educational and research systems, gaining the understanding that those systems can provide equally serious approaches to knowledge; and

4. the opportunity to take a break from MIT, allowing students to step back from their day-to-day education and understand its deeper value.

The first two goals speak directly to the value of international experiences *per se*, which may be approached in different ways. The first goal addresses international education at a basic level, asking that students be generally aware that other cultures differ from their own, and suggesting that there are low-risk ways of improving global awareness. Some very short-term projects, such as those that happen during the IAP (Independent Activities Period) or semester-long classes already taught in the existing curriculum, might readily address the first goal. Many of these types of opportunities already are embedded in the MIT curriculum; with some encouragement and strategic infusion of new resources, these experiences could quickly gain greater visibility at the Institute.

The second goal, which builds on the first, directly addresses professional preparation, pointing us to experiences that are deeper in intellectual content, richer in cultural contact, and longer in duration. These experiences might unfold across a series of semesters, as students engage in extensive preparation on campus, an extended (multi-month) internship abroad, and then extensive reflection and follow-up study back on campus. As we illustrated in the introduction to this chapter, MIT has pioneered in developing such opportunities, though at a modest scale. These opportunities not only have the greatest potential to transform our educational environment and the lives of MIT students, but also require the greatest infusion of new resources and institutional commitment to reach their full potential.

The third and fourth goals are not intrinsic to global education alone, but are still aims to which international experiences can be directed. These goals often are invoked when students reflect on their experiences with CME; oftentimes, they learn that the practices at overseas universities – which initially strike them as "soft" – may provide an even better preparation for life than some practices at MIT. Our experience with students who return from Cambridge is that, as a consequence of having mastered two educational systems, they have become more mature learners and more confident of their abilities.

While we value immeasurably the distinct opportunities available on the MIT campus, we also believe that undergraduates will be better prepared as individuals and professionals if they gain perspective on this education through experiences elsewhere, whether those be through study abroad or internships.

We suspect that the second goal will resonate most readily with the MIT community, providing a way to open up international experiences that are congruent with dominant MIT norms. For students, we believe that the most immediate entrée into international affairs will be through more practical approaches, such as internships and projects of less than one year. When students do pursue more traditional study-abroad programs, they are likely to gravitate toward those that are well integrated into established professional paths as defined by the MIT faculty.

Still, we must keep in mind each of these four goals as we develop a more comprehensive approach to international education; professional development is an entry point to – and not the end of – international engagement.

Overcoming the Challenges of International Education in the MIT Environment

International education is a particular challenge at MIT for three main reasons. First, engineering curricula tend to be highly prescribed and rigidly sequenced. If a student wants to develop a deep understanding of another country's culture and how that country approaches certain problems, when will that occur? The irony here is that the best engineering curricula may be the most resistant to traditional study-abroad schemes, as its faculty members have designed a seamless sequence of classes particularly suited for the Institute and its students. For these students, gaining international experience may present the risks of losing academic continuity and failing to graduate on time.

The second problem is related to the first. We have heard many MIT students say that they are hesitant to undertake study abroad because they cannot imagine receiving a science or engineering education anywhere else in the world that is nearly as good; therefore, studying or working elsewhere would be a waste of their time and money. The moment they first walk through the doors of MIT, many enterprising students grasp the opportunities that present themselves on campus. For these students, to take time away from the MIT campus is to interrupt a set of expectations that has been eagerly anticipated since the start of – if not before – first-year orientation. To encourage them to spend time away from campus requires that these experiences be at least as compelling as those foregone on campus.

The final problem is the lack of a study-abroad tradition among engineering students nationally, which is partially due to a reaction to the stereotype of how the junior-year-abroad option functions at many liberal arts colleges. Given the applied focus of engineering programs, it is easy to regard some junior-year-abroad programs as – at best – finishing schools and – at worst – extended vacations. Generally, this is only a stereotype, however, as is evidenced by the high-quality programs that exist in many colleges and universities. Many of these programs are integrated with internationally flavored majors, providing outstanding opportunities for students in the humanities, arts, and social sciences to gain direct experience within their chosen fields, just as laboratory experience gives invaluable experience to engineering and natural science majors. The study-abroad model offered by most universities is largely inappropriate for the majority of students at MIT. As we have already shown, when opportunities to study abroad are consistent with MIT's culture and educational practices, students will participate and, along with their faculty mentors, will regard the experience as formative.

Our experiences with the international education initiatives that have already succeeded here convince us that, if we subtly customize these programs to the special obstacles we face at MIT, students will gain the international exposure they need to prosper in their lives. Since these obstacles are common to a critical sector of American higher education of which MIT is a part, the Institute can also serve as a model for how technologically oriented universities can more readily involve their undergraduates in international education.

Our experiences also suggest that the Institute must do more than simply declare that all undergraduates should undertake some international engagement while at MIT. There is a real danger that if we build it, they will not come. It is not obvious that if MIT simply provides more opportunities and money for international study, large numbers of undergraduates will eagerly embrace the chance. For instance, it is striking that MIT's lowest participation rates in international education are among students who are pursuing majors that are among the most flexible. For these students, MIT clearly has not communicated that international study and work are valuable ways to take advantage of this flexibility.

Therefore, the Institute must overcome more than the obvious problems that attend opening up international experiences to more students. Faculty members must nudge the MIT culture and show that international education is a priority, even in the face of factors that make such experiences challenging. We must not only declare this as a priority, but must also back up this declaration by devoting time to it. Faculty must disabuse students of the misinformation that leads them to conclude that they can ignore the rest of the world, or that they will have plenty of time to encounter foreign countries following graduation.

Workable Approaches to International Education at MIT

If one thinks about the eventual array of international study opportunities at MIT as a garden, then the current situation can be likened to a test plot. A number of the developed species appear to be thriving in the distinctive micro-environment of

MIT's landscape. Many of these robust specimens were highlighted at the start of this chapter. While each differs in important ways, each also has adapted to key, recognizable features of our educational culture, rather than requiring that our educational culture be rooted out.

For instance, the MISTI program has succeeded because it responds directly to the value placed on internships and UROP-like research opportunities that are so highly prized by both students and faculty. The CME program is successful because it has built alliances between particular faculties, one at a time, to assuage concerns about continuity in professional development and the ability of students to graduate on time. (The same is also true of smaller, department-specific exchange programs, such as those sponsored with Delft University of Technology in architecture and those with six major European universities in aeronautics and astronautics.) The Hyperstudio environment has thrived at MIT as a teaching tool not only because of compelling results, but also because developing the environment is such a distinctly MIT enterprise. As a result, it naturally draws in the creative energy of students, faculty, and research staff, along with the support of outside funding sources. The success of the D-Lab experience is twofold. It leverages off the delight of our many students who participate in hands-on projects and public service, and also profits from the expertise of the Edgerton Center in moving students from the tactile experience of engineering to the larger design, economic, and social issues that arise when technological solutions are applied to actual human problems. Finally, the AIS minor combines a series of experiences that students might undertake already as a part of the HASS Requirement – the study of language, international economics, and comparative politics, for example – with foreign travel in programs like MISTI, CME, and D-Lab. Students find this learning opportunity more valuable precisely because of its coherence, which allows them to avoid following a strategy of simply piling on more courses.

We are also convinced that these programs have flourished because they have been created, championed, and guided by the faculty. This is a key feature of international educational opportunities that must be sustained, both for the continued success of existing programs and for the development of new ones. One of the limiting factors of the existing programs is that the faculty time that enabled these programs to succeed is MIT's rarest commodity. Therefore, a critical issue in continuing and expanding international programs is how to sustain the high degree of faculty involvement that has made these programs so successful. The Institute must work to find pathways to ensure that proven programs have tangible institutional support, in the form of budget and fundraising assistance.

An obvious first step to be undertaken by the Dean for Undergraduate Education is to undertake an inventory of successful programs already thriving at MIT, to explore the issue of scalability of each, and to begin moving expeditiously to expand these programs to a larger, yet sustainable, size. At times like this, it is tempting to devote energy to creating new initiatives and requirements, but we can achieve more momentum by focusing on learning from our current successes.

If there is an activity that requires a new initiative and immediate action, it is in communicating more clearly and directly with an array of constituents – potential students and their families, current students, faculty, and employers. We must emphasize the importance placed on international education by the Institute, as well as the established paths that students might follow in exploring the international dimensions of their education. Presently, only a current student with a good understanding of the intricacies of MIT – or one lucky enough to benefit from favorable word-of-mouth – can get a comprehensive view of the international education opportunities available at MIT and how to pursue them. Potential applicants are unlikely to encounter much by the way of information on international opportunities unless they dig deep, which is in sharp contrast with many of our competitors who have less to offer, but show it off more energetically. The Dean for Undergraduate Education recently established a Study Abroad Office, but this is just one part of a communication strategy that needs to become much more vigorous.

Moving beyond where we are now – both in terms of the programs MIT provides and in how we communicate what the Institute offers – will require a concerted effort by a dedicated cadre of faculty and administrators. Over the next few years, they will need to work together in exploring new initiatives that we might undertake. At MIT, managing the expansion of international education is more complicated than at many other universities. Our culture is one that values the ground-up entrepreneurial activity of the faculty – and existing programs have succeeded because of that activity. However, international engagements, by their very nature, call on a more centralized involvement by the Institute administration than do most other activities. For this reason, it is important that the future cultivation of international education at MIT be an active and joint concern of both the faculty and the administration.

A top agenda item of involving more MIT undergraduates in international experiences is providing 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 individual's undergraduate experience, regardless of major. This signal can take many forms, but the most important are those that show the faculty is serious about raising the stature of international education among MIT students. Thus, an international alliance that is started by a department's faculty to allow its undergraduates to engage in international co-ops – or a change in a curriculum to accommodate a semester of foreign study – will do more to spur an increase in international experiences than merely supplying information on applying to other universities' study-abroad programs.

This is not to deny that streamlining how MIT handles students who study abroad under existing conditions would be beneficial. Students who currently wish to study abroad must each individually navigate a series of hurdles in order to make things happen. These range from discovering opportunities and judging their credibility to arranging for transfer credit and financial aid, to not being penalized in Institute housing once they return to Cambridge. MIT has taken valuable steps to remove these obstacles, and we encourage the Deans for Undergraduate Education and Student Life to continue working together to ensure that administrative practices do not fall in the way of students who wish to pursue study abroad.

In addition to creating a climate that raises the profile and stature of international education at the Institute and nurtures the expansion of existing successes, we can identify three general sets of strategies that MIT must either engage in or expand. These strategies concern: (1) altering majors and making study-abroad opportunities more explicit; (2) developing partnerships with other universities; and (3) taking advantage of the summer and the IAP.

Few departmental programs have been designed with attention to accommodating students who wish to study abroad. Because studying abroad in any context requires considerable preparation, it is important that even entering first-year students know how each department feels about its majors gaining international experience. In addition, each major will publish a credible roadmap through its program for students who wish to integrate their major with an international component.
The Committee on the Undergraduate Program will issue a call to all academic departments, requesting that they provide formal guidance to all majors who may wish to pursue international study. Departments must be strongly urged to provide paths through their majors that allow for international study, either by maintaining a "flexible option" or by participating in an alliance with a foreign university. The guidance from all departments will be collected together in a publication that is updated annually and widely disseminated to both existing and prospective MIT students.

Providing such information to students is just a start, however, since it will help those who are already amenable to going abroad to navigate the complexities of

MIT. Among faculty and students, there is a deeper inertia that needs to be overcome – one that cannot be addressed by simply giving greater guidance to majors or by loosening up major requirements. Based on a small amount of experience at MIT with department-specific international alliances (and greater experience at other universities), we believe that MIT departments must be encouraged to explore formal arrangements with comparable universities in other countries, in order to promote undergraduate study and research exchanges. Models for these sorts of partnerships already exist at MIT, the most famous of which is CME. We suspect that other arrangements with other universities could also be developed, but they will not just happen if we wait passively.

In considering the efforts necessary to expand MIT's efforts at global education, it is natural to consider the role and scope of foreign language education for undergraduates. Currently, we are unprepared to recommend that MIT adopt a foreign language requirement, just as we are unprepared to require an international experience of all undergraduates. However, understanding foreign languages is often a critical starting point for students who wish to engage with foreign cultures. Therefore, if we recommend that any student who wishes to study abroad should be allowed to do so, it follows that MIT should also allow any student who wishes to study a foreign language to do so, too. This principle requires serious study before it can be implemented, however. Therefore, we recommend that the Dean of Humanities, Arts, and Social Sciences commission a study of current and future demand for foreign language instruction at MIT, with the goal of devising a plan for meeting the demand that may exist.

Finally, we note that the Institute has maintained a series of "culture houses," since the construction of New House in the mid-1960s. At a time when the Institute is dedicating itself to greater support for international education, we cannot neglect the mission of these residences, which were chartered precisely to further the types of educational goals we have been discussing. These residences were initially established with ties to academic departments; over the years, however, many of these ties have lapsed into desuetude. We recommend that the Dean for Student Life, working with the Deans of the Schools, reinvigorate the internationalizing missions of these residences and, where necessary, reestablish formal ties between these residences and academic units.

Conclusion

MIT stands at a juncture that offers great challenges, as well as equally great opportunities, to respond to globalizing pressures. High-school students considering MIT must understand that international engagement is important and that they can acquire a firm foundation for global engagement during their four years at MIT. Any entering MIT student who wishes to engage in study, internships, or research abroad while an undergraduate will be able to do so without undue impediments, from the Institute or the departments.

Because of MIT's distinctive form of undergraduate education, we cannot prescribe one path to make this goal a reality, nor can we make an international experience a requirement of all students. However, the Institute can make the path easier by providing unified leadership, ensuring that every part of the undergraduate curriculum accommodates the greater engagement of MIT undergraduates with an increasingly global society.

Summary of Recommendations

1. ***The Institute should undertake immediate efforts to undergird the efforts of existing programs at MIT that have proven especially effective in creating meaningful encounters between undergraduates and foreign countries.*** These efforts include assessing the optimal sustainable scale of these programs, the resources necessary to reach this scale, and feasible strategies for expanding the reach of these programs.

2. ***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 particular, students who undertake meaningful study abroad should be able to graduate in four years and will be assisted in financing foreign study, especially for summer experiences, where financial aid is generally unavailable.

3. ***The Dean for Undergraduate Education should provide intellectual guidance for the expansion of MIT's engagement with international education at the undergraduate level.*** The Dean should have the necessary resources to encourage faculty members to explore formal arrangements with comparable universities in other countries, in order to promote undergraduate study and research exchanges.

4. ***The Committee on the Undergraduate Program will issue a call to all academic departments, requesting that they provide formal guidance to all majors who may wish to pursue international study***. Departments also should be encouraged to explore developing educational partnerships with universities in other countries and develop avenues for undergraduates to gain international experience during the IAP and the summer. The Dean for Undergraduate Education should ensure that information about each department's international education opportunities is updated annually and widely disseminated to current and prospective students.

5. ***The Dean of Humanities, Arts, and Social Sciences should commission a study of current and future demand for foreign language instruction at MIT, with the goal of devising a plan for meeting the demand that may exist.***

6. ***The Dean for Student Life, working with the Deans of the Schools, should bolster the internationalizing missions of the Institute's international theme houses and, where necessary, work to strengthen ties between these residences and academic units.***

Massachusetts Institute of Technology

Report of the Task Force on the Undergraduate Educational Commons

5. FURTHER EFFORTS TO ENHANCE THE EDUCATIONAL COMMONS

The enhancement of our curriculum relies not only on formal changes, but also on attention to the underlying conditions that allow a curriculum to be successful. We highlight six of these conditions: first-year coherence and integrity; upperclass advising; classroom resources and scheduling; diversity; resources for educational innovation, renewal, and assessment; and faculty governance.

The reforms we propose earlier in this report create conditions for establishing an even more unified approach to the first year at MIT, by strengthening orientation, bolstering the advising system, and supporting a variety of efforts to foster coordination among the instructors who teach large numbers of first-year students.

Advising and mentoring all students, not only those in the first year, are critical tasks about which the entire community must be concerned. The advising experience of MIT undergraduates is, at best, varied. MIT must strive to create for each undergraduate a network of individuals who can be counted on to provide the needed advice and counsel to help navigate the passages of a four-year experience. To assist in making this a reality for all students, we must strengthen the existing resources, empower the departmental undergraduate offices, and provide concrete recognition for faculty members in their roles as advisors.

The quantity, quality, and composition of our classrooms are inadequate for our current teaching needs; this is a topic that demands immediate attention if the reforms we propose are to succeed. Also, the time scheduling of classes has become chaotic, which exacerbates the classroom shortage and encourages a nonacademic or even an anti-intellectual approach among students when they choose classes.

We affirm MIT's commitment to recruit a highly diverse student body and the efforts to use that diversity as a resource in the education of our students. Efforts to increase the number and quality of meaningful interactions among students of diverse backgrounds should be vigorously pursued, as should efforts to monitor and document the effects that our curricular reforms have on the ability of students to succeed when they live and work with people of varying backgrounds.

The past decade has brought a new level of professionalism into the development of new subjects and teaching modes and in assessing the success of our efforts. We should expand on these efforts to raise the professional level of our teaching approach by enhancing our capacity to improve the skills of our teaching staff at all levels, making assessment a common Institute practice, working to improve connections between MIT classes, better documenting the teaching experiments that are conducted at MIT and disseminating good practices, as well as strengthening the capacity of the Dean for Undergraduate Education to work with departments and Schools in their efforts to improve the curriculum.

Finally, we must accomplish the enhancement of undergraduate education by forming a leadership partnership among the faculty Committee on the Undergraduate Program, the Dean for Undergraduate Education, and the School Deans. An especially important task in providing leadership for these new efforts is the cultivation of a new generation of academic leadership among our less senior faculty.

In the preceding pages, we reviewed three significant topics that form the core of our recommendations: the General Institute Requirement (GIR) in science, mathematics, and engineering; the GIRs in humanities, arts, and social sciences; and international education. We believe that the Institute's faculty and administration should devote their greatest energies to these programmatic areas in the coming years, as we endeavor to improve even further the common education of all students and to prepare them for the challenges of the coming century.

However, these are not the only areas on which we have deliberated, as many pressing issues emerge in the rare moments when universities examine their common curriculum. Some of these issues, like classroom space, have substantial financial implications and bear obviously on the success of the major themes we have discussed. Other issues, such as the scheduling of classes and curriculum assessment, might strike some as less momentous, but are obviously pieces of the larger puzzle that must be constructed if our plans to renew the curriculum are to be fulfilled.

In a report such as this, it is tempting to produce a comprehensive catalogue of the educational issues about which conscientious faculty, staff, and students are concerned, in the hopes that no worry will be left behind. We have tried to avoid this temptation by encouraging the existing faculty governance and administrative structures of the Institute to address these issues in ways that are consistent with our vision of the future. Among these issues are the following:

1. ***Double majors.*** MIT currently requires undergraduates who wish to pursue two majors to complete ***two undergraduate degrees***, rather than simply completing the departmental requirements of the two majors. As we see no justification for continuing this practice, and recognize that students who wish to pursue two degrees at MIT are often put in a situation of making unwise choices about the use of their time, we urge the faculty committee system to develop a proposal that eases the path for students who wish to receive a proper "double major." The student who wishes to accomplish a double major will need to satisfy the commons requirements and the requirements for both majors, but will have no additional requirements (such as a larger number of total units). We believe this change not only will provide incentives for students to make the right decision about whether or not to double major, but also will offer additional flexibility for those students who do decide to pursue a double major.

2. *Academic calendar.* Insightful comments made by faculty, staff members, and students have led us to appreciate that details of MIT's academic calendar may induce undergraduates to allocate their time unwisely and limit the time available for reflection on what they have learned. Specific issues include the late Drop Date, the absence of a true reading period prior to final exams, and the benefits of formalizing meetings between advisors and advisees during an extended pre-registration period.

Both matters fall under the jurisdiction of the faculty committee system, particularly the Committee on the Undergraduate Program (CUP); we urge the CUP to assess systematically these topics and propose changes to the faculty as they see fit.

Beyond these two issues, we wish to discuss six topics – a small bundle of programmatic themes, resource needs, and administrative hurdles – that we believe are critical to the success of the proposals we have already made, and thus deserve to be highlighted within this report. These six topics are:

1. **First-year coherence and integrity;**
2. **Upperclass advising;**
3. **Classroom resources and scheduling;**
4. **Diversity;**
5. **Resources for educational innovation, renewal, and assessment; and**
6. **Faculty governance.**

First-Year Coherence and Integrity

The first year is critical for setting the tone for the distinct educational experience at MIT. Indeed, the first hours on campus establish a set of expectations, practices, and attitudes that unfold, for better or worse, across the next four years. Focusing on classroom education, the first year is when so much of the common curriculum is experienced by students, particularly in natural science and mathematics. Even though the humanities, arts, and social sciences curriculum unfolds across four years at the Institute and is less pyramidal than the accompanying Science Requirement, the first year is critical for establishing the importance of these subjects in achieving a complete education and for developing the base of skills and knowledge that these subjects provide.

For these reasons, it is important that the classes that MIT students first encounter immediately engage them in the excitement of new discovery and provide a compelling window into an increasingly rewarding set of discoveries. These subjects must be taught exceptionally well, and must always be fresh and new. However, excellent and compelling classroom teaching in the first year is only one important element of getting undergraduate education off on the right foot. To help achieve the proper momentum, there must also be:

- ***an orientation period*** that prepares first-year students for the challenges they are about to face, frames the larger context in which their education is set, and helps them begin to grasp the larger world that they are entering;

- ***a first-year advising system*** that supports students in a challenging transition and offers a rich array of information on future educational opportunities, such as majors; and

- ***an integrated, more general view of the first year.***

MIT currently has many of these elements, which have primarily been the responsibility of the office of the Dean for Undergraduate Education. However, the next few years present the opportunity for the Institute, led by the Dean, to further increase its focus on the whole first-year experience as it shapes the learning environment of our entering students. In providing a more comprehensive stewardship of the first year, we believe the Dean for Undergraduate Education must focus on the following key elements – orientation, advising, and the coordination of primarily first-year subjects.

Orientation

The Task Force on Student Life and Learning called for renewed attention to Orientation, writing in 1998 that:

> …undergraduate orientation concentrates too heavily on living group selection: the way undergraduates are asked to make immediate choices about living arrangements obscures larger choices and more important values. By and large, the current system of undergraduate orientation detracts from the sense of an overall community at MIT, and discourages faculty-student interaction. . . .
>
> The central purpose of orientation should be to create the feeling of joining a single, campus-wide community. First-year orientation should consist of a program that continues throughout the first year, and should be filled with experiences that establish a connection between incoming students and experiences in academics, research, and community. To do this, there should be more activities that involve faculty, graduate students, and undergraduate students in shared experiences. In all parts of orientation there should be an equal role for academics, research, and community.[1]

Over the past decade, developments have helped to address many of the criticisms that were directed at first-year orientation. Residential selection is less dominant during orientation week than it was a decade ago. While some new academic features have been added to orientation in the past decade, it has yet to be determined whether the orientation roles for academics, research, and community have reached the equilibrium called for by the Task Force on Student Life and Learning.

Achieving a balance among academics, research, and community during orientation requires that the faculty provide the leadership necessary to set the stage for the *intellectual* journey upon which first-year students are about to embark. Effectively articulating the purposes and goals of the core curriculum is an important task of orientation. Presently, the most prominent encounters that students have with the core curriculum are the placement exams that many take – and mostly fail – early in orientation week as well as the so-called "Core Blitz" that occurs immediately before meetings with first-year advisors. It would be appropriate to enhance opportunities during orientation for all entering students to engage in the big questions that will face them during their four years at MIT and, indeed, during their lives.

One interesting development over the past decade has been the rise of the pre-orientation programs which, in 2006, have grown to over a dozen distinct programs sponsored by departments and administrative units. These programs help to introduce incoming students to leadership, social, athletic, service, and academic

1
Task Force on Student Life and Learning, pp. 37, 43.

activities at MIT. Roughly half of the entering Class of 2010 participated in pre-orientation programs.

The rise in popularity of first-year pre-orientation programs, the decrease in residential selection as an orientation activity over the past decade, and new opportunities will need to be taken into consideration by first-year students and their advisors as the GIRs evolve over the next several years. Therefore, we recommend that the Dean for Undergraduate Education work together with the Committee on the Undergraduate Program, ensuring that these activities achieve the important *intellectual* goals that orientation should be putting first.

First-year advising

MIT has long been proud of its first-year advising system, which involves a wide segment of the MIT community – students, faculty, and staff – in helping to guide the newest members of our academic community through their first year. Equally important to the academic advice imparted to incoming first-year students is the strong network of personal support that advising groups and advisors can provide. In the past several years, the Dean for Undergraduate Education's Academic Resource Center has redoubled its efforts to make more information available to advisors, while more thoroughly supporting the efforts of those advisors.

Because the proposed changes to our curriculum are so focused on the first year, these efforts must be redoubled yet again in the immediate future. In particular, these efforts must ensure that the greater latitude afforded first-year students in designing their science, mathematics, and engineering curriculum will be well utilized. We are particularly concerned about the decrease in the number of faculty members who have served as first-year advisors over the past decade. Because faculty members possess a subtle understanding of the MIT curriculum, every effort must be made to increase these numbers in the immediate future.

An equally compelling reason to encourage faculty members to engage in first-year advising is to foster contact between undergraduates and faculty members in the first year. Close faculty contact was a primary motivator behind establishing the Freshman Advising Seminar system that once was the keystone of first-year advising at MIT. Because so much of the Science Core is taught in large lecture classes, the Institute must sustain some other means of encouraging faculty and students to become acquainted in a meaningful way. In recent years, the number of students being advised in seminar groups has declined, as has the number of faculty members teaching them. Oftentimes, this has been for good reasons – seminars consume units that many first-year students wish to use for other worthy activities and classes. The effect remains, however, that our first-year students have been drawn away from early contact with the faculty over the past ten years.

The changes proposed in the Humanities, Arts, and Social Sciences (HASS) Requirement possibly may add to the separation between faculty members and students in the first year. Currently, the HASS-Ds that first-year students take have typical enrollments in the range of 18-to-20 students. By shifting the first encounter with HASS subjects to classes more in the range of 80-to-120 students, we run the risk of creating a first year in which a student seldom encounters a faculty member face-to-face. In Chapter 3, we note the importance of ensuring that all the classes in the HASS First-Year Experience Program include smaller sections or mini-classes to guard against the isolation of faculty from students. Even so, encouraging more faculty involvement in first-year advising is among the simplest ways of fostering more faculty-student interactions, especially in fields that stress large-enrollment classes in the first year.

We are not lacking in ideas about how to advise our freshmen more effectively. Over the past decade, at least three major faculty-led committees have examined the issue and have made a series of sensible recommendations to improve advising at MIT. These examinations have uniformly called for greater faculty involvement in first-year advising. Faculty involvement has continued to decline, nonetheless, because the Institute has not addressed how to shift faculty attention from other highly valued activities to advising. If direct faculty-student interaction is a top goal of the first year, then the Institute must find ways for materially recognizing and encouraging these efforts, rather than continuing to treat first-year advising as an activity that advisors do out of the goodness of their hearts.

Coordination of primarily first-year subjects

The traditional first-year experience at MIT offers opportunities for students to immediately see the connections between academic disciplines and the synergies that flow when different approaches are brought to bear on a problem. This tight integration of the first-year curriculum, particularly in science, led the Zacharias Committee to articulate a “planning principle” for our form of education. As a result, these interdisciplinary synergies would be actively exploited and the connections between fundamental science subjects and “header” subjects in the majors would be actively developed, rather than left to emerge haphazardly.

These synergies and connections continue to be captured in several ways, such as the occasional meetings of first-year instructors to coordinate subject content and examination schedules, as well as innovative uses of the OpenCourseWare (OCW) initiative to encourage greater coordination between first-year classes and major subjects.

Energy devoted to coordination activities such as these has waxed and waned over the past twenty years. We have encountered no faculty member who believes that greater coordination between subjects is a bad thing or who is unwilling to help students see the connections between subjects whose substance intersects. Coordination does not just happen, however; it must be someone's active responsibility. The Institute must continue to give special attention to assisting collaborations by supporting platforms such as OCW as a teaching tool. In the particular case of the typical first-year subjects, the office of the Dean for Undergraduate Education should be responsible for ensuring that instructors for the core classes in the Science and HASS Requirements regularly consult with each other.

Even with the proliferation of "flavors" of Science Core subjects and the acceleration through that core undertaken by many of our students, the first year at MIT is already seen as a cohesive experience for our students. With the shifts we propose in the HASS Requirement, this cohesiveness will increase even further. To make this experience *be* cohesive rather than *look* cohesive requires vigilant attention from the faculty, as a whole, and the Dean for Undergraduate Education. For the first year to be more than a seriatim collection of subjects, the Institute must devote special attention over the next few years to beefing up orientation, advising, and the coordination of primarily first-year subjects.

Upperclass Advising

Because of proposed changes to the General Institute Requirements, it is critical for the MIT faculty and administration to devote renewed attention to first-year advising. A related concern that we have encountered is the advising system for upperclass students. Perhaps the word that best describes the quality of advising for upperclass MIT undergraduates is "varied." In a typical group of students, some will have had a helpful and supportive advisor at some point in their careers, others will have found such a mentor outside of their official advising relationships, and still others will not have developed that sort of relationship with anyone in the MIT community. Going to college can be a very daunting task for even the best students, and the Institute should strive to provide a solid advising/mentoring experience for all students. The best relationships go beyond choosing classes and fulfilling degree requirements to more general discussions about education and life during and after MIT. This goal is often a difficult one to achieve, however, as it requires the full cooperation and effort of the student and his or her advisor.

During the time of our deliberations, two notable documents were released that stressed the importance of advising to undergraduate education generally and gave some suggestions on how to improve the quality of advising at MIT. One was a joint effort of the faculty Committees on the Undergraduate Program and on Student Life;[2] the other was by the Student Advisory Committee to the Task Force. One of the key points in both reports is that advising students is a responsibility shared by every member of the community. Every student has many potential mentors, not all of whom are necessarily given an official title. In addition to first-year or departmental advisors, students seek help and advice from individuals, such as professors, bosses, upperclassmen, residence advisors, and coaches – or even from entire groups of people, such as departmental offices or the Careers Office. This *network* of advisors is an essential part of the undergraduate program and should be supported and enhanced.

These reports offer a variety of ideas for streamlining and improving advising. One that is common to both documents is the idea of creating a network of mentors for each student. The Associate Advisor program, which pairs upperclassmen with first-year advisees, can be expanded to pair sophomores or new students to a major with more experienced students in that program. The Undergraduate Office in each department not only can monitor advisor-student relationships, but also can provide resources and support directly to the students; currently, not all of these offices are equally effective in doing so. Additionally, the Student Advisory Committee report suggests creating a list of open advisors in a department; these individuals can be faculty or staff and will serve as an additional resource for students who are not yet in the department or who do not feel comfortable talking with their advisors about a problem.

Another way to improve advising relationships is to streamline the necessary paperwork so that students and advisors have more time for meaningful discussions.

2
Committee on the Undergraduate Program and Committee on Student Life, *Report to the Faculty on Advising and Mentoring of Undergraduates*, Cambridge, Massachusetts, Massachusetts Institute of Technology (March 2005). Available at http://web.mit.edu/committees/cup/advising_and_mentoring.html.

Some ways of doing that include publishing clear information about first-year requirements and opportunities that advisors can quickly review with their students and maintaining up-to-date information for students on easy-to-access websites. Departments also can make available a chart for each student to track his or her completed degree requirements for the major; some departments, such as mathematics, already distribute a form that allows students to see immediately what classes they must take. Although improving the efficiency of the course selection process might mean that students spend less time with their advisors, setting aside a minimum amount of contact time in the semester will help to increase the amount of quality advising time given to each student.

The Committees on the Undergraduate Program and on Student Life offer further suggestions with regard to improving the transition between first-year and upper-class advising. The report suggests assigning the major advisor earlier in the first year, as soon as students are prepared to declare a major. Doing so will allow for a meeting or discussion between the old and new advisors, while enabling the new advisor to understand the student's needs as soon as possible.

Finally, both reports expect students and faculty to understand their roles in the advising experience. Everyone involved in the advising network must receive sufficient training so that they can go beyond listing the degree requirements and answering basic questions to truly serving as strong mentors for their students. The Institute must properly outline the goals of satisfactory advising so that advisors understand their roles, and students must be educated on how to get the most out of their advising experience. Like faculty, students must understand the program goals and know what to expect from their relationships with faculty members. In addition, students must maintain contact with their advisors and must network with other members of the MIT community, particularly if their relationships with their assigned advisors are not strong. Only when all parties understand the expectations of the advising program will all students be able to establish meaningful mentor relationships at the Institute.

It is clear that the role of the faculty in the effort of advising, and especially mentoring, undergraduates is critical. Historically, many faculty members at MIT have devoted extraordinary efforts to this task, and students have benefited greatly from these efforts. However, it is also true that historically the Institute has not provided consistent recognition and rewards for faculty who devote time to undergraduate advising and mentoring. For example, most departments do not give teaching credit for freshmen seminars.

Advising and mentoring of undergraduates, especially beyond the first year, is a challenge for all universities. If MIT is to make significant improvements in this program, we must do more than follow the excellent suggestions from reports like those of the CUP/CSL effort and the Student Advisory Committee; we also must ensure that faculty and other advisors and mentors are appropriately and consistently recognized and rewarded for their efforts. In practice, this means that student advising and mentoring are explicitly included in yearly salary reviews and in promotion and tenure cases. The School Deans can help by working together to devise a consistent plan for including such contributions and then making sure that departments implement such a plan. We recommend that a working group of the School Deans and other key players (such as the Dean for Undergraduate Education and the Chair of the Committee on the Undergraduate Program) be formed to begin making progress in this area.

Classroom Resources and Scheduling

One topic that will unite every member of the MIT faculty is the current state of MIT's classrooms – there are too few of the right types of classrooms to properly teach the classes currently offered.[3] Conflict over control of space is acute at MIT. In recent years, the fraction of space devoted to teaching has declined from more than 50 percent to a current fraction of about 5 percent, with constant pressures on teaching space from departmental needs, such as administration and laboratory space for new faculty.

Classroom maintenance has been deferred for too long, while teaching technologies are often broken and out-of-date. There has been a recent move to renovate some general-use classrooms, despite an average cost of some $785 per square foot for main group rooms and a serious effort to upgrade the audiovisual support in these rooms. Nevertheless, upon surveying these matters, we concluded that MIT lags noticeably behind its peers in the overall maintenance and upgrading of classroom space. This deficit is most striking in the maintenance of our signature lecture rooms, 10-250 and 26-100, but it extends to many of our general-use classrooms, as well. The base funding for repair and renovation of classrooms is some $1,000 per classroom annually. Obviously inadequate, this has been supplemented by *ad-hoc* funds for various upgrades.

If our curricular recommendations are implemented, these criticisms will only increase in number and intensity, since the teaching modes we believe should be

3
In the 2004 Faculty Quality of Life Survey, when asked about how satisfied they were with resources that support teaching at MIT, the quality of classrooms and the availability of funds for educational innovation tied for greatest faculty dissatisfaction. Among all resources that support faculty activities – educational, research, and administrative – infrastructural issues uniformly elicited the most complaints. The nicest comment the faculty, as a whole, made about their classrooms is that they were conveniently located.

more emphasized require classrooms that currently are the scarcest. The proposed first-year project-based subjects will increase the need for highly flexible space, perhaps similar to the TEAL classrooms, in the immediate future. The first-year subjects proposed for the HASS Requirement will demand the construction of several new classrooms, auditoriums, and performance spaces that will hold between 80 and 120 students, as well as more seminar rooms that can serve the needs of discussion-based classes.

There is a serious need for the faculty and administration to work together to develop a plan of classroom renewal. In the past decade, similar efforts have been made to this end. However, they have not made satisfactory progress from the perspective of the faculty, owing to a variety of reasons, most of which come back to the mismatch between the size of the task and the magnitude of the response. MIT is so constrained by the lack of high-quality teaching spaces that when serious efforts are undertaken to improve the situation, such as the current project to renew Buildings 4 and 6, the disruptions are severe.

We recommend that the visibility of classroom planning be increased and that a faculty committee be appointed, to be chaired by the Dean for Undergraduate Education. This committee immediately must conduct long-range planning of classroom space needs at MIT, assess the new classroom needs that are implied by the reforms proposed in this report, make recommendations concerning maintenance and new construction, and exercise oversight of these actions as appropriate. In particular, this committee should immediately give serious consideration to the possibility of constructing a dedicated Teaching and Learning Center, which has been discussed at MIT for many years. No standing committee of the faculty is charged with continually monitoring the status of classrooms – either their current condition or strategic development. Therefore, the Rules of the Faculty should be amended to lodge this oversight responsibility with one of the standing committees.

Related to the lack of appropriate teaching space are the difficulties in scheduling that space. In the face of classroom shortages, we have learned that classrooms are *not* being efficiently scheduled; to quote Pogo, "We have met the enemy and he is us." The difficulties the Registrar's Office faces in sustaining the standard, coordinated classroom scheduling are often due to the unwillingness of many faculty members to teach on Fridays or to teach before 10 a.m. or after 3 p.m.

Scheduling difficulties produce obvious problems of classroom allocation, but we find they also produce another, more troubling *intellectual* problem that was introduced in Chapter 3. We have been told time and again that the primary algorithm for picking elective classes, particularly those in the humanities, arts, and social sciences, is to start with the classes in one's major and then see what time slots are available for other classes. Because of the chaotic scheduling practices that have grown up, the number of subjects that fit within a student's schedule can actually be very limited, *even when the formal list of classes seems to be quite long*. For instance, even though there are routinely over fifty HASS-D subjects available each semester, we regularly encounter students who could only avail themselves of four or five of these, for scheduling reasons. When we overlay the requirement that HASS-D subjects be distributed across subject areas, what seems to be a requirement with tremendous choice can quickly become one in which a particular student has no relevant choices available.

For both the wise management of our limited real estate and the goal of ensuring intellectual excitement among our classes, the faculty, administration, and Registrar must work together to re-establish a common system of classroom scheduling that can be maintained. We also believe that if the faculty adopts the proposed changes to the HASS Requirement, setting aside dedicated time slots for the first-year subjects will help improve the experience of our incoming first-year students.

We wholeheartedly echo the Task Force on Student Life and Learning's call for MIT to make the quality of community life one of its top priorities. A decade ago, that task force was responding to a sense that the campus design fostered a separation of community-building activities from research and teaching. Since then, the Stata Center has been a notable example of how an academic building can be designed with substantial informal space that allows students and faculty members to interact. From the perspective of community spaces, the success of the Stata Center should be built upon as MIT continues to construct new academic buildings and renovate existing structures.

Furthermore, departments should be encouraged to provide and budget space to allow students to remain near their department during "interclass" times. These spaces can include conference rooms where students work together, tables in open spaces, snack service, lockers, computers, and supplies in the academic area of the campus. A library annex also might be part of such a facility. Many of these components already exist on campus, but few are located so as to become synergistic. We suggest that a planning effort be made to provide facilities that will allow synergistic centers that encourage students to remain in the academic areas of the campus throughout the day.

The physical size of the academic space at MIT and the number of students suggest that several of these centers will be needed. They can be organized around a few academic departments, so that the students and faculty who frequent an academic "town center" will have similar interests. These smaller communities will make it more difficult for individual students to fade into the larger (big city) population of the entire Institute. Such academic town centers also will encourage the faculty to come out of their offices and labs to interact with the more general student population.

The physical space in which teaching and learning takes place plays a critical role in the success of our educational mission. One of the most important ways we can support this mission is by optimizing the space accommodating it. Architectural space colors all human activity – and space that is well designed and appointed enhances the human endeavors it houses. William Mitchell, former Dean of MIT's School of Architecture and Planning, has stated, "Spaces for learning … are social spaces. They're spaces that support some sort of learning community."[4] If our educational mission is to succeed, a wide variety of learning communities at MIT must be supported by appropriate architecture.

Diversity

MIT has long recognized that its educational mission requires that the Institute be accessible and relevant to all individuals and groups in society. This is reflected in our formal antidiscrimination policy; in committees composed of faculty, staff, and students that highlight issues of educational inclusiveness; in classes taught in the regular curriculum; and in special programs that are designed to translate our good intentions into positive action. Furthermore, we believe that all students benefit when the MIT campus reflects a broad range of intellectual, cultural, and demographic perspectives. A diverse campus increases the interaction among a range of students and thus challenges stereotypes, broadens perspectives, and sharpens critical thinking. This campus milieu not only promotes learning, but also better prepares students to be constructive citizens in a multicultural society while thriving in a global workforce.

Considerable research has been conducted into how increasing meaningful interactions among diverse populations of college students affects learning outcomes. Among the findings, we discovered that college students who have had more meaningful interactions with students of different backgrounds (primarily racial) have higher levels of racial understanding, leadership development, and civic

4
William J. Mitchell, interview by Frederico Casalegro for his research project on "creativity and learning," Design and Fabrication Group @MIT (Fall 2003), p. 1.

engagement. While there are nuances to these studies, we conclude that a campus environment that captures this diversity and deliberately uses it is more likely to produce graduates with the personal and intellectual qualities essential to succeed in life.

The question, then, is how to capture this diversity in an intentional way. The goal at MIT should be to encourage opportunities for more meaningful interactions between individuals of differing backgrounds, identifying the various ways to foster these interactions, structuring the development of our curriculum so that diversity is appropriately reflected, and assessing the progress we have made in achieving our goals.

This perspective arises from a reading of the developmental literature as it pertains to higher education. Diversity introduces discontinuity and discrepancy that spur cognitive growth. Life transitions such as going to college present both challenges and opportunities for learning that extend beyond the mere scholastic. This discontinuity, which Piaget labels "disequilibrium," is also helpful for the construction of identity, an important developmental vector for adolescents. To foster disequilibrium, universities must not merely focus on the representation of various groups. Rather, they must institutionalize interactions among groups of different backgrounds and experiences, thereby limiting their retreat to familiar associations and surroundings.

Providing a useful framework, Gurin and his colleagues classify diversity as it pertains to higher education in three parts.[5] First, *structural diversity* refers to the numerical representation of diverse groups on campus. Second, *informal interaction diversity* applies to the frequency and quality of intergroup interactions which, they argue, is the key to meaningful experiences in college. Finally, *classroom diversity* or *learning about others* builds content knowledge and enables students to gain experience with diverse peers in the classroom.

Although we must not become complacent about this situation, MIT is one of the most racially diverse campuses in America; among universities that focus on science and technology, the Institute is among the most gender-balanced. Therefore, we start from a position of structural diversity that should be easy to exploit. In such a case, it is natural to believe that our residential system and burgeoning student association scene should be major foci for increasing informal interactions among students, ranging from the casual to the more structured. Although there are many signs of hope at MIT, there is a puzzling tendency to adopt rigid positions when the residential system is asked to participate fully in increasing meaningful

5
P. Gurin *et al.*, "Diversity and Higher Education: Theory and Impact on Educational Outcomes," in *Race and Higher Education: Rethinking Pedagogy in Diverse College Classrooms*, eds. A. Howell and F. Tuitt (Cambridge: *Harvard Educational Review*, 2003).

interactions among students. We certainly recognize the importance of balancing values like choice with the maintenance of safe, unique social/cultural spaces that are the hallmarks of our residential system. Still, if we truly believe that diversity is a top issue at MIT for the life success of our students, that increasing comfort with a diverse set of people requires attention to formal and informal interactions, and that MIT's residential system is our richest locus of such informal interactions, then we must insist that the residential system play a major, active role as we devote more attention to matters of educational diversity.

It is in the classroom where the Task Force's greatest competence lies. Our own personal experiences confirm what the research literature tells us: Neither the quality of students nor the intellectual engagement in our classrooms suffers because of diversity. We also know that our colleagues vary in the degree to which they are comfortable dealing with issues of diversity that may emerge in the course of their teaching and in their knowledge of how diverse racial, ethnic, gender, class, and national backgrounds may affect the learning styles of their students. We have heard a strong concern, from both faculty members and students, that teaching assistants (TAs) are especially heterogeneous in embracing the value of diversity and teaching in an environment that is as varied as MIT.

Special issues of diversity in the classroom emerge in a curriculum that focuses so much on science and technology. Faculty members in the humanities, arts, and social sciences (especially younger faculty) are often steeped in issues of diversity, from a variety of perspectives; therefore, the content of their classes commonly addresses issues of race, sex, ethnicity, class, and nationality. Diversity is not typically an emphasis in science and engineering PhD programs, nor is the subject matter of classes often directly about these topics. For this reason, well-intended faculty members in these departments are sometimes caught unawares when class material is dissonant to MIT's diversity goals or, more often, are unaware of how various teaching methods might unintentionally advantage or disadvantage different groups. It is natural to imagine that the greatest gains in classroom diversity at MIT will come about in humanities, arts, and social sciences classes where topics of diversity can be directly addressed. Yet, because the great majority of our students intend to pursue technical careers, diversity must be a topic that informs teaching in the sciences and engineering, as well. It is in this area that MIT can perhaps exhibit its greatest national leadership.

The engagement with diverse peers made possible by a diverse student body is a necessary condition for us to achieve our educational goals and to position our students for global participation and leadership. We must continue our efforts to create a pluralistic climate on campus – one in which students from all backgrounds can reap the full rewards of diversity. The impact of college on students is the cumulative result of informal and classroom interaction with peers of different racial, ethnic, and other background characteristics that are sustained over time. Such interactions spur cognitive growth, racial understanding, and an increased sense of citizenship. As the leaders of MIT's educational enterprise, the faculty not only must be explicitly aware of diversity's influence on how we perceive our mission, but also must be leaders in translating our collective intentions into new and novel curricular, pedagogical, and research practices. We must be clear in expressing our commitment to diversity, first by embracing the diverse student body we have attracted, and then by fostering informal interaction and classroom discourse among a wide range of reference groups.

Reflecting on the major proposals we have made for improving our common curriculum, we offer the following recommendations with the intention of enhancing our commitment to the value of diversity in our education and furthering its contributions.

1. MIT will continue to state clearly the paramount importance of maintaining a diverse student body from the perspective of its educational mission and resist efforts imposed from the outside to diminish or dilute those efforts. We further embrace the Institute's continued support of programs that are intended to increase the diversity of MIT's student body, and the student bodies of colleges focused on science and engineering more generally, such as Project Interphase, the Minority Introduction to Engineering and Science (MITES), the Women's Technology Program, and the MIT Summer Research Program (MSRP).

2. We regard MIT's efforts to increase the diversity of its faculty and administration to be integral to the success of our educational goals, and those of American higher education more generally; therefore, we recommend that the faculty and administration vigorously pursue current efforts. We know that a more diverse faculty reinforces the gains made by students who study amidst a diverse student body.

3. We recommend that all new subjects that are created in response to our curricular reforms address directly the relationship between the subject design and the diversity goals of the Institute. We

must be creative in how this recommendation is implemented. At a minimum, *the entire* common curriculum is taken by a student body that is exceptionally diverse; we owe it to our students to be actively aware of that diversity when we design classes that should be engaging to all of them. Beyond that, all classes will vary in the degree to which diversity, *per se*, will be an explicit topic. We can begin by asking faculty members to articulate where their subjects fit in a continuum of possibilities. To assist faculty members as they design new subjects and revamp old ones, the Office of Minority Education, working with the Teaching and Learning Lab, should develop and maintain a database of resources, case studies, and other reference materials that faculty members can consult.

4. The macro-level assessment of our curriculum must pay explicit attention to the dimensions of each student's experience that constitute meaningful interactions among diverse groups of students and with issues that bear upon diversity. In recent years, MIT has increased the frequency and depth of its efforts to monitor learning outcomes associated with our education. The most notable of these are surveys administered to students at various points in their academic journey, as well as to alumni. However, none of these instruments is particularly rich in items that gauge the number or quality of meaningful interactions at MIT or the contribution MIT makes to the development of a sense of ease with and appreciation for different types of people. In future general assessments of the MIT experience, we will utilize existing literature on measuring outcomes related to diversity goals.

5. The Committee on the Undergraduate Program will work with the Dean for Undergraduate Education to develop a faculty-led strategy to monitor the contributions of our curriculum reform efforts in fostering greater comfort on campus among minority group students, addressing diversity issues, and making an annual report to the faculty on the status of informal interaction diversity and classroom diversity. While several groups on campus work diligently to raise issues concerning diversity at MIT and to provide information to the community, there is currently no faculty-led group that focuses on curriculum.

One proposal that was put on the table directly by a largely student group was that MIT should institute a "Diversity GIR" as part of its graduation requirements.[6]

6
Dexter Ang, Mary Presley, and Jacob Faber (Representatives of MIT Advocates for Awareness), *Incorporating Diversity into the MIT Undergraduate Curriculum* (presentation at the meeting of the Task Force on the Undergraduate Educational Commons, Massachusetts Institute of Technology, September 27, 2004).

After deliberating on this matter at length, we are not convinced that the structure of our curriculum lends itself so easily to such a class-based requirement. However, we *are* convinced that more careful attention to issues of diversity in our formal curriculum would assist our students in achieving the success in life we intend. This greater attention must be part of the strategy we employ to ensure that all students graduating from MIT have a richer understanding of the diversity of human situations that array themselves along racial, gender, ethnic, national, class, and cultural lines. As with all important goals at a busy place like MIT, the trick comes in structuring the environment to align the incentives of faculty, students, and staff members so that an MIT student will not graduate without encountering issues that invoke diversity in multiple ways.

We may be wrong in our judgment on the Diversity GIR proposal. The recommendations that we have embraced are structured, in part, to raise the awareness of diversity on this campus as an educational issue, document its status, and make this documentation an explicit part of the feedback loop that informs our educational improvement. We intend for these proposals to document where we succeed and where we fail, as well as to help us make the necessary corrections as needed.

Resources for Educational Innovation, Renewal, and Assessment

Over the past decade, MIT faculty members have engaged in pedagogical and curricular innovations at an unprecedented rate. We have reviewed examples of these in the preceding chapters. This innovation convinces us that our proposals are feasible and would effect positive change for our undergraduates if made more generally available. These experiments have been stimulated by generous funding through several unique grant opportunities, particularly the Microsoft Research-funded iCampus Alliance, the d'Arbeloff Fund for Excellence in Education, the Cambridge-MIT Institute, and the Singapore-MIT Alliance. These new sources of grant support have been welcome supplements to existing sources offered by the Class Funds and by the Schools, as well as the backing of private organizations such as the Starr Foundation.

Other developments have further focused faculty attention on teaching. OpenCourseWare (OCW) – initiated by recommendation of the faculty in 1999 and funded by the William and Flora Hewlett Foundation, the Andrew W. Mellon

Foundation, and MIT – represents MIT's entry into web-based dissemination of course material. As of May 2006, OCW had published extensive material for some 1,400 courses. With its impressive growth, OCW clearly represents a powerful addition to the pedagogical arsenal at MIT.

The very existence of this new, substantial, and diversified support has demonstrated the high value placed on teaching at MIT. First, it has involved a much larger group of faculty in teaching innovations than ever before and has brought together faculty from different departments and different Schools to promote learning at MIT. Second, it has stimulated a growing culture of professionalism around the exercise of teaching. Over the past forty years, educational research has led to increased understanding of the conditions affecting efficiency of learning in an academic environment. In addition, the funding mentioned above has allowed for substantial experimentation, here in the MIT context, with practices derived from this research. Finally, it has led to the creation of new classroom space at MIT designed to facilitate various forms of active learning.

All this taken together suggests that, as we redesign the MIT educational commons, we should also grasp the opportunities to consolidate what we have learned about the process of teaching and learning, thereby broadening its reach. The pedagogical aspects of our GIR proposals are designed to capitalize on this experience. We recommend that MIT enhance its capacity to promote professionalism in its faculty's pedagogical efforts. The faculty should demand of itself the scholarly rigor and data-driven attitude expected in its disciplinary research.

In particular, we propose six strategic themes that will bring the rising level of professionalism to the faculty as a whole, thus further enhancing the quality of undergraduate teaching. These actions are the following:

1. ***Enhancing MIT's capacity to improve the teaching skills of faculty members and graduate students.*** A faculty member is both a researcher and a teacher, with a responsibility to strive for professionalism in both areas of academic life. There is much to learn about teaching, and the MIT faculty must embrace this challenge. Teaching is a skill. It is not innate, though it comes more easily to some than to others. To be successful at teaching, an intimate knowledge of the content is a necessary condition, but by no means sufficient. One learns to teach as one learns other skills. Furthermore, one needs guidance, a chance to observe good examples, opportunity to practice in a safe environment, and recognition of success. As we move forward to strengthen the support of teaching improvement, we should keep in mind these requirements.

We owe special consideration to the youngest of the MIT teaching community as they develop these skills. Teaching assistants play a crucial role in the MIT educational system, as they most commonly witness students' conceptual struggles and guide them to safety. Their task is often made harder by inexperience with the cultural expectations of their students. TAs tend to regard their teaching assignments as an integral part of the training they receive here at MIT. Too often, however, they are denied reasonable guidance and a sense of participation in the affairs of their assigned subject.

Because the roles played by TAs differ widely from one department to another, each department should develop a training program that is appropriate to the educational needs of its classes and the professional development of its graduate students. The office of the Dean for Undergraduate Education can facilitate the development and implementation of these programs by helping departments design and implement them. Learning to teach is a lifetime endeavor, and faculty as well as TAs can benefit from feedback and professional consultation. Resources should be developed to encourage the continual development of faculty teaching skills.

2. ***Making assessment an Institute policy***. This recommendation of the Educational Design Project deserves to be repeated. Its many aspects include the following:

    a. ***Improving the breadth of coverage and the usefulness of end-of-term class evaluations.*** **End-of-term evaluations are currently administered haphazardly. Some classes are evaluated, others are not; some classes receive survey instruments back from virtually all students, others from only a small sample. The forms used are generally generic and difficult to tailor to the learning goals of each class. A comprehensive effort of class assessment will address all the shortcomings of our current system.**

    b. ***Encouraging a feedback cycle between students and faculty throughout the term, as frequently as each class meeting, when appropriate.*** **Some faculty members have begun measuring what students know when they begin a class and then use simple techniques, such as "muddy cards," to ensure that teaching stays on course.[7] Others have begun using "formative**

7
A "muddy card" is a brief comment written by each student at the end of class specifying the "muddiest" part of the lecture, or asking a residual question. An important part of this instrument is that these points must be subsequently answered by the teacher.

assessment" through midterm class questionnaires that are used to assess whether students are learning the material as expected and to make midcourse teaching corrections, as appropriate. A comprehensive assessment program will diffuse these techniques throughout the entire faculty.

c. ***Assessing the curriculum as well as the teaching.*** **Evaluating the effectiveness of a given lecturer is important; but if we are to understand the effectiveness of the underlying curriculum, we must appraise it, as well. A more comprehensive system of classroom assessment will naturally assist more frequent evaluations of the learning goals associated with an entire curriculum.**

3. ***Working to improve connections among and within MIT classes.*** As is true at all large research universities, the natural tendency at MIT is to treat each subject as a "tub on its own bottom." However, as previously noted, there are important exceptions to this observation at MIT, particularly among the large first-year science lectures. Efforts to coordinate between classes have a positive effect on empowering students to accumulate strands of knowledge so that they can be used to tackle complex intellectual puzzles on their own. As we have also noted, drawing together these relationships and fostering cooperation among faculty members teaching complementary subjects does not happen automatically – it must be nurtured.

   In addition to greater coordination between classes and instructors, the faculty must articulate more explicitly the content of MIT's general education. Everyone associated with GIR subjects – from instructors to members of the Dean's Office who help to train advisors – should embrace every opportunity to express the general goals of the GIRs, to articulate their relationships with each other, and to express how the goals of the GIRs relate to later professional preparation. Instructors of GIR subjects should give extra attention to the creation of a sense of community among the teaching staff. Instructors should be expected to clearly state each subject's learning objective, which is a separate exercise from articulating the topics covered by a subject. Departments, Schools, and the Dean for Undergraduate Education should encourage the types of cooperation previously discussed that connect the content and goals of a subject with those of other subjects in the students' past, present, and future at MIT.

4. ***Better documenting the teaching experiments that are conducted at MIT and disseminating good practices.*** Eight years ago, the Task Force on Student Life and Learning addressed this point and wrote the following:

> [I]nformation about educational experiments and teaching innovation is not adequately disseminated Institute-wide. In our discussions about educational innovation with faculty throughout the Institute, we found that many exciting experiments were taking place, . . . However, very few of these are being assessed, recorded, and communicated to other faculty. There is a need to create and support an environment of sharing and analysis of educational innovation.[8]

Fortunately, the requirements of granting agencies and the good offices of the Teaching and Learning Laboratory (TLL) have put us in a better position than when these words were written. Still, many at MIT are unaware of the breadth and imaginativeness of teaching innovations undertaken right here. We believe that increased awareness will stimulate wider adoption of new and effective pedagogical techniques, and also will increase the impact of this work more broadly across the higher education establishment. In their disciplinary research, MIT faculty members routinely publish their results, and are persuaded by the published results of others. It should be so in educational research at MIT, as well.

Having made strides over the past decade to better document our educational experiments and disseminate "successes," we believe that a series of next steps are necessary to make MIT more widely known for its educational innovation and to broaden the culture of excellence in educational practice. These strategies include the following:

a. **compiling reports and assessments of pedagogical innovations and making them more visibly available to MIT faculty members;**

b. **offering assistance to "next adopters" of teaching innovations, after initial experiments have proven successful and appropriate for greater dissemination across the faculty; and**

c. **earmarking new resources for teaching improvements and rewards for success.**

8
Task Force on Student Life and Learning, p. 24.

5. ***Enhancing the role of the Teaching and Learning Laboratory.*** One important development over the past decade has been the creation of the Teaching and Learning Laboratory, which was founded in 1997 as part of the Office of the Dean for Undergraduate Education. Its charter states that its goals:

> "…are to strengthen the quality of instruction at the Institute; better understand the process of learning in science and engineering; conduct research that has immediate applications both inside and outside the classroom; serve as a clearinghouse to disseminate information on efforts in science and engineering education nationally and internationally; and aid in the creation of new and innovative educational curricula, pedagogical methods, technologies, and methods of assessment."[9]

The TLL has served an important role in raising the awareness among the faculty about best practices in teaching. Frequently, the TLL has worked effectively in conjunction with departments and individual faculty to promote and refine educational innovations, such as those we have mentioned in this report.

Because the analogues of the TLL at peer institutions tend to be larger and to have broader charters than the TLL, its reach has not been extended throughout the Institute nearly to the degree that it could be. The TLL has demonstrated the value of having a professional cadre of educational researchers at MIT who can form partnerships with faculty members to improve both individual classes and entire curricula. We support its expansion as a professional enterprise, while acknowledging that efforts such as those undertaken by the TLL are most effective when they complement initiatives and efforts that emerge from within individual departments. Currently, the TLL is at its capacity – it will need to grow in size if it is to contribute to even a fraction of the curriculum reforms we are proposing. Finally, TLL's charter focuses its efforts on science and engineering. However, half of the teaching in the common curriculum is in the humanities, arts, and social sciences, so its charter limits its interaction with this important element of our curriculum. We have not deliberated on whether it makes sense to expand the mission of the TLL *per se*, but we do note an asymmetry in resources devoted to applying professional teaching insights across our common curriculum. We recommend that the Dean for Undergraduate Education work with the faculties in the humanities, arts, and social sciences, along with the relevant School Deans, to develop a plan that addresses this imbalance.

9
Teaching and Learning Laboratory website, http://web.mit.edu/tll/. (September 20, 2006).

Recognizing faculty-wide the need for professional excellence in assessing learning and disseminating best practices is one of the most important actions the Institute can take. Such recognition not only will include the role of the TLL, but also will encourage and foster the many ongoing efforts within individual departments and by individual faculty to assess pedagogical innovations and disseminate new methods. Going the next step will ensure that the goals we seek are achieved and that the next decade will be as active in teaching innovation as the past decade. To ensure that curricular changes stay on course, this structural shift must go hand-in-hand with changes needed in the faculty governance system, which is discussed in the next section.

Faculty Governance

The changes we are recommending in this report will be successful only if we – as a unified faculty devoted to the highest expectations about the complete education of our undergraduates – embrace a governance structure which ensures that the educational goals of the revised GIRs continue to guide their implementation and evolution. Historically, MIT has indeed governed the GIRs centrally, although departments that teach the subjects in the GIRs clearly have much to say about the details of what is taught and how. We believe that in implementing the changes we are proposing, it will be more important than ever before to maintain an institutional perspective and governance of the educational commons.

Specifically, governance of the GIRs should be a shared responsibility of the Committee on the Undergraduate Program (CUP), representing the faculty as a whole; the Dean for Undergraduate Education; and the School Deans. The implementation and maintenance of recommended changes would likely work best if the Dean for Undergraduate Education, working directly with the CUP, led the effort. An existing model is the current oversight of the Communication Requirement, which delegates the ongoing oversight of the requirement to a Subcommittee on the Communication Requirement. This subcommittee is composed of a small cross-section of faculty members working with relevant members of the office of the Dean for Undergraduate Education who are responsible to the CUP and, through it, to the faculty.

The faculty committee structure also is expected to interact at different levels with this process, especially, as noted above, the Committee on the Undergraduate Program. Many have observed problems with the current faculty committee structure; therefore, the faculty might consider instituting some changes to make the structure and membership as effective as possible in a moment of curricular reform.

We also note that a relatively new practice has developed at the Institute to shield younger members of the faculty from activity in this committee structure. As we attempt to reflect changing currents in educational practice – and establish a new set of expectations at MIT that should become standard operating procedures for years to come – now is an especially important time to involve younger faculty members in educational innovation.

Finally, the large scope of the faculty committee system often creates redundancies, which, in turn, create jurisdictional friction over elements of the curriculum. We have no prescriptions for fine-tuning the current structure of the faculty committee system. However, we do believe that now is the time for faculty leaders to do so, in the interest of smoothly implementing curricular reforms.

Conclusion

Throughout this report, we have aimed to describe how our common curriculum could be altered to fit the changed realities of the new century, provide new opportunities to our students, and generalize a set of successful experiments to the entire student body. Changing the rules and conditions under which students pursue their education is an important way to help unlock opportunities that have been difficult to pursue in the past, but MIT must do more than that. The Institute must also:

- create a compelling narrative about the educational paths students will pursue;
- provide opportunities for the learning paths of MIT students to unfold in new and exciting ways;
- establish supportive environments that nurture the risk takers among us;

- supply the physical spaces for the exceptional minds and hands of the MIT community to meet;
- construct a nurturing environment in which students learn the difficult lessons about living fully in a diverse world; and
- design ways for the educational enterprise at MIT to be continually assessed and improved.

If our best dreams for our students are to be fulfilled, we must succeed in all these tasks.

Summary of Recommendations

General recommendations

1. ***The Committee on the Undergraduate Program and the Committee on Curricula should work to bring a plan to the faculty that will allow students who wish to pursue a double major at MIT to do so by simply completing the General Institute Requirements (GIRs) and the programs of the desired majors.***

2. ***The Committee on the Undergraduate Program should commission a study of MIT's academic calendar and recommend changes to the faculty that will help undergraduates better allocate their time during the semester and have greater time for reflection on and integration of what they have learned.*** Specific issues that should be addressed include the Drop Date, the absence of a true reading period prior to final exams, and formalizing meeting times between advisors and advisees during an extended pre-registration period.

First-year coherence and integrity

1. ***The Chancellor should convene a faculty committee to examine first-year orientation and ensure a more equal balance among student life, academics, and research.*** As part of this effort, consideration should be given to the impact of the new pre-orientation first-year programs and how they contribute to the important intellectual goals of first-year orientation.

2. ***The School Deans and the Dean for Undergraduate Education should undertake a consideration of the factors that will lead to an increased number of faculty members advising first-year students.*** Included in this study should be recommendations on ways to materially recognize the efforts of faculty members to advise first-year students.

3. ***The School Deans and the Dean for Undergraduate Education should enhance the support given to efforts to coordinate the content of classes that satisfy the GIRs as well as efforts to coordinate this class content with the needs of departmental programs.***

Upperclass advising

1. *The School Deans, along with the Dean for Undergraduate Education, should develop plans to ensure that the efforts made by faculty members to assist in the advising and mentoring of undergraduates are acknowledged in annual salary reviews and in promotion and tenure cases.*

Classroom resources and scheduling

1. *A committee should be appointed to conduct long-range planning of classroom space needs at MIT in light of current and future needs, make recommendations concerning maintenance and new construction, and exercise oversight of these actions, as appropriate.* This committee should give serious consideration to the possibility of constructing a dedicated Teaching and Learning Center, which has been discussed at MIT for many years.

2. *The Faculty Policy Committee should give consideration to how faculty interests about the oversight of classroom resources should be explicitly lodged with a standing committee of the faculty.*

3. *The Registrar should work with the School Deans and the Committee on the Undergraduate Program to examine current class scheduling practices and recommend reforms to more efficiently utilize the classroom space that currently exists and allow for more flexible choice of GIR subjects in the first and sophomore years.*

Diversity

1. *MIT should continue to state clearly the paramount importance of maintaining a diverse student body from the perspective of its educational mission and resist efforts imposed from the outside to diminish or dilute those efforts.*

2. *All new subjects that are created in response to our curricular reform should address directly the relationship between the subject design and the diversity goals of the Institute.*

3. *Macro-level assessment of our curriculum should pay explicit attention to the dimensions of each student's experience that constitute meaningful interactions among diverse groups of students and with issues that bear upon diversity.*

4. *The Office of Minority Education should work jointly with the Teaching and Learning Lab to develop and maintain a database of resources, case studies, and other reference materials that faculty members may access when developing new or modifying existing classes.*

5. *The Committee on the Undergraduate Program should work with the Dean for Undergraduate Education to develop a faculty-led strategy to monitor the contribution of curricular reform efforts in fostering greater comfort on campus among minority group students, and in more generally addressing diversity issues.* The CUP should make an annual report to the faculty on the status of issues related to formal and informal interactions on campus that affect diversity.

Resources for educational innovation, renewal, and assessment

1. *MIT should strive to make the improvement of undergraduate education a high priority and support efforts to continue raising the professional standards of these efforts at the Institute.* Among these efforts are expanding programs of teaching improvement at MIT, expecting each department to develop a training program for its teaching assistants, enhancing the capacity to assess the curriculum and classroom teaching and learning, and documenting and disseminating best practices developed at MIT.

2. *The Dean for Undergraduate Education should work with the School Deans and the departments to consider ways to further cooperation between the Teaching and Learning Laboratory and individual departments.* An important question to be considered is how broadly distributed MIT's capability to assess curriculum reform and disseminate the results should be, particularly how to extend these capabilities across the entire common curriculum.

Faculty governance

1. *The Faculty Policy Committee should undertake a study of the faculty governance system at MIT to ensure that the structure of faculty governance is fine-tuned to help implement the reforms that flow from this report.*

APPENDIX

Individuals and Groups Who Met with the Task Force and Served on Task Force Working Groups

Faculty members and teaching staff who met with the Task Force

Professor Harold Abelson, *Electrical Engineering and Computer Science*
Professor John Belcher, *Physics*
Dr. Michael Bove, *Media Laboratory*
Dr. Lori Breslow, *Teaching and Learning Laboratory and Sloan School*
Professor Sylvia Ceyer, *Chemistry*
Professor Phillip Clay, Chancellor; *Urban Studies and Planning*
Professor Edward Crawley, *Aeronautics and Astronautics; Engineering Systems*
Professor Martin Culpepper, *Mechanical Engineering*
Professor Rick Danheiser, *Chemistry*
Professor Peter Donaldson, *Literature*
Professor Suzanne Flynn, *Linguistics*
Ms. Carrie Moore, *Physical Education*
Professor Emeritus Paul Penfield, *Electrical Engineering and Computer Science*
Professor Robert Rose, *Materials Science and Engineering*
Professor Candace Royer, *Department of Athletics, Physical Education, and Recreation*
Professor Donald Sadoway, *Materials Science and Engineering*
Professor Alex Slocum, *Mechanical Engineering*
Professor Karen Willcox, *Aeronautics and Astronautics*
Professor Dick Yue, *Mechanical Engineering*

Staff members who met with the Task Force

Ms. Mary Callahan, *Registrar*
Mr. Gregory Harris, *Office of the Provost*
Ms. Marilee Jones, *Dean of Admissions*
Dr. Barbara Masi, *Office of the Dean of Engineering*
Mr. Karl Reid, *Office of Minority Education*
Ms. Lydia Snover, *Office of the Provost*

Members of the MIT faculty who served on Task Force working groups

Professor Peter Perdue, *History*
Professor Shankar Raman, *Literature*
Professor Warren Seering, *Mechanical Engineering*
Professor Merritt Roe Smith, *Science, Technology, and Society*
Professor Janet Sonenberg, *Music and Theater Arts*

Members of the HOC+

Professor John Carroll, *Sloan School of Management*
Dr. Bette Davis, *Humanities, Arts, and Social Sciences Education Office*
Professor Deborah Fitzgerald (chair), *Science, Technology, and Society*
Professor Suzanne Flynn, *Linguistics*
Professor Danny Fox, *Linguistics*
Professor Jonathan Gruber, *Economics*
Professor Caspar Hare, *Philosophy*
Professor Stefan Helmreich, *Anthropology*
Professor Diana Henderson, *Literature*
Professor Meg Jacobs, *History*
Mr. Samuel Kesner, *Class of 2006*
Ms. Cynthia Lin, *Class of 2007*
Professor James Paradis, *Writing and Humanistic Studies*
Professor Nasser Rabbat, *Architecture*
Professor Shankar Raman, *Literature*
Professor Jonathan Rodden, *Political Science*
Professor Janet Sonenberg, *Music and Theater Arts*
Professor Charles Stewart III, *Political Science*
Professor Emma Teng, *Foreign Languages and Literatures*

Members of the Task Force Student Advisory Committee

Mr. Kevin McComber, *Class of 2005, Chair*
Ms. Sherry Xia, *Class of 2007, Vice Chair*
Mr. Thomas Coffee, *Class of 2005*
Mr. Jacob Faber, *Class of 2004*
Ms. Elizabeth Greenwood, *Class of 2005*
Ms. Jessica Rhee, *Class of 2006*
Mr. Christopher Suarez, *Class of 2006*
Mr. John Velasco, *Class of 2005*
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