Preliminary Findings and Recommendations of the Educational Design Project
August 1999

Summary

After wide-ranging conversations with the MIT community, the Educational Design Project – a task-oriented subcommittee of the Committee on the Undergraduate Program – recommends a concerted effort to reinvigorate the MIT freshman program. This effort should be organized around the following principles:

- Every freshman should have a serious 'hands-on' learning experience.
- The academic rigor of the current freshman program (as embodied in the General Institute Requirements) should be maintained, but improved methods for teaching these subjects in a more integrative way should be pursued.
- The faculty and administration should collaborate to develop, implement, and maintain a freshman program consisting of well-coordinated core subjects and integrative, project-based learning experiences.

Achieving these results will require MIT to develop an institutional strategy for the freshman year and to establish a well-defined set of goals for the freshman experience. We envision a first-year program with subjects that emphasize inquiry-based learning, that give students a better understanding of the relationships among concepts introduced in the freshman year, that better inform students about the broad sweep of educational opportunities offered throughout the Institute, and – most importantly – that establish an enthusiasm for learning which persists throughout the undergraduate program. After discussing many ways to implement this vision, we encourage the Institute to conduct several curricular experiments in order to better inform a final design. These experiments include: pilot offerings of 'mini-courses' specially geared toward providing brief introductions to engineering practice; a pilot offering of a project-based subject designed to showcase the value of interdisciplinary collaboration in solving complex problems; and a pilot offering of laboratory-practice subjects focussing on problems in specific disciplines.

Introduction

In its far-ranging report on the undergraduate experience at MIT(1), the Presidential Task Force on Student Life and Learning recognized that the Institute must stand ready to adapt its educational programs – even its educational principles, if necessary – to maintain its leadership role among the world's universities as we approach the next millennium. By any reasonable measure, we provide our students with an education of very high quality, but an increasingly competitive atmosphere among top-rank institutions of higher education demands that we continually ask the question: 'Can we do better?'

Each academic department at MIT undertakes regular reviews of its directed educational programs for majors (and minors, in many cases), but comprehensive reviews of the general educational programs pursued by all students, regardless of major, are infrequent. This is an unfortunate state of affairs because these programs – which we refer to here as the 'educational commons' – include what is arguably the single most critical aspect of an MIT education: the freshman curriculum. In the first few months of life at MIT, students begin to develop the study skills and intellectual perspectives that will determine their course through MIT. The freshman year is the foundation upon which a MIT education is built. Regular inspection and maintenance of that foundation must be a top priority for the Institute.

For some time, there has been a sense among many faculty and students that the freshman educational experience at MIT is not as good as it might be. The Presidential Task Force described it as follows:

> One problem with the current undergraduate curriculum is the perceived lack of enthusiasm and excitement in the first-year program. Many students who come to MIT with exciting goals and ambitions rapidly become disillusioned about the education they receive here. There are undoubtedly multiple explanations for first-year cynicism. For some, MIT represents the first exposure to hard work. For others, the steady flow of problem sets presents a stark contrast to their expectations of working on interesting projects and to the dreams they came to MIT to fulfill. The large lecture format of many subjects, combined with the small amount of interaction between freshmen and faculty, means that many students have few opportunities to overcome the initial perception that MIT is about drudgery and requirements rather than the thrill of discovery and progress. Finally, many have complained that some of the material in the freshman core is

> presented in a dry and uninteresting way. Increasing the level of excitement in the first-year program should be a priority in the design of the undergraduate program(1).

In recognition of this problem, the faculty (through the Committee on the Undergraduate Program, or *CUP*) and the administration (through the Office of the Dean of Students and Undergraduate Education, or *ODSUE*) have established a committee of faculty to review the current educational commons, particularly the freshman educational program, and make recommendations about how it might be redesigned to be more effective. This document represents a first report of the committee, which has come to be known as the Educational Design Project (or *EDP*). In it, we describe our preliminary findings regarding the freshman educational program and make specific recommendations for procedures that will lead to an improved freshman experience.

History of the Educational Design Project

The EDP was established formally as a subcommittee of the CUP in late Fall of 1998. Co-chaired by Professor Stephen Benton of the Program in Media Arts & Sciences and Professor Kip Hodges of Earth, Atmospheric, and Planetary Sciences (then Dean for Undergraduate Curriculum), the EDP was asked to explore further the 'problem' of the first year, to investigate models for improving the freshman-year educational commons, and to suggest pilot initiatives that may lead to concrete improvements in the freshman-year experience. The original charge to the committee is reproduced in Appendix I.

The Educational Design Project held its first meeting on October 23, 1998, and, with a few exceptions, met biweekly through the end of May 1999. Largely as a consequence of such intense activity, the membership of the committee has been changing throughout the history of the project. However, the EDP has consistently had faculty representation from all schools, usually augmented by student representation. Membership on the committee as of the time of submission of this report may be found in Appendix II.

Committee Activities – Isolating the Problem

Recognizing that the 'problem' of the freshman year would require better articulation before a viable solution could be found, the EDP spend much of the past

academic year trying to distill the sense of the Institute community on this issue. We collected information in five ways.

Alumni-Student Focus Group Meetings

In order to capture the perspectives of MIT alumni and current students, both undergraduate and graduate, we invited representatives from all three groups to a series of evening brainstorming sessions between November 12 and December 18. We asked them to ruminate upon what was right and what was wrong with the MIT freshman experience from both modern and historical perspectives. The alumni representatives, chosen with the assistance of the Alumni Office, were particularly helpful in defining valuable workplace competencies that are – or should be – nurtured early in the undergraduate experience at MIT. The students were remarkably candid in their assessments of the MIT freshman year.

Each of the four sessions had a specific theme: 'Attributes of a Well-Educated Person', 'Inquiry-Based Learning'#, 'Strengths and Weaknesses of the Current System', and 'Alumni Advising and Mentoring'. A session consisted of two parts. The first permitted students and alumni to discuss the theme separately for an hour with the help of a facilitator. Both groups were brought together for the second part of the session, during which the ideas of both groups were compared and contrasted. While the alumni and students placed different emphases on specific aspects of the freshman year, there was remarkable coherence between the student and alumni lists of what should and should not be modified in the freshman curriculum. Ultimately, the participants were encouraged to produce a list of specific ideas for improvements to the current freshman year experience consistent with the theme of the session.

Departmental Meetings

The EDP's principal approach to gathering faculty perspectives on the freshman year has been to hold discussion meetings with departments across the Institute. Representative members of the EDP met either with small groups of faculty from a single department or attended departmental faculty meetings. As of May, 1999, the following departments have had meetings with the Educational

'Inquiry-based learning' is code for 'learning by doing'. In some exercises, students are asked to observe natural phenomena, to propose explanatory hypotheses, and to test those hypotheses through experimentation. In others, they are asked to propose solutions to a problem and evaluate them systematically until they arrive at an optimal solution. The activities of the EDP are a form of inquiry-based learning.

Design Project sub-committee: Civil and Environmental Engineering, Mechanical Engineering, Material Science and Engineering, Architecture, Chemistry, Electrical Engineering and Computer Science (two meetings), Physics, Brain and Cognitive Sciences, Chemical Engineering, Economics, Aeronautics and Astronautics, Political Science, and Mathematics. At each meeting, we asked attendees whether or not they agreed or disagreed with the passage from the Final Report of the Presidential Task Force that is reproduced above, and we asked for ideas about how the freshman experience might be improved.

Freshman Advisor Meetings

In collaboration with ODSUE, the CUP subcommittee on freshman advising sponsored a series of dinners over the 1998-1999 academic year honoring faculty and staff who volunteer their services as freshman advisors. The EDP took advantage of these events to explore the advisors' perspectives regarding the freshman-year experience. The discussions ranged over a wide variety of topics, but some of the most valuable input (from the perspective of the EDP) related to how the current freshman-year curriculum relates to freshman attitudes toward academics.

Freshman Lecturer Meetings

The Office of Academic Services in ODSUE sponsors meetings each semester among the lecturers for Science Core subjects to facilitate the free exchange of thoughts about how the subjects are going and to encourage better interdepartmental communication. As Dean for Undergraduate Curriculum, Hodges took these opportunities to explore the perspectives of the Science Core lecturers on the freshman experience. These meetings provided important insights into trends in enrollment and student performance in the Science Core subjects.

Meetings with Academic Services Staff

The staff who work in the Academic Services Office, especially those attached to the Academic Resource Center and actively involved in freshman advising, freshman orientation, and UROP, have unique perspectives on the freshman year. We have tried to capture their ideas through one formal meeting with the staff in the Fall of 1998 and through numerous informal discussions.

Findings: Positives, Negatives, and Opportunities for Improvement

As might be expected, these activities produced a broad spectrum of opinion regarding the freshman year. There are those in our community – faculty, students, and alumni – who feel that our freshman programs function well as presently constituted and provide an appropriate foundation for more advanced studies. And there are those in each of the three constituencies who consider our freshman programs to be fatally flawed, and in need of complete reconstruction. We have found that both of these extremes represent minority opinions. Rather than review the entire range of opinion, we report here the persistent themes that characterized our meetings with the MIT community in the hope that they reflect a broad consensus.

The Virtue of Educational Breadth

The MIT community remains committed to what was articulated as 'Principle 6' in the Final Report of the Presidential Task Force on Student Life and Learning: the value of fundamentals. We heard no sustained arguments in favor of reducing the broad educational sweep of the current Science Core and HASS requirements and moving toward a more narrowly focussed curriculum. At the same time, both students and faculty expressed an enthusiasm for more expanded freshman-targeted offerings that might enhance the current curriculum by providing exposure to fields with no current representation in the freshman year. These might include, for example, subjects dealing with basic engineering practice.

The Importance of Rigor

Students and faculty alike value the intellectual discipline of MIT and want no changes that might 'dumb-down' the freshman year. Most of our freshmen chose to attend MIT because they wanted to be challenged academically and they expected to work hard as a consequence. We heard few complaints that freshman subjects are just too difficult.

The Limited Significance of 'Pace and Pressure'

Often the pursuit of rigor results in a pressured environment for learning, and 'too much pace and pressure' has been a persistent mantra for those in our community who are most critical of the freshman year experience at MIT. In fact, we heard very few complaints from students about pace and pressure *per se*. Based on our investigations, we suspect that much of the purported 'freshman overload' can be attributed to three phenomena:

- *Poor study skills.* Many MIT faculty – especially those involved with freshman advising – believe that a surprisingly large number of our freshmen are slow to develop good study skills. Ultimately this leads to an inefficiency of learning that manifests itself as pressure.

- *Weak coordination among Science Core subject assignments.* Although the syllabi of all Science Core subjects are distributed among the core lecturers each semester, there has been no systematic effort to ensure that the workload of a typical freshman is

distributed evenly across the semester. This has led to brief, highly stressful periods of intense academic activity, separated by relatively low-demand intervals.

- *Curriculum creep.* In a typical year, roughly 80% of the freshman class enters MIT with academic credit equivalent to at least one subject in the Science Core through advanced placement or the application of transfer credits. In principle, most of our students could take fewer subjects during the freshman year and still be on track for graduation in four years. Instead they choose to fill their schedule – especially in the second semester – by registering for more advanced General Institute Requirements that are traditionally considered to be upperclass subjects. Alternatively, they take particularly strenuous subjects in their chosen majors while they are still eligible for pass-no record (P/NR) status. The effect is 'curriculum creep': sophomore-level subjects are take in the freshman year, junior-level subjects in the sophomore year, and senior-level subjects in the junior year. Students then take abnormally light loads in the senior year, or they use the extra time to pursue multiple majors and/or minors, or they get a head start on graduate studies (e.g., the Masters of Engineering program in Course VI).

The Importance of Educational Variety

While students embrace the MIT ethos of hard work, they question the notion that the only effective route to rigorous learning requires bushwhacking through a thicket of problem sets. They are not alone in that opinion. There is strong sentiment among the MIT faculty and alumni communities that the first-semester freshman curriculum quickly becomes a continuing grind through problem sets, with little opportunity to reflect upon content. Buoyed by literally dozens of educational research reports that show the improved efficacy of 'inquiry-based' methods of teaching, the recent Boyer Commission report on undergraduate education in research universities (2) was especially critical of the 'lecture-problem set-quiz' model that is employed in many MIT freshman subjects:

> The inquiry-based learning urged in this report requires a profound change in the way undergraduate teaching is structured. The traditional lecturing and note-taking, certified by periodic examinations, was created for a time when books were scarce and costly; lecturing to large audiences of students was an efficient means of creating several compendia of learning where only

> one existed before. The delivery system persisted into the present largely because it was familiar, easy, and required no imagination. But education by inquiry demands collaborative effort; traditional lecturing should not be the dominant mode of instruction in a research university.
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> The experience of most undergraduates at most research universities is that of receiving what is served out to them. In one course after another they listen, transcribe, absorb, and repeat, essentially as undergraduates have done for centuries. The ideal embodied in this report would turn the prevailing undergraduate culture of receivers into a culture of inquirers, a culture in which faculty, graduate students, and undergraduates share an adventure of discovery.

Our committee found that many MIT faculty understand and appreciate the value of inquiry-based or 'project-based' learning, but most are not prepared to abandon traditional methods entirely. One could argue that the disciplined approach of the 'lecture-problem set-quiz' model is an appropriate pedagogy for building an educational foundation in the freshman year, and that inquiry-based learning is best left to the sophomore through junior years. It is certainly true that project-based learning is a fundamental part of the upperclass experience for most of our undergraduates. Moreover, the teaching effectiveness of some of our lecturers – whose delivery can almost be described as performance art – is legendary. If there is a consensus opinion among the MIT community on teaching style, it is that effective educational programs must incorporate a variety of styles tailored to the unique requirements of each subject.

The Value of Coherence and Integration

Students and alumni, in particular, lament the lack of academic coherence in the freshman year. A seldom-articulated aspect of 'Principle 6' in the Task Force Final Report is the notion that literacy in science and technology requires appreciation of the deep interrelationships among fundamental concepts in various disciplines. Quite logically, our physics instructors are expected to teach physics, our chemistry instructors are expected to teach chemistry, and so on. But our faculty too often presume that the students will know instinctively how to put disparate concepts together to build a durable mastery of scientific principles. Moreover, our students enter the freshman year without a clear understanding of what the freshman curriculum has to do with the rest of their education, and they often leave the freshman year just as uninformed. Under such circumstances, it's little wonder that some students feel that 'MIT is about drudgery and requirements', as the Task Force put it. By not

sufficiently emphasizing the long-term relevance of the freshman curriculum, we create an environment that encourages superficial learning of the fundamentals. The effect, as noted by many faculty in our meetings, is that many students reach the sophomore year with a 'brittle' understanding of concepts covered by freshman-year subjects.

This particular problem with the MIT curriculum is nothing new. It was noted in the first half of this century, for example, by no less a luminary of the MIT community than Vannevar Bush:

> [Bush] attacked the reliance on fragmentary courses that students must pass "in rigid sequence". Students tended "to 'take courses' instead of studying subjects…. When the course is passed he forgets it as far as possible. Our system degenerates into a series of forgetting points." Bush bemoaned the failure of teachers to show students how to tackle a "comprehensive engineering problem in its entirety, drawing his tools from various sources," ranging across mathematics, physics, chemistry and even economics. Instead, students were usually taught by "a narrow specialist with an interest in the minutiae of a very limited field." As a result, "The student is hounded," Bush insisted. "His hours are crowded and closely scheduled; he has little time for reading and reflection, and he does little such. All but the exceptional students become automatons." (3)

Bush's call for more cross-disciplinary educational integration was echoed a half-century later by the Boyer Commission, who went on to articulate the structural problems that might be responsible:

> In the earlier decades of the century, research was characteristically confined within traditional boundaries of disciplines that had themselves been defined only a few generations earlier…. But in the years since World War II the continuing appearance of new departments and new programs that merge fields has proven repeatedly the permeability of the lines between disciplines. Individual researchers find that pushing the limits of their field takes them into new territories and that the work they are doing may have much more in common with that of colleagues across the campus than with members of their own departments.
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> The principal barrier to interdisciplinary research and study has been the pattern of university organization that creates vested interests in traditionally defined departments. Administratively, all educational activity needs to "belong" somewhere in order to be accounted for and supported; that which has no home cannot exist. Courses must be offered under some kind of sponsorship; students are asked to place themselves in one discipline or another. The limitations

> on this kind of structure are recognized in every university by defining new departments, approving new programs, and creating new centers within which to house courses, often experimental, that do not fit into the disciplines. But those centers repeatedly must call on the departments to teach the courses, knowing that the departments may balk at doing so since the interdisciplinary programs deplete staffing for their own departmental courses.(2)

While it may be impractical to expect the Science Core, for example, to be taught in a fully integrative way, many in the MIT community believe that we should do more to establish better connections among our curricular offerings for freshmen.

The Need for More Excitement in the Freshman Year

The EDP found general agreement with the observation of the Task Force that our students enter the freshman year with great excitement and enthusiasm, but many become disenchanted in the first semester. Some of this is, undoubtedly, a natural consequence of the transition from learning in a high school environment to learning in a college environment. But the EDP spoke with many students, faculty, and alumni who believe that our current curriculum does not do enough to sustain student enthusiasm for learning, or to leverage upon their enthusiasm and sense of academic direction to achieve better educational results.

Differences Among Constituencies

Although we found general agreement on many issues regarding the freshman year, our meetings with student, faculty, and alumni representatives did reveal some differences of perspective. In particular, students want a freshman year that:

- Serves as a transitional period from high school to college in terms of both social and intellectual development;
- Encourages collaborative and not just 'competitive' learning;
- Provides more opportunity for self-motivated and self-directed learning;
- Nurtures critical-thinking skills and does not overemphasize the mere absorption of subject material transmitted through lectures;
- Forges a link between classroom learning and the research enterprise at MIT; and
- Prepares students to make a well-informed choice of major.

Alumni emphasize that the freshman year should:

- Encourage the development of good social skills and teamwork capabilities;
- Place more emphasis on intellectual creativity;

- Establish good communication skills;
- Nurture a sense of intellectual fearlessness and self-confidence; and
- Build a sense of citizenship and an appreciation of world affairs.

Faculty especially want:

- Students to learn quickly that satisfactory college-level work involves dedication and mental self-discipline;
- Students to be more engaged in the subject material;
- Students who want to be full partners in the learning process;
- A freshman curriculum that builds a robust foundation for more advanced learning, particularly in math and physics; and
- No modifications of the freshman curriculum that require excessive demands on faculty time.

A Call for Change

Our committee found general agreement that the freshman-year curriculum, as currently constituted, does not serve our freshmen as well as it should. Given anticipated changes in the educational needs of our students (as articulated in Section 3 of the Task Force Final Report) and an increasingly discerning clientele, we feel that the gap between what students expect and what we deliver in the first year is widening. Consequently, we urge the Institute to take a proactive approach to this problem and recommend the following first steps toward a better freshman program.

Recommendation 1: Develop and Publicize an Institutional Strategy for the Freshman Year

We believe that the freshman-year educational program should be viewed as having strategic importance for MIT because it largely defines the tenor of the remainder of the academic experience here. As a consequence, the Institute as a whole – and not just the departments and schools responsible for teaching freshman-level subjects – must develop a cohesive freshman program that can be adapted quickly to serve the rapidly evolving educational needs of our students. *This may require changes in the way we do business.* The 'department-centric' structure of MIT provides a good environment for undergraduate education once a student has decided on a major, but it leaves the planning of the freshman year to an unfocussed and inadequately conceptualized process. We are doubtful that the faculty will self-organize adequately to permit the development of a powerful freshman year program without prompting by the Senior Administration and a conspicuous display of leadership in this direction. We encourage the Senior Administration to make it clear that it will be a strategic priority of the Institute in the coming years to develop a carefully programmed freshman experience that will sustain and nurture the enthusiasm of the entering students in the face of extraordinary academic demands. In publicizing this initiative, they should be explicit that providing the resources for this 'revitalization' of the freshman year will be a priority of the upcoming fundraising campaign.

Recommendation 2: Define An Improved Freshman-Year Curriculum

The single most effective way to revitalize the first-year curriculum is to ensure that all freshmen participate in at least one substantive inquiry-based educational activity.

Exactly how best to accomplish this remains a matter of active debate in the EDP. Our research suggests that simply expanding the UROP program to involve more freshmen is an improbable solution because most faculty believe that most freshmen arrive at MIT without sufficient grounding in fundamental scientific concepts to be productive researchers in working laboratories. Another possibility would be to modify existing freshman-level GIRs by injecting significant components of inquiry-based learning. We hope that such modifications will occur naturally over time, as inquiry-based learning becomes better established as the educational paradigm, but we feel it would be a strategic error for MIT to simply wait for this to happen. Based on our deliberations thus far, it appears that the most expeditious course of action is to introduce one or more additional requirements to address educational gaps identified by students, faculty, and alumni. Our committee has discussed three different models for such additional requirements; they are briefly described in the next three recommendations. We believe that the CUP (and the Institute in general) should sanction and fund curricular experiments to explore their feasibility. None of these experiments should be undertaken until we have established (and found funding resources for) a formal assessment program.

We encourage the Institute to build on the work of our committee by empowering a task force to design an improved freshman year curriculum. There are at least two possible models for the proposed task force. One is to simply view it as the next evolutionary stage of the EDP, a group that includes representative members of the faculty and one or two students. After due deliberation and experimentation, this group could make specific recommendations to the CUP, which would then – in collaboration with the Committee on Curriculum – bring a proposal for a redesigned freshman program to the full faculty for a vote. The problem with this model is that the entire process hinges on acceptance by the full faculty of a detailed freshman program, and we believe that there would be great potential for derailment by technicalities.

Another model is to first charge the EDP with developing a set of guidelines for freshman curricular design that would be fine-tuned by various faculty committees and, ultimately, go on to a vote before the full faculty. Such guidelines might be viewed as the list of core competencies and academic credentials that we expect students to have before entering the sophomore year. In this case, the faculty vote would be to accept or

reject a set of principles rather than a specific set or sequence of subjects. It would then fall to the task force – which might include designated faculty representatives of all schools and *should* include students – to act with power in redesigning a freshman program that would adhere to principles adopted by the full faculty. This model is not unlike the Institute's approach to the development of specific subjects in the General Institute Requirements. For example, our faculty mandates that all students take two subjects in Physics, but it is left to the Physics department to design the content of these subjects and to implement them. By analogy, the faculty might mandate that all students engage in some independent research as part of their freshman program, but it would be up to the task force to decide how that principle would be implemented. Presuming that this second model is the better choice of the two, recommendations 3 through 5 below are designed to provide the task force with the background information needed for selecting the best implementation strategy.

Recommendation 3: Sanction Experimental Freshman 'Mini-Courses'

While most of the engineering curriculum is inaccessible to freshmen who lack prerequisites, many engineering concepts can be introduced to students with limited backgrounds. Providing an early opportunity for new students to explore engineering fields would encourage more informed choices of majors. We envision a variety of half-semester, six-unit subjects without prerequisites that are specifically designed for freshmen. We propose them as 'mini-courses' of limited duration so that students can "mix and match" to explore interests that might lead to major choices, and so that students can adjust their load depending on the demands of other subjects. While these subjects ought to be creatively linked with the evolution of the Freshman Advising Seminars, their spirit and style is intended to be very different. Although the first-module instructor may very well be the student's advisor, the advising process would be more in the traditional "cluster" mode. In the spirit of the Task Force's call to develop better integration of student life and learning, this part of the curriculum could be residence-based in those cases where special facilities are not needed.

Recommendation 4: Sanction An Experimental 'Freshman Mission'

Project-based learning, a model that has been very successful in departmental major programs at MIT, should be a fundamental part of a revitalized freshman

curriculum. An experiment that might demonstrate the viability of one implementation strategy is ‘Mission 2003’.

The Concept

Mission XXXX (where ‘XXXX’ stands for the graduation year of the freshman class) would be a new 12-unit, required freshman subject designed to review and reinforce concepts from the Science Core and the humanities, to require the creative integration of those concepts to address complex problems, and to encourage students to collaborate on finding solutions to those problems. Mission 2003 could be a pilot version designed to explore the feasibility of such a class. At its first meeting, students would be given a vague but intellectually challenging mission: to design a program to determine whether or not life has existed on Mars. Their goal for the semester would be to develop a Mission 2003 web site to articulate fully their proposed program. For the remainder of the first class, the students would brainstorm to decide on how the problem might be broken down into ten distinct tasks (raising funds for the mission, designing a biological “test” for signs of current or past life, designing a delivery vehicle for the test apparatus, etc.). Each of these tasks will be assigned to a 5-person working group, and these groups will coordinate their efforts to create the final web site.

Structure and Staffing

The pilot would accommodate 50 second-semester freshmen, preferably having sufficient credits to qualify for sophomore standing so that taking an additional subject would not slow them down in their progression through the standard curriculum. The subject would be lead by an educational team consisting of two faculty supervisors (or a faculty supervisor and a graduate assistant), a technology coordinator, and ten upperclass mentors. The faculty would bear the responsibility of establishing the overall structure of the subject and of modifying that structure during the semester as necessary. The technology coordinator would ensure the development of a web-based communication infrastructure for the subject. The upperclass mentors would be responsible for facilitating team development as the semester progressed.

Classroom Requirements

The subject would meet formally for three hours each week. The Monday meeting will be devoted to lectures by the faculty and other guests on subjects pertinent to the mission. Preferably, these meetings would take place in a lecture hall with excellent

audiovisual capabilities. The Wednesday meeting would be run by each team in turn for weeks 2-11. Each team would present their plan for carrying out their task and the faculty would lead a whole-group discussion during which other teams would give the "team-of-the-week" advice and offer any suggestions they may have to improve their effectiveness. The Friday slot would be a specified time for breakout meetings of the teams and would require 10 classrooms or (preferably) casual meeting spaces for ~6-8 people.

Grading

Grading would be based on team performance (on the Wednesday presentations and the final web project) and on individual participation during discussions.

Recommendation 5: Sanction Trial Laboratory Subjects for Freshmen

A different way to incorporate project-based learning is to require each freshman to take one of a variety of more specialized laboratory subjects. We have referred to this model informally as the 'Freshman Project'.

The Concept

The central aim of the Freshman Project would be to incorporate inquiry-based learning in the first year, and to provide students with hands-on experience through laboratory subjects that include a strong experimental design component. In steady state, it might consist of 20-40 'Freshman Project Laboratory', subjects that are created and taught by a individual faculty members – or multi-disciplinary teams of faculty – with the help of advanced undergraduate teaching assistants. The students would work in teams to devise a solution to a problem defined by the faculty member (or members) leading the class. The project in each subject would involve an experimental or design component, broadly defined. In fact, it is not appropriate to be too rigid about the form and content of the proposed new courses since they will span a variety of disciplines including experimental science, engineering design, social science studies, etc. There should be, however, a set of principles and guidelines formulated by what we might think of as a 'Freshman Project Steering Committee' drawn from the ranks of the faculty and charged with approving proposals for new laboratory subjects established to consider and approve proposals for these courses. The guiding principle could be

drawn directly from the description of the current undergraduate Laboratory Requirement as described in the MIT Bulletin. In these subjects

> the student plays a substantial role in planning the design of the experiment, selecting the measurement technique, and determining the procedure to be used for validation of the data…. The laboratory subjects….emphasize as much as possible work of project type rather than routine experimental exercises. The subjects are designed to stimulate the student's resourcefulness and ideas….

In order to accommodate the Freshman Project into our first-year program, we might substitute it for the current Laboratory Requirement and Freshman Advising Seminars. In this scenario, all first-year students would enroll in the Freshman Project for 3-6 units in the Fall semester. During this phase, faculty instructors would lay out the background to problems that ultimately would be addressed by the student projects. These subjects would be run much like the current Freshmen Advising Seminars. Students would choose three different sections and rotate through these sections during the fall; faculty would thus present their section to three different groups of 25-50 freshmen. At the end of the semester, students would choose which project they wished to enroll in for the spring, and a lottery system would be employed to ensure appropriate distribution of students among different Freshman Project Laboratory subjects. In the spring semester, students would enroll in the Freshman Project for 9-12 units, and this phase of the subject would focus on the design and execution of the project, with students working in teams of two to five members depending on the nature of each project.

Structure and Staffing

Unlike the Mission XXXX model described previously, the success of the Freshman Project depends on whether or not we can provide a uniformly beneficial educational experience with independent subjects that may have highly idiosyncratic structures. An effective evaluation of this model requires at least two – and ideally more – pilot subjects. Given that laboratory-based Freshman Advising Seminars have been very successful, we can predict that the first-semester, seminar-format offerings in the Freshman Project would be so as well, so we see no need to sanction pilots for them. We would focus our pilot study on prototypes of the 9- to 12-unit design and execution components. Each would accommodate 25 second-semester freshmen, again preferably

students having sufficient credits to qualify for sophomore standing. Inasmuch as the model can accommodate projects defined in the context of many different disciplines, we should consider sponsoring one pilot in each school. *At least*, we should sponsor one pilot in the School of Science and one in the School of Engineering. Each subject would require at least one faculty member, perhaps two working as a team. Each would require approximately five teaching assistants who would be drawn from the ranks of advanced undergraduate students.

For the purposes of experimentation, the pilot subjects could be taught in existing laboratory space, but the competing demands of research production and research education would require dedicated space for the Freshman Project in the steady state. Ideally, this would be in the form of a new building, or part of one. This facility would house laboratories, shops, classrooms, and the headquarters for the administrators of the Freshman Project. Most importantly, the Freshman Project Center would include a coffeehouse, cafeteria, social interaction areas, and the like, where first-year students, instructors, and teaching assistants could meet together informally. The Freshman Project Center might serve as a focal point for Freshman life and thus promote a sense of unity and community among the first-year class.

Grading

As envisioned in our meetings, the Freshman Project is a collaboration between instructors, teaching assistants, and students. In a sense, the faculty and their assistants are coaches more than instructors. To encourage the student participants toward this view, the evaluation and grading of projects would be the responsibility of one or more faculty other than those participating in the project. During the pilot program, instructors of one project subject might grade the results of another. In some cases it may be desirable to recruit scientists and engineers from industry to assist the evaluation teams.

Recommendation 6: Establish a Process of Routine Review and Maintenance of the General Institute Requirements

The General Institute Requirements should reflect the core academic competencies necessary for the lifelong success of our students. History shows that society changes more quickly than standard university curricula, so it should be taken as a challenge to develop a set of General Institute Requirements that can accommodate routine

restructuring on a 5–10-year cycle to ensure continuing relevance. Because well over half of the General Institute Requirements are fulfilled by students in the first year, this means that the freshman program must be highly adaptive. The development and maintenance of such a program will be very difficult without better communication and collaboration among key departments. One way to ensure that this develops is to establish an 'Office of the Freshman Year' within ODSUE and charge it with the coordination of the freshman educational program and the maintenance of academic performance data to support ongoing faculty evaluation of the program. An alternative is to invest a faculty committee with the exclusive responsibility for evaluation and to form a partnership between that committee and ODSUE to develop appropriate coordination strategies. We urge the Institute to explore such models and to implement the most promising as quickly as possible.

Recommendation 7: Make Educational Assessment an Institute Priority

As an institution, MIT has been negligent about evaluating the educational efficacy of its freshman programs. Other than traditional student evaluation forms – a notoriously unreliable device for assessment – we have almost no data to indicate objectively what works and does not work in our freshman curriculum. There has been considerable research in recent years regarding how best to evaluate educational programs, and there are now well-established methods that we could use to benchmark our current subjects and to evaluate curricular experiments. It is not so important, we feel, to ask questions like: "Is Professor So-and-So a good lecturer?" or "Were there too many problem sets?". Instead, we advocate that the design of each freshman subject begin with an articulation of the important concepts that students must grasp to achieve basic facility with the subject matter. Then, for each subject being assessed, students should be tested for their mastery of those concepts before and after taking the class in order to measure the 'effectiveness' of the subject. Under ideal circumstances, the students should be tested again on those concepts – perhaps in the sophomore year – to evaluate the durability of their learning.

Implementation of such strategies will require substantial effort and expertise that we do not have at present at MIT. Our peer institutions (e.g., Stanford) have established large programs in educational assessment, and it is time that we take appropriate steps

to develop a central institutional resource office for determining how successful we are at various kinds of education.

Final Suggestions and Cautionary Notes

As recommendations 3 through 5 imply, the EDP feels strongly that new educational experiences are necessary to provide our students with the best possible freshman program. We argue that there is time available for such experiences in the program if: 1) current trends in the awarding of AP and transfer credits are maintained; and 2) we can control curriculum creep (as defined earlier). There has been some suggestion among faculty recently that we should review our policies concerning AP credit and perhaps either limit the credit offered or offer none at all. While these suggestions reflect legitimate concerns, we believe that sweeping changes in our current AP policies might have a devastating effect on the freshman program. If, for example, we eliminated AP credit for freshman calculus today, the number of students that must be accommodated in 18.01 or one of its variants every fall *would more than double*. From the perspective of the EDP, such a move would eliminate any hope of injecting a meaningful component of inquiry-based learning into the first-year program without complete restructuring of one or more core subjects in the General Institute Requirements.

While some freshmen are capable of exemplary performance in subjects that are more advanced than those traditionally regarded as first-year subjects, most faculty believe that MIT students have a tendency to overextend themselves, especially in the second semester. The phenomenon of curriculum creep has serious negative consequences. Many students are overwhelmed by the extraordinary academic pressure brought about by these more advanced subjects and they either perform poorly in them or they neglect other subjects in order to cope. The culture among MIT students is such that 'success' – even if it means passing by the slimmest of margins – is preferable to the voluntary admission of failure that accompanies a choice to drop advanced subjects in the freshman year. Curriculum creep also encourages faculty who teach more advanced subjects to lower their expectations and adjust course content to meet the academic capacity of a less-advanced class. If they give in to such pressure, the effect is just the sort of 'dumbing-down' of the curriculum that the MIT community wants to avoid. Without discouraging those few, truly gifted freshmen who belong in

advanced classes, we should find a way to minimize the negative effects of curriculum creep. The most effective way to do this may be to change the pass-no record policy, but the best way to affect such a change remains unclear. Our committee discussed several possible implementation schemes without reaching consensus:

- Eliminating P/NR for the second semester of the freshman year;
- Assigning P/NR status to specific subjects that might be considered 'freshman-level';
- Assigning P/NR status only to the introductory subject in each department, regardless of the year in which it was taken; and
- Replacing second-semester P/NR with the opportunity to take one subject on P/NR during each of the junior through senior years, with some subjects removed as possibilities at the discretion of individual departments.

There has been much discussion among faculty about changing the current freshman P/NR policy, and numerous reasons have been cited as the motivation. These range from a sense that freshmen develop too cavalier an attitude toward the significance of grades to a sense that students overextend themselves by taking subjects that are too advanced simply because they are not 'on-grades'. A change could have a profoundly positive effect on enrollment patterns and provide students with more time in the freshman year for exploration. Assuming that changes are coming, it is our belief that the Institute's choice of implementation strategy should be made carefully and should be coordinated with the introduction of new freshman-level subjects that would provide viable alternatives to taking advanced subjects for grades during the freshman year.

References

1. R. J. Silbey, R. J. Hansman, *et al.*, "Final Report of the MIT Presidential Task Force on Student Life and Learning" http://web.mit.edu/committees/sll/tf.html (1998).
2. The Boyer Commission on Educating Undergraduates in the Research University, "Reinventing undergraduate education: A blueprint for America's research universities" http://notes.cc.sunysb.edu/Pres/boyer.nsf (1998).
3. G. P. Zachary, *Endless Frontier: Vannevar Bush, Engineer of the American Century* (The Free Press, New York, 1997).

Appendix I: Charge to the Educational Design Project Committee

The Committee on the Undergraduate Program – in partnership with the Dean for Undergraduate Curriculum – is undertaking an initiative to improve the educational experience of MIT undergraduate students. The subcommittee will focus primarily on the period of time before students have chosen their major. The responsibilities of this group will be to design a new common educational program through several stages:

1. *The identification of those aspects of the current common* educational program that support the vision outlined in the report of the Task Force on Student Life and Learning.

2. *The investigation of models for improving the common educational experience, including best practices at other universities.*

3. *The design of pilot initiatives -- with the input from various constituency groups -- that increase educational excitement and provide more opportunities for inquiry-based learning in the first and second years.*

4. *The preparation of a preliminary report to CUP outlining initial designs for one or more curricular experiments. Assuming that CUP endorses these experiments, they will be conducted in the 1999-2000 academic year, with the purpose of developing an experimental database to inform the final design of a new comprehensive program.*

5. *The oversight, evaluation, and assessment of these initiatives.*

6. *The preparation of a proposal for a final design in AY 2000-2001. If approved by the CUP, by other pertinent faculty committees, and ultimately by the faculty as a whole, this program would be implemented in AY 2001-2002.*

Throughout this process, the subcommittee will be expected to report to the CUP on a regular basis and to communicate with academic departments and individual faculty and students in the spirit of keeping our community informed of its progress.

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* The "common educational program" refers to more than just the General Institute Requirements. It also includes learning that takes place outside the classroom during the first two years.

Starting points for this initiative should include explicit and implicit recommendations harvested from the report of the Task Force on Student Life and Learning, feedback from a variety of constituency groups (including alumni and future employers as well as students and faculty), as well as survey data and work begun by the Committee on the First Year Program (CFYP).In addition, it is recommended that the subcommittee refer to the report from the Boyer Commission on "Educating Undergraduates in the Research University."

Many of the findings and recommendations of the Task Force relate to aspects of the undergraduate experience that are the responsibility of the CUP. The report recommends, for example, that the CUP "*adopt practices which encourage educational experimentation, such as in the creation of alternative GIR subjects and in the integration of educational technologies."* In its discussion of the first year experience, it mentions the "*perceived lack of enthusiasm and excitement in the first year program*" and urges that "*increasing the level of excitement in the first year program should be a priority."* The report discusses the importance of the undergraduate research experience in the education of all students and makes specific recommendations for freshman advisory research seminars as a way to introduce students to the variety of disciplines at MIT.

The Task Force report is critical of the current state of faculty governance in education at the Institute level, and comments on the relative strength of governance at the academic department level and the corresponding effects on collaborative activities between departments or Schools. *"The needs of the undergraduate program transcend departmental barriers,"* the report states. In discussions with Task Force members, the CUP has been urged to use its license to authorize educational experimentation in a pro-active (and, say some, audacious) way – instead of waiting for ideas to come from without or charging yet another review of the core requirements.

The CUP has thus concluded that its response to the recommendations of the Task Force (and to the perennial calls for a review of the General Institute Requirements) will be to forego the usual faculty committee review process and instead to charge a faculty design team to exercise their imagination and bring ideas for proposals to CUP for a new and enhanced common educational program. Ideally, these experiments will attempt to develop some of the competencies outlined in the Task Force report's

"*Attributes of an Educated Individual.*" In addition to the competencies cited in that report, students should be given the opportunity to experience major intellectual traditions of cultures and other related domains of inquiry other than those they have experienced or known.

In its charge to the Committee on the First Year Program, the CUP identified some broad issues that it hoped would be taken up by that group. These issues are still relevant and appropriate and should also be considered as this subcommittee moves forward:

- Housing all freshmen on campus: what educational opportunities present themselves?
- Excitement and curiosity: analytic approaches versus "gee whiz" experiences;
- Making use of new technologies in the general educational program;
- The role of engineering subjects or other exposure to engineering in the first year;
- The practicality of the current philosophy of exposing all students to a homogeneous, non-discipline related first year: should first-year students experience an academic program more closely related to their interests?
- Should there be a hands-on or laboratory experience available to all first year students? Should it be required?
- Is the current mix of Science Core subjects the right one? What other subjects might be candidates: statistics, economics, computation?
- With the increasing numbers of students bringing in AP credit, what opportunities exist for those students?
- Major selection: are there better ways for students to choose majors so that the great disparities in the sizes of departmental enrollments (and advising and teaching loads) are lessened?
- Should first year subjects be better integrated? Was there a benefit to the earlier "pairing" of recitation section classes and teachers?

- How can we better insure that all students will have experienced at least one strong and meaningful interaction with a faculty member by the end of the second year? What is the role of an advisor in this process?

We encourage the subcommittee to begin its work by identifying the core components of the first-year educational program and the commons as it extends into the second year. What is it we understand to be "good" about the current common educational experience, and where are there opportunities for improvement and change? The best ideas are likely to be ones that are scaleable; that is, capable of being generalized to the entire class as opposed to developed into another alternative program.

Resources have been identified in advance to support the work of this subcommittee. Thus, substantial but not unlimited resources will be available to underwrite proposals – at least insofar as resources would be needed to purchase equipment and underwrite teaching assistantships for small-scale pilot experiments.

The CUP will serve as the final forum for ideas and proposals from the subcommittee. It is hoped that the subcommittee will be able to report briefly upon its progress to the CUP each month throughout the academic year.

Appendix II: Committee Membership (1998-1999)

Professor Stephen Benton, co-chair (Media Arts and Sciences)

Professor Kip Hodges, co-chair (Earth, Atmospheric, and Planetary Sciences and Office of the Dean of Students and Undergraduate Education)

Professor Rick Danheiser (Chemistry)

Professor Jonathan Gruber (Economics)

Professor Steven Hall (Aeronautics and Astronautics)

Professor Daniel Kleppner (Physics)

Ms. Sarah L. McDougal, ‘00

Ms. Abigail Pelcyger, ‘01

Professor J. Kim Vandiver (Ocean Engineering)

Ms. Marsha Orent, staff (Office of Academic Services)

Professors Steven Eppinger (Sloan School of Management) and Robert Jaffe (Physics) were early members of the committee but asked to be relieved of duty because of other commitments.