The MIT Faculty Newsletter

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A New Proposed SB Degree in Chemical-Biological Engineering: Course XB

Karen K. Gleason

Background and Motivation

To complement our existing Course X and XC SB degree programs, the Department of Chemical Engineering proposes to offer a new SB Degree in Chemical-Biological Engineering: Course XB, starting with the '04 -'05 MIT Bulletin. After passing through a full series of departmental, school, and institute review stages, this proposal was presented at the Institute Faculty Meeting of October 15, 2003, and is scheduled to be voted on in the same forum on December 17, 2003.

The educational opportunity afforded by the new XB degree reflects the long standing recognition of the importance of biology as a fundamental science in biomedical and industrial applications by the Chemical Engineering Department at MIT. Rapid advances in molecular biology and the recent explosion in genomics research have created numerous opportunities for applications of biology in medicine and industries such as biotechnology, pharmaceuticals, fine chemicals, and materials. Growth of these professional opportunities brings to the forefront the importance of establishing new educational pathways for engineers that include biology as an enabling science.

Quantification and integration of biological systems have created numerous prospects for exciting research in biotechnological and medical applications, including biochemical reactor engineering, bioseparations, biocatalysis, metabolic engineering, gene therapy, biomaterials, cell and tissue engineering, drug delivery, drug design and discovery, functional genomics, and lab-on-a-chip devices. The pervasive intellectual

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TEACH TALK

Improving Student Understanding with TEAL

John W. Belcher

Introduction

Over the last three years, the MIT Physics Department has been introducing major changes in the way that 8.02, Electromagnetism I, is taught at the Institute, through the TEAL (Technology Enhanced Active Learning) Project [Supported by the d'Arbeloff Fund for Excellence in MIT Education, the MIT/Microsoft iCampus Alliance, the MIT School of Science, and NSF] (Belcher 2001). After being taught as a prototype twice, in fall 2001 and fall 2002, TEAL went to a large-scale implementation for the first time in spring 2003.

In the first two prototype years of the program, student reaction as judged by commentary in *The Tech* was generally positive (Chen 2001), but in spring 2003 the student reaction ranged from positive to mixed (Li 2003) to very negative (Agarwal 2003, LeBon 2003), with numerous questions raised about the format.

In this article, I address the educational efficacy of the TEAL format, using assessment results from TEAL fall 2001, TEAL spring 2003, and from a control group from spring 2002, when on-term 8.02 was taught in the traditional lecture/recitation format. This assessment strongly suggests that the learning gains in TEAL are significantly greater than those in the traditional lecture/recitation. This result is consistent with many other studies of introductory physics education over the last two decades. It is also consistent with the much lower failure rates for

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From The Faculty Chair

Preserving the MIT Community

Rafael L. Bras

Call me a romantic. What has kept me at MIT for so long is the sense of loyalty created by respect of my colleagues, awe at the quality of students, and gratefulness to the institution that makes it all possible. My feelings are not based on naiveté and certainly not on the belief that all is perfect at MIT. They are based on the humbling realization that despite my talents, my accomplishments are inexorably linked to the Institute.

What makes the Institute? I believe first is the commitment to truly being a university dedicated to generating new knowledge within the context of educating individuals. I emphasize the meaning of "university": entertaining intellectual diversity, bringing together and promoting a world of ideas within old and new disciplines. This is unquestionably a far cry from a narrowly defined institute of technology. Second, is the response that the Institute elicits from all of us. That response has elements of loyalty and dedication.

Will the MIT of the future have the characteristics I have described? There is no clear evidence to the contrary, but there are, in my opinion, disturbing cracks in the façade. Let me end with a few anecdotes, collected as I meet more and more colleagues.

More than once I have heard that the Institute is becoming too "corporate." Some believe that market forces are the only forces operating and we are losing our soul as an institution of higher learning.

Far too many times I have heard colleagues expressing unacceptable derision of other colleagues. Words like "those that we, after all, do not respect" are devastating to a healthy institution. Putdowns of whole fields, at the highest levels of decision-making, are equally common.

Finally, not long ago I heard, from a faculty member, words to the effect that after all "I am just renting space from MIT." This is coming from more than one faculty member who, in the eyes of some of us "lifers," were receiving the largesse of the Institute. This is disturbing; not the fault of the individuals, but a reflection of a change of character of the Institute that, if it were to continue, will undermine the reason why most of us are here.✥

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First Impressions

The Faculty Newsletter *recently invited new faculty members to share with us their initial impressions of the Institute. We will continue to publish these reflections throughout the year.*

Yasheng Huang
Associate Professor, Sloan School of Management

My first impression of MIT is how open this institution is. Many doors are unlocked and faculty can go into each other's office with ease. There are also other characteristics that are closely related to this culture of openness – lack of hierarchy, an informal style, etc. I am very impressed by and feel very comfortable with this environment. I believe that this kind of environment is conducive to honesty and creativity.

Another impression I have is that some of the buildings and classrooms are named after their – presumably – Chinese benefactors. This tells me a lot. These people must have enjoyed their experience at MIT to feel comfortable to donate a large amount of money. Many of the best educational institutions in North America have had a long tradition of drawing students from Asia but to actually succeed in cultivating a sense of belonging or loyalty from them is not easy. I may be completely wrong on this but it appears that MIT did a better job than others.✥

Mary L. Cummings
Assistant Professor, Aeronautics & Astronautics

Overwhelming, energizing, and intimidating: these were my first impressions coming to MIT from the idyllic Jeffersonian culture of the University of Virginia. Although a new PhD, I am not as young as many of my peers. Prior to life in academia, I was a Navy fighter pilot, and intimidated is not a state I find myself in very often. But in anxious times, I am reminded of Soren Kierkegaard who said, "To dare is to lose one's footing momentarily. To not dare is to lose oneself."

Perhaps my most lasting impression of MIT is the electric spirit of collaboration, which pervades almost every aspect of campus life. On my second day at MIT, I found myself lost in Central Square. I asked a passerby for orientation and he replied, pointing in the direction of Harvard, "That way is Harvard. That is where all the rich kids go to school." Then pointing in the opposite direction, he said, "That way is MIT. That is the center of the universe." I was comforted knowing I was headed in the right direction, both physically and professionally! It turned out this random passerby was the president of a local robotics company (and an MIT grad, of course!). Since I conduct research with humans and autonomous vehicles, our meeting was quite fortuitous and losing my footing literally has led to new research opportunities. In how many other places can just asking for directions result in new avenues of research?✥

A New Proposed SB Degree: Course XB

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impact of biology on chemical engineering is reflected in the activities and planning of major players in the chemical industry, such as Dow and Dupont, and of chemical engineering departments across the country.

Chemical Engineering at MIT has played a leading role in cellular and molecularly based biological engineering application. Approximately 35 years ago, Professor Emeritus Edward W. Merrill taught the first biomedical engineering class at MIT. Leaders on our faculty who have brought and continue to bring fundamental ideas from biology to bear on chemical engineering applications include Professors Clark K. Colton, Charles L. Cooney, William M. Deen, Robert S. Langer, Douglas A. Lauffenburger, Gregory Stephanopoulos, Daniel I.C. Wang, and Dane K. Wittrup. Only a few select highlights of achievements from this group follow. Professor Langer was awarded the 2002 Charles Stark Draper Prize, the highest honor conferred by the National Academy of Engineering for developing biocompatible polymer technologies that control the release of medicine over time. In 1985, Professors Wang, Cooney, and Gregory Stephanopoulos founded the NSF Engineering Research Center (ERC), the Biotechnology Process Engineering Center (BPEC), which is still operating today, making it the longest running ERC in NSF history. Chemical Engineering provided the largest number of engineering faculty, including the current director, Professor Lauffenburger, to the creation of the Biological Engineering Division. Biological ideas and applications have been incorporated into the teaching and research of an even larger group of our department's faculty.

Interest in biology is also significant and growing among the undergraduate chemical engineering students. In June 2002, 10 X/VII double majors were granted and 25 Course X students completed the Biomedical Engineering (BME) Minor. There are additional students who fall short of meeting the total number of units mandated for a double degree or encounter scheduling difficulties that do not permit them to complete all of the requirements for the BME minor. The new XB program would provide clear acknowledgement of the education students receive in both chemical engineering and biology within the units required for a single SB degree.

The structure of the Course XB degree parallels that of the traditional Course X program. In addition to the General Institute Requirements, both programs have three areas of emphasis:

1) Fundamental education in chemistry and biology delivered by faculty of these respective science departments;

2) Education in the triad of core chemical engineering sciences: thermodynamics, transport, and kinetics with an emphasis on quantitative methods of analysis;

3) Integration and synthesis of fundamental science and engineering science principles for solving engineering problems and understanding complex systems.

The overall number of required units and number of subjects for the Course X and XB degrees will be identical. In addition, the early requirements are similar, so that undergraduates should have the ability to switch between the X and XB programs after the sophomore year.

The following sections address each of these three segments of the curriculum in more detail.

Required Subjects in Chemistry and Biology

As can been seen in the table, many of the fundamental science requirements for Course X and XB are similar. Requiring biochemistry (7.05 or 5.07) of both X and XB students allows biologically oriented applications to be included for both groups of students in the later engineering science and integrative subjects. The additional biology subjects required by the Course XB degree are the introductory biology lab, 7.02; genetics, 7.03; and cell biology, 7.06. The three additional biology subjects for course XB are accommodated by eliminating the introductory chemistry laboratory, 5.310; separations, 10.32; and 24 units of restricted electives in chemical engineering. Note that the XB degree requirements include all of the subjects required by the Course VII SB departmental program and thus provide a comprehensive background in modern biological science.

In discussions with the Biology Department, a concern was raised regarding the ability to accommodate the XB majors in the laboratory subject 7.02. While over the past four years, between 24 and 42 Course X majors were among the approximately 200 students per year that completed 7.02, the high demand for this subject necessitates a lottery. To address this limitation, the Chemical Engineering Department will offer a course jointly with the Biology Department, 7.020J/10.702J. This new subject will mirror the content of 7.02 and provide additional capacity for up to 36 students per year. The first offering of 7.020J/10.702J is planned for spring 2005.

Chemical Engineering Core Subjects

The proposed XB degree will retain the three core chemical engineering topics of the Course X degree. However, as the result of an extensive curriculum review process during spring 2002, increased biological applications are being developed for two of the chemical engineering core subjects. The renewal of the thermodynamics subject, 10.213, has been undertaken by Professors T. Alan Hatton, Jefferson W. Tester, and Karen K. Gleason. The redesign of the kinetics offering, 10.37, has been undertaken by Professors Cooney and Gregory Stephanopoulos. Last year, the course descriptions of these two subjects were updated to reflect these changes. These revised subjects should serve both Course X and XB majors well.

Although our department feels that this increased emphasis on life science will

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serve all of our students well, we also believe there is a significant group of students who would benefit from completing all of the fundamental biology courses; and this requires the establishment of a new XB major. Once the Course XB major is established, further course development projects in our department and in other programs throughout MIT will be considered as future means to continue evolving the requirements for the Course XB major. In the next year, alternative courses for the core transport subjects, 10.301 and 10.302, are expected to be put in place.

Comparison of Requirements for Courses X and XB

17 GIRs	X	XB
General Science	5.11	no change
General Science	8.01	no change
General Science	8.02	no change
General Science	18.01	no change
General Science	18.02	no change
General Science	7.01x	no change
REST*	18.03	no change
REST*	5.60	no change
Humanities	8 subjects	no change
Inst Lab*	5.310	**7.02**
198 ADDITIONAL UNITS		
	5.12	no change
	5.07 or 7.05	**7.05**
	10.10	no change
	10.213	no change
	10.26/27/28	**10.28**
	10.301	no change*
	10.302	no change*
	10.32	**removed**
	10.37	no change
	ICE	no change
	RE lab	**7.03**
	RE in ChE	**7.06**
	Unrestricted electives (48 units)	no change

*New subject to be developed in the next one to two years

Integrative and Synthetic Subjects

Integration of engineering concepts in Course X and XB are addressed via an introductory subject, a 24-unit senior design series, and a capstone laboratory experience.

The introductory subject, 10.10, will be common to both Course X and XB. The 10.10 course currently incorporates both chemically and biologically driven examples of engineering applications.

In addition, the 24-unit senior capstone design subject, Integrated Chemical Engineering (ICE), will be used for both degrees. Since its inception, ICE has been a modular subject. While some of the modules are mandatory, the students can select among various topics for completing the remaining modules. The Course XB students will be advised to select biologically-oriented elective modules, such as the one offered by Professor Langer on controlled drug delivery. As a result of the spring 2002 curriculum review, Professor Gregory J. McRae offered a new mandatory ICE module on continuous bioprocessing. Additional development of new biologically-oriented ICE design modules is anticipated.

A new capstone engineering laboratory, 10.28, has been developed for Course XB by Professors Wang and Greg Stephanopoulos. The 10.28 laboratory subject was offered for the first time this fall and demand for enrollment exceeded the initial limit of 18 students. Additional capacity will be made available in the coming years.

Closing Comments

Significant faculty planning and departmental resources were devoted to the design and logistical planning for the proposed Course XB program and clearly demonstrate the department's strong commitment to undergraduate education. The ability to offer new laboratory subjects required for the degree is only possible because of investment in the renovation and outfitting of a new undergraduate teaching lab.

The emphasis on fundamentals and quantitative approaches serve as an excellent background for engineering graduate studies and professional degrees in medicine. Retention of the full ICE design experience and capstone engineering laboratory experience will be valuable to students seeking professional industrial employment immediately upon completion of their SB degree. These important attributes of the proposed Course XB degree support the department's mission statement: "To be the global leader in chemical engineering education and research. We train students to be the best in shaping complex problems, particularly the translation of molecular information and discovery into products and processes. Our programs are enriched by an emphasis on leadership; fundamental understanding of physical, chemical, and biological processes; engineering design and synthesis skills; and interdisciplinary perspectives on technological, economic, and social issues."✣

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Biological Engineering: How MIT is Defining the Educational Frontier

Linda Griffith and Douglas Lauffenburger

Biology is now a foundational science for engineering. As with other scientific revolutions, the molecular and genomics revolutions in biology require engineering analysis, design, and synthesis in order that breakthrough discoveries can be translated effectively into products and create new industries – as well as to foster further developments in the basic science. Each established engineering discipline addresses a certain range of problems within biology that fall within the scope of tools and approaches of that discipline, but more than the linear sum of each of these contributions is needed to fully exploit the potential of biology.

The fusion of engineering with modern biology requires development of a new biology-based engineering discipline, termed "Biological Engineering," which brings to bear on biology the appropriate tools and perspectives from chemical, civil, computer, electrical, materials, mechanical, and nuclear engineering in an integrated way. Biological Engineering is not envisioned as replacing these individual efforts, but rather complementing and taking its place alongside them.

It has been clear that creation of a new discipline could not be accomplished without a formal academic structure that provided faculty FTEs for curriculum development. Thus, the Biological Engineering (BE) Division was created in 1998 to foster development of teaching and research programs that fuse engineering with biology. BE currently offers the PhD degree in Biological Engineering and is comprised of 32 faculty members – 11 with primary affiliation, 11 with dual affiliation, and 10 with joint affiliation (corresponding to 16.5 FTEs). Roughly half the faculty members were educated in science disciplines (approximately 1/3 in bio/medical sciences) and five have appointments in the Biology Department.

About two years ago, the BE Undergraduate Program Committee began a serious effort to craft an undergraduate curriculum that would capture the intellectual essence of the BE PhD program in a 4-year SB Major degree, building somewhat on certain subjects that had recently been developed by BE for the BME minor, including "Laboratory Fundamentals in Biological Engineering" (BE.109) and "Molecular, Cell, and Tissue Biomechanics" (BE.310/2.797J) – but mainly starting from scratch to develop a set of about 10 new core subjects which fuse engineering with biology in a substantial manner. Two additional new core subjects, the sophomore-level subject "Statistical Thermodynamics of Biomolecular Systems" (BE.011/2.772J) and the upper-level subject "Foundations of Computational & Systems Biology" (BE.490/7.91J) have been taught so far, with the remaining core subjects under development this current academic year. Thus, the proposed BE major differs substantially from 10B in the scope of new course development.

The October 1997 charter for formation of the BE (at that time, BEH) Division stated that BE should develop "new educational programs" at the undergraduate level with an eye toward "success in bridging the connection to biology across engineering departments to allow new education and research that would be difficult or impossible in existing departments." And the BE Division Review Report from this past spring 2003, chaired by current Faculty Chair Rafael Bras, concluded that "the Division should proceed with the development of the undergraduate major in Biological Engineering." This Report emphasized that "the intellectual underpinnings and objectives articulated by BE and ChE are different and can co-exist and offer complementary tracks to MIT students." There is, in fact, very little intellectual overlap between the Course 10 subjects required for the proposed 10B Major and the BE subjects required in the envisioned BE Major, and none of the Course 10 subjects required for 10B will be required in the proposed BE SB.

At the same time, although the integrated core of the BE SB Major is intellectually distinct from other departmental majors, many of the individual proposed subjects can (and do) serve a dual role in the BE core and in a departmental curriculum. It is not a coincidence that three of the four BE core subjects mentioned above are co-listed and co-taught with other departments. For example, Mechanical Engineering is co-teaching or co-developing three of the BE core subjects as components of the 2A option for Mechanical Engineering students who want to emphasize bioengineering. What we envision ultimately is a continuum of degree offerings ranging from the traditional Biology SB (no engineering content) to a traditional Engineering SB (no biology content beyond GIRs) with a range of options in between: Biology SB coupled with a BE or BME Minor; Biological Engineering SB; Engineering SB with an option or emphasis on bioengineering (e.g., 2A or 10B); various other departmental curricula that now include biological applications more prominently in the core (e.g., the new DMSE and EECS curricula). We expect that the biology application content in the various SoE departmental curricula will surely continue to grow and rightfully so. Over 100 SoE faculty (~1/3) conduct at least some research in bioengineering and recent hiring trends in several departments have emphasized bioengineering.

If the popularity of a BE SB degree follows trends in popularity of BME majors introduced recently at comparable schools, we may grow to encounter large student enrollments. To address this

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Griffith/Lauffenburger, from preceding page

possible concern, we are hoping to facilitate distribution of freshmen throughout the many "Bio" options within the SoE by providing intensive advising in the freshman year. Two years ago, SoE Dean Tom Magnanti supported development of a freshman subject "Introduction to Bioengineering" (BE.010). In addition to providing a basic technical perspective on bioengineering, BE.010 showcases the educational activities in several SoE departments so that students get a good sense of the spectrum of opportunities available. We are also cognizant that even modest enrollments (~50) may strain resources in other academic units, particularly Biology, which will offer classes required by the BE Major. We introduced our "Laboratory Fundamentals in Biological Engineering" (BE.109) subject a few years ago in part to help relieve enrollment pressure on 7.02; many BME Minor students were opting to take 7.02, which has a limited enrollment due to space constraints. Like 7.02, BE.109 fulfills GIR and premed requirements, but has content more geared toward engineering and serves as a more appropriate course for the BE SB. We have been in discussion with the Biology Department for about a year regarding possible teaching synergies and are exploring a plan that might offer new opportunities for students while simultaneously relieving at least some prospective enrollment pressures.

One question which may be raised concerns the expected career paths for BE SB students. Our experience with the BE PhD program indicates that our colleagues in the biotechnology and pharmaceutical industries view the graduates of BE programs as pursuing important new kinds of career paths that did not previously exist for engineers from other disciplines, including chemical engineering, electrical engineering, and mechanical engineering. As one prominent example new opportunity, these industries are excited about having biological engineers predominantly working alongside biological scientists in drug discovery and development areas, for example, rather than mainly in production and manufacturing. Biological Engineering holds the promise to change these industries and push them into an increasingly productive future.

The challenges inherent in creating a formal new curriculum for a biology-based engineering discipline within the context of existing undergraduate programs means that we are still at least a year away from having all the key subjects in place and feeling comfortable in being ready to open our doors to undergraduate students. Our intention to move ahead with planning for the BE SB Major was endorsed in principle by Engineering Council last spring, and we have begun discussions with CUP and CoC about bringing forward a formal proposal toward Institute approval during the 2004-05 academic year. We will be discussing the curriculum in many MIT forums in the next few months, and invite input, questions, and perspectives from our colleagues across campus.✣

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Computer Security Update

Gerald I. Isaacson

Countdown 7,6,5,4,3,2,1. That's how many seconds it took for an unprotected Windows computer on our network to become compromised in the last round of attacks. Once compromised, a reasonably computer proficient person could restore the computer and previously saved data in about six hours.

Using Windows Update one could have installed the preventive patches in under half an hour.

Over 1,000 machines had not been patched against the latest announced vulnerability before the recent Network Security Team notification effort.

If you're not one of those with time to spend or research to lose then here are five things you can do to protect your computers or expedite their reconnection to the network once compromised.

1. Do keep up to date on your anti-virus software – on Windows machines daily updates are suggested – and they can be done automatically.

2. Do keep up to date on Windows patches, on Windows 2000 and XP machines it can be relatively automatic, too.

3. Do keep contact information about your computers current and in particular have someone listed who knows where each machine is, and has the necessary access rights to the machine to make any necessary changes.

4. Do use TSM or other means to have your vital data backed up. See <http://web.mit.edu/is/topics/backup/index.html>.

5. Do subscribe to the security-fyi and mitvirus mail lists to keep up to date on tools, prevention, and new vulnerabilities.

Here are a few Web links that you might want to bookmark:

For virus protection: <http://web.mit.edu/is/topics/virus/index.html>.

For network security: <http://web.mit.edu/net-security/index.html>.✣

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the spring 2003 8.02 (a few percent) compared to 8.02 failure rates in recent years (from 7% to 13%).

I also discuss, with hindsight, the missteps we made in the transition from the prototype course to the mainline course in spring 2003 that contributed to the adverse student reaction. Many of these missteps had to do with insufficient training of *both* students and instructional staff for teaching and learning in this new format. The major lessons of the TEAL experience for educational innovation at the Institute are: (1) any serious educational reform effort at MIT must be accompanied by a robust assessment effort; and (2) any move from small-scale innovation to large-scale implementation requires careful thought about a number of design issues, and training.

Motivations for Change

The TEAL format is centered on an "interactive engagement" approach, merging lecture, recitations, and desktop laboratory experience into a technologically and collaboratively rich experience. It is taught in a highly interactive, hands-on environment, with extensive use of networked laptops in a classroom especially designed for this approach (the d'Arbeloff Classroom, 26-152). We are not the first to try this format. "Studio Physics" loosely denotes a format instituted in 1994 at Rensselaer Polytechnic Institute by Jack Wilson. This pedagogy has been modified and elaborated on at a number of other universities, notably in NCSU's *Scale-Up* program under Robert Beichner. We have expanded on the work of others by adding a large component centered on active and passive visualizations of electromagnetic phenomena.

What is the motivation for this transition to such a different mode for teaching introductory physics? First, the traditional lecture/recitation format for teaching 8.01 and 8.02 has had a 40-50% attendance rate, even with spectacularly good lecturers (e.g., Professor Walter Lewin), and a 10% or higher failure rate. Second, there have been a range of educational innovations in teaching freshman physics at universities other than MIT over the last few decades that demonstrate that any pedagogy using "interactive engagement" methods results in higher learning gains as compared to the traditional lecture format (e.g., see Halloun and Hestenes 1985, Hake 1998, Crouch and Mazur 2001), usually accompanied by lower failure rates. Finally, the mainline introductory physics courses at MIT do not have a laboratory component. This is quite remarkable – to my knowledge MIT is the only major educational institution in the United States without a laboratory component in its mainline introductory physics courses. The motivations for moving to the TEAL format were therefore to increase student engagement with the course by using teaching methods that have been successful at other institutions (including Harvard, see Crouch and Mazur 2001), and to reintroduce a laboratory component into the mainline physics courses after a 30-year absence.

The TEAL Format Spring 2003

In the TEAL classroom, nine students sit together at a round table, with a total of 13 tables. In five hours of class per week (two two-hour sessions and one one-hour problem-solving session led by graduate student TAs), the students are exposed to a mixture of presentations, desktop experiments, and collaborative exercises. The course was broken down into six sections. A physics faculty member, assisted by a physics graduate student, an upper-level undergraduate who had previously taken the course, and a member of the Physics Demonstration Group, taught in each section. In spring 2003, Professors Wit Busza, Michael Feld, Eric Hudson, David Litster, Ernest Moniz, Jr., and Dr. Justin Kasper led the six sections of 8.02.

Students were assigned to groups of three and remained in those groups for the entire term. In the two prototype versions of the course, we assigned students to groups based on their score on an electromagnetism pre-test, discussed below, using heterogeneous grouping (i.e., each group contained a range of student backgrounds as measured by the pre-test score). In spring 2003, because of the logistics of dealing with over 500 students, we assigned students to groups randomly. The grade in spring 2003 was based on: in-class activities, desktop experiment summaries, and worksheets; standard weekly problem sets; questions about reading assignments that were turned in electronically before each class; three one and one-half hour exams; and a final. Three-quarters of the tests were made up of the standard "analytic" problems traditionally asked in 8.02; one-quarter of the tests were made up of multiple-choice conceptual questions similar to questions asked in class and on the pre- and post-tests. Students typically score lower on these multiple-choice questions because they test concepts that may not be well understood, and because there is no partial credit.

The course was not curved. In other words the cut-lines for the various letter grade boundaries were announced at the beginning of the term. Because collaboration is an element, it was important the class not be graded on a curve, either in fact or in appearance, to encourage students with stronger backgrounds to help students with weaker backgrounds. Also, the cut-lines in the course were set in such a way that a student who consistently did not attend class could not get an A. This was a deliberate policy to encourage attendance, based on the belief that at least part of the reason for the traditionally high failure rates in 8.02 is the lack of student engagement with the course.

Successes and Failures in the Large-Scale Implementation

In many ways we were pleased with the results of the large-scale implementation

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of TEAL in the spring of 2003. The physics faculty teaching the course felt that students were learning more with this new method of instruction than in the traditional lecture/ recitation format. This feeling was borne out by our detailed assessment results, [see "TEAL Assessment and Evaluation," Page 10]. To summarize those results, the learning gains in TEAL spring 2003 by standard measures are about twice those in the traditional lecture/recitation format. The fact that interactive-engagement teaching methods produce about twice the average normalized learning gains when compared to traditional instruction replicates the results of many studies obtained at other universities, including Harvard.

However, what was disappointing was that much of the student reaction to the course in spring 2003 was mixed to negative. The CEG overall course score for spring 2003 was 3.7/7.0, a very low ranking. What accounts for this glaring discrepancy between learning gains and student satisfaction with the spring 2003 course?

In hindsight, there were a number of missteps we made that contributed to this situation. For example, our prototypes were taught in off-term 8.02. Two-thirds of the population in off-term 8.02 consisted of upper-class students who had failed either 8.01 or 8.02 in their freshman year, and one-third of the population consisted of freshmen who had received credit for 8.01, most of whom had an excellent high school physics background including an introduction to electromagnetism. In any case, almost all of our students in the prototype course had seen the material before at some level, and thus had some comfort level with it. This was not the case in spring 2003, when some students entering the course had never seen the material before. Our introductory material did not take this into account, and thus many of these students felt lost at the beginning of the course.

To compound this error, we used group work extensively in class, and although in the prototype courses we grouped according to background (that is, every group had a range of prior knowledge based on the pre-test), in spring 2003 we simply assigned students to groups randomly, because we thought the spring population was more uniform in its background than the fall term course, and because we did not think we could make heterogeneous assignments in a timely way with 550 students. The result was that some of our groups consisted entirely of students who had never seen the material before. A frequent student complaint in our focus groups and in the course surveys was that "the blind can't lead the blind" in group work, and the more homogeneous grouping on our part certainly contributed to that reaction. It also contributed to the perception of the students that they were not learning enough in class because of the emphasis on students teaching themselves. Students complained they felt they did most of their learning outside class, and only came to class because they knew class participation was part of their grade.

Another factor was that the sections in spring 2003 were led by faculty who had never taught in this format before. The prototype courses were taught by Peter Dourmashkin and myself. Although we did train the faculty in the teaching methods in the course, with hindsight our training was not thorough enough to prepare them for the new environment in the d'Arbeloff Classroom, both in terms of the technology in the room and the teaching methods used in "interactive engagement." In particular, we provided to the teaching staff PowerPoint presentations for the material to be covered in a given class, and many students felt that the section leaders went through this material too rapidly. They preferred more traditional board work, which moderates the pace of the presentation of material.

Moreover, we did not do enough training of the student groups themselves in collaborative work. Ideally, collaborative work is a positive experience for everyone in the group – the students with poorer backgrounds can learn from more advanced peers who have recently struggled with the same concepts, and the students who have stronger backgrounds find that the best way to clarify one's understanding of material is to explain it to others. But to function in this way instructors need to train students to understand the purpose of group work. We did not do a good job of setting out the mechanics of group work, and in particular we did not set up mechanisms for corrective action for groups that were not working.

Finally, many students did not find the experiments useful – they were unsure of what they were supposed to learn from them, and the length of the experiments was such that frequently students did not have a chance to finish them.

Future Directions

Because the TEAL Project has had a robust assessment effort from the outset, we have been able to understand and document the successes and failures of the implementation over the course of the last three years, and to learn from them. For TEAL to succeed in the long term, it is crucial we improve the learning environment for the students. In particular, since we feel that class attendance is a central part of this teaching method, we must structure the course so that coming to class is seen by the students as a profitable use of their time. The changes we plan to make in the future are: (1) heterogeneous grouping, and more training of students in collaborative methods; (2) more extensive training for course teaching staff, both section leaders, graduate student TAs, and undergraduate TAs; (3) an increase in numbers of the course teaching staff (students felt we were understaffed during class); (4) fewer experiments that are better

(Continued on next page)

Improving Student Understanding with TEAL

Belcher, from preceding page

explained and better integrated into the course material; (5) better planning of individual classes to break our active learning sessions into smaller units that can be more closely overseen by the teaching staff.

The lessons of the TEAL experience thus far for educational innovation at the Institute are first, that any serious educational reform effort at MIT must be accompanied by a robust assessment effort. One needs some quantitative measure of the effectiveness of instruction to gauge whether the innovation is actually producing results that are superior to or equal to what it is replacing. Second, as is well known in educational circles, the most perilous part of any innovation is the attempt to move from small-scale innovation to large-scale implementation. With hindsight, we feel that our major misstep in this transition was not training course personnel and students adequately to prepare them for this new method of teaching.✥

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TEAL Assessment and Evaluation

The TEAL Project has had a robust assessment and evaluation effort underway since its inception. This effort is led by Professor Judy Yehudit Dori <http://caes.mit.edu/people/dori.html>, a faculty member in the Department of Education in Technology and Science at the Technion. Professor Dori is an internationally-known educator whose expertise is the assessment of learning strategies in science and technology education. We use a variety of assessment techniques, including the traditional in-class exams, focus groups, questionnaires (in addition to MIT's CEG questionnaire), and pre- and post-testing. We concentrate here on the results of the pre- and post-testing. Our pre- and post-tests consists of 20 multiple choice questions covering basic concepts in electromagnetism. Some of these questions are taken from standardized tests that have been developed and used at other institutions, and some of these questions were developed at MIT.

The figure shows the results of the pre- and post-testing for spring 2003 8.02 (Dori and Belcher, 2004). The results are given for three categories of student scores: High, Intermediate, and Low. This separation allows us to gauge the effectiveness of instruction across the range of student backgrounds; the separation is made using the student's score on the pre-test (the dividing lines are: greater than 45/100; between 30 and 44/100; and less than 30/100). The difference between the pre- and post-scores is a measure of the effectiveness of instruction.

The table shows these results in the standard form for assessment studies using the normalized gain <*g*> (Hake, 1998)

$$\langle g \rangle = \frac{\%Correct_{post-test} - \%Correct_{pre-test}}{100 - \%Correct_{pre-test}}$$

In calculating <*g*> we are normalizing the student's improvement in his or her score from the pre- to the post-test to the maximum improvement possible. We also show in the table the pre- and post-test results for the TEAL prototype taught in fall 2001 and for a control group that consisted of 121 volunteers from the spring 2002 course, which was taught in the traditional lecture/recitation format (Dori and Belcher, 2003).

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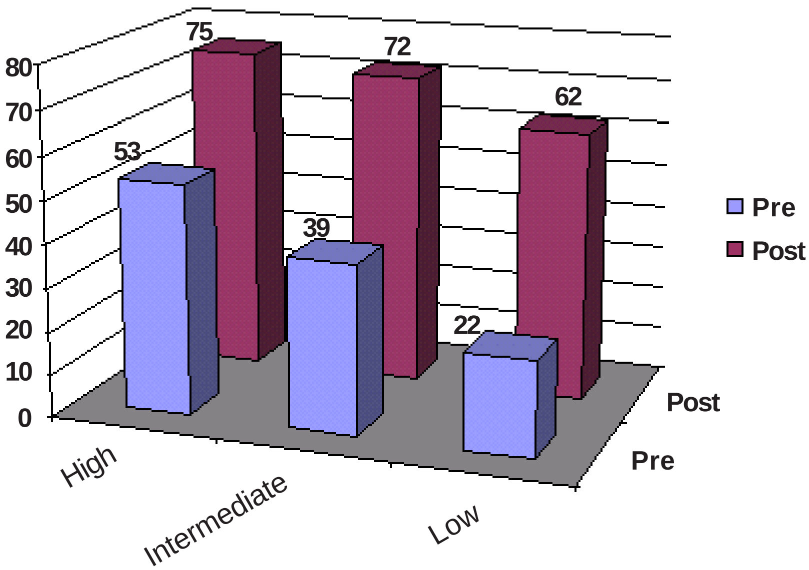
TEAL Assessment and Evaluation

from preceding page



Pre- and Post-test Results for Spring 2003 8.02

Group	Large-Scale TEAL Spring 2003		Prototype TEAL Fall 2003		ControlGroup Lecture/Recitation Spring 2002	
	N	Gain	N	Gain	N	Gain
All	**514**	**0.52 ± 0.22**	**176**	**0.46 ± 0.26**	**121**	**0.27 ± 0.31**
High	40	0.46 ± 0.33	58	0.56 ± 0.29	19	0.13 ± 0.43
Intermediate	176	0.55 ± 0.22	48	0.39 ± 0.26	50	0.26 ± 0.34
Low	298	0.51 ± 0.19	70	0.43 ± 0.22	52	0.33 ± 0.20

Normalized Gains for the Pre- and Post-testing for the Terms Shown

The table demonstrates that in spring 2003 our normalized learning gains are the highest we have achieved in the TEAL format, and are broadly spread across all levels of student background. The achieved <g> = 0.52 for all 514 students is comparable with <<g>> = 0.48 of 48 interactive engagement mechanics courses surveyed by Hake (1998), where the double angle brackets mean an average of the averages. They are better than the results in fall 2001 TEAL, both absolutely and in the spread of the learning gains across student background. Moreover, the learning gains in TEAL spring 2003 by this measure are about twice those in the traditional lecture/recitation control group of spring 2002. The fact that interactive-engagement teaching methods produce about twice the average normalized learning gains when compared to traditional instruction replicates the results of many studies obtained at other universities, including Harvard.

Any comparison between the spring 2002 control group and the spring 2003 TEAL group has a number of limitations. One might be concerned that the TEAL spring 2003 instructors "taught to the post-test," but in spring 2003 the six section leaders had almost no knowledge of the content of the pre- and post-tests, so "teaching to the test" was not a significant factor. There are other limitations which stem from the fact that not all the variables in the TEAL groups and the control group were identical: unlike the TEAL students, who responded to both conceptual and analytical problems as part of their 8.02 course work, the control group students only solved analytical problems in their weekly assignments and on the course exams; the conceptual pre- and post-tests administered to the TEAL group students were mandatory, whereas the control group students volunteered to take the pre- and post-tests and were compensated for their time; students in the TEAL groups were encouraged to attend classes because they got credit for doing so, while the control group had no such encouragement; the TEAL students consisted of the entire class population, while the volunteers in the control group accounted for about 20% of their classes (however, the average final grade of the volunteers in the control group traditional course was 66/100, higher than the average score of 59/100 for the entire control group class, so the volunteers were not unrepresentative of the abilities of the entire class); the control group is from spring 2002, when the Pass/No Record system was still in effect; in spring 2003, the grading system was ABC/No Record, which undoubtedly increased student motivation to do well in the course.✣

Research at MIT

Center for Space Research

Jacqueline N. Hewitt

Founded in 1965 with NASA support, MIT's Center for Space Research (CSR) is an interdepartmental center that conducts research in space science and engineering and in astronomy and astrophysics. Faculty and students from the Departments of Physics, Aeronautics and Astronautics, Mechanical Engineering, and EAPS are resident in CSR and work closely with CSR's research staff. We have offices and laboratories in three locations on campus: Building 37, Building NE80, and Buildings NW17\NW22. CSR also supports MIT's participation in the Magellan Consortium, a consortium that operates two 6.5-meter optical telescopes on a mountaintop in Chile.

CSR's flagship project is our participation in the Chandra X-ray Observatory, a "Great Observatory" launched by NASA in July 1999. With its unprecedented combination of spatial and spectral resolution, Chandra is revolutionizing X-ray astronomy. For the first time, we have X-ray images with resolution comparable to that of optical images. CCD cameras on board the spacecraft produce the X-ray images. Inserting a transmission grating into the optical path allows the cameras to record X-ray spectra of astrophysical objects rather than images. Of the four instruments on Chandra, two (one CCD camera and one transmission grating) were built by CSR scientists and engineers. The precision construction techniques required for X-ray diffraction gratings were developed at CSR's Space Nanotechnology Laboratory.

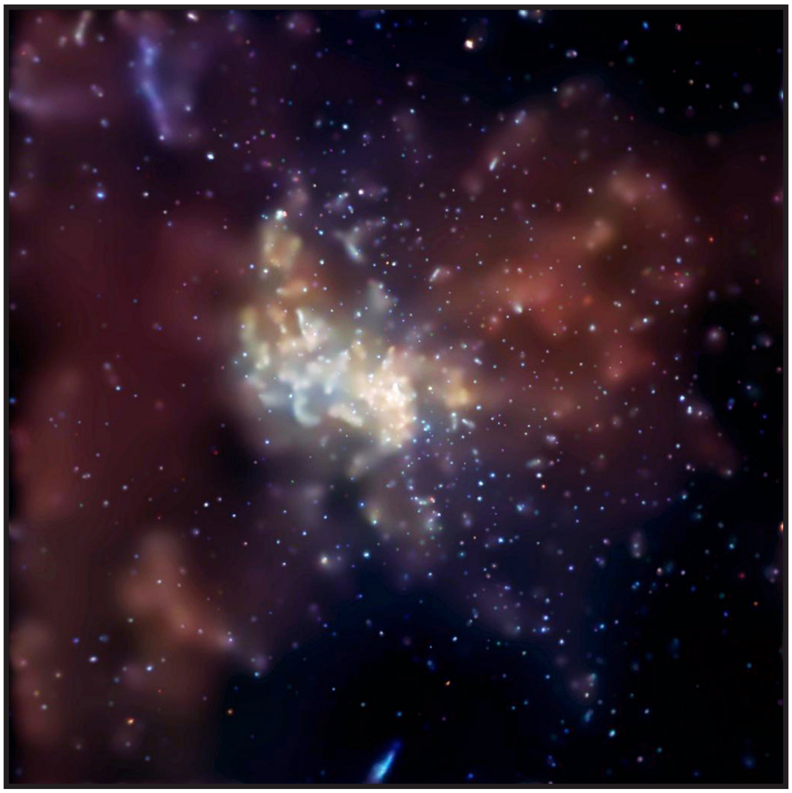


Photo credit: NASA/CXC/MIT,F. K. Baganoff et al.

Astrophysical X-ray sources are laboratories for high-energy phenomena such as supernovae, the accretion disks and jets associated with neutron stars and black holes, and high-energy particles that fill galaxy clusters. As an example, the figure shows a Chandra image of the center of our Galaxy. The bright emission at the center of the image is believed to be due to a black hole with a mass over a million times that of the sun. The evidence for the existence of this black hole is found in optical measurements of the orbits of stars around the black hole and in Chandra's measurements of rapid flaring activity. These Chandra studies also resulted in the serendipitous discovery of over 2,000 new bright X-ray sources in the Galactic Center region. The new sources are believed to be primarily hot white dwarfs and neutron stars in our Galaxy.

We are involved in several other X-ray missions in addition to Chandra. The small explorer satellite, HETE-2, was designed and built at CSR, and is now operated from a laboratory in Building 37. HETE-2 carries wide-field X-ray and gamma-ray detectors designed to identify and localize gamma-ray bursts, extremely intense rapid bursts of gamma rays that are believed to originate in the collapse of massive stars. Another wide-field instrument, the All Sky Monitor on the Rossi X-ray Timing Explorer, was also designed and built at CSR. Still in operation since its 1995 launch, the ASM continuously surveys the sky, monitoring known bright X-ray sources and identifying new transient sources for further study.

Looking to the future, CSR scientists, engineers, and students are part of a worldwide collaboration that has its goal to develop a new type of astronomy, gravitational wave astronomy. Einstein's General Theory of Relativity predicts that accelerated masses should produce gravitational waves, in a way somewhat analogous to the production of electromagnetic waves by accelerated charges. There is indirect evidence for the existence of gravitational waves that comes from the observation of the loss of energy in an orbiting system consisting of a neutron star and a pulsar. Gravitational waves are much more difficult to detect than electromagnetic waves, however. If

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Considering 100 Memorial Drive

Paul E. Gray

October 14, 2003

This note, provoked by the idea that MIT might subsidize rents for young faculty at the 100 Memorial Drive apartment building, is written to lay out some relevant facts and observations. Priscilla and I have lived at 100 Memorial Drive for 13 years; until 1997 in the penthouse, and since then in a twelfth-floor apartment. Thus, the following observations and comments come from an interested, but not necessarily unbiased, tenant.

Built in the mid-to-late forties, the building was sold in the mid-nineties, by New England Life (the developer) to a partnership in which Martin Trust, (MIT '58) is the general partner. The Cambridge Rent Control board had been very tough on owners and landlords for more than 25 years, and the price paid reflected that fact. As a consequence, the building deteriorated significantly and had a backlog of deferred maintenance when Martin Trust bought it.

A year or so after the sale the voters of the Commonwealth eliminated rent control. Since that time, the rent on our apartment (which we began renting in October '96 to hold it for our use commencing in July '97) has approximately tripled, in just seven years. The owners have put some money into the building, mostly for cosmetic improvements such as new carpets and paint in the public spaces, a renovated garden area, a play area for children, etc. More substantial renovations are difficult because of the design and construction of the building; corridors every third floor, reinforced concrete construction in the interior, 1940s wiring, heating and plumbing, single-glazed casement windows that leak air and rain, rooms small by present standards, no provision of air conditioning (except tenant-supplied window units), in-apartment laundry facilities not possible, limited storage space, etc.

Because of the demand-driven rapid escalation of rents, many retired MIT folks, some of whom had been tenants for many decades, have had to move out. They have been replaced primarily by students, who often double- or triple-up (or more). I had an advisee a couple of years ago who was renting a three-bedroom apartment with four other unrelated students! The willingness of students to arrange rent-sharing with others has been one of the factors that sustains the extraordinary rate of increase of rents. The sense of community that existed a decade ago is largely gone.

When the insurance company owned the building there was a provision in the ground lease from MIT that gave absolute first priority in rentals to MIT people. For many years Bill Dickson [former MIT senior vice president] maintained a list of interested persons who wished to move into the building. I assume that this privilege was retained when MIT consented to the sale and extended the ground lease to ca. 2024. No such list has been used recently, because the rent structure has left vacancies (note the "Now Leasing" banners on both the front and back of the building).

If the owners were to have an assured supply of subsidized faculty renters, their persistent instinct for higher rents, which they endeavor to justify by comparing the accommodations with "luxury housing" in the area would, I believe, be unbounded. I do not know how to reconcile this dilemma with the genuine need for more close-in housing for MIT people, particularly young faculty.✣

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Center for Space Research

Hewitt, from preceding page

theoretical expectations about source strengths are correct, detecting gravitational waves requires building an instrument that can detect a change in distance between two objects of less than 10^{-18} meters! MIT is collaborating with Caltech on the construction of two large laser interferometers, one in Washington state and one in Louisiana, that are designed to detect such small changes in distance. This Laser Interferometry Gravitational Wave Observatory has begun operation, and r&d for a planned upgrade is in progress.

In addition to the X-ray and gravitational wave projects described above, we have active programs in ground-based optical and radio astronomy, human adaptation to space flight, space engineering, space plasma physics, and planetary science. To learn more, I invite you to visit our Website, <http://space.mit.edu> or to take one of the tours we will be offering during IAP.✣

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Digitizing Shakespeare

Peter Donaldson

In the past 10 years, I have spent much of my time developing electronic resources for Shakespeare teaching and research. The Shakespeare Electronic Archive group which I direct has assembled a rich collection of electronic texts, high resolution digital images of early editions and works of art, as well as several films. *Hamlet on the Ramparts* (http://shea.mit.edu/ramparts) presents a selection of these materials free of charge on the World Wide Web. With iCampus funding we have developed a Cross Media Annotation System (XMAS), which has made it possible for the first time to include video citations defined in "real time" in on-line discussion of Shakespeare films. We are now adding production photographs and other images from the collections of the Royal Shakespeare Company and the Shakespeare Centre Library to the archive, and plan to include many of these in MIT's OpenCourseWare (OCW) site. If we can find continued funding, there is a rich future for digital Shakespeare at MIT.

My entry into this world began with a specific teaching problem: namely, how to make best use of Shakespeare performances on film in a discussion class. Shakespeare's plays were scripts for performance first, literary texts secondarily, yet the traditional Shakespeare class was almost always a text-based course. Film – especially multiple film versions of a single play – offered the possibility of close study of one of the most central aspects of Shakespeare's work: its open textured quality. Though sometimes called "universality," I prefer to think of this quality as Shakespeare's seemingly limitless power to inspire divergent interpretation, and I thought that this could be understood best through group discussion of the specifics of text and film in conjunction – with evidence and examples available during the class hour for consultation. Just as we learn "close reading" of a sonnet, I wanted the complex interplay of text and performance to be something a class could read together, closely and carefully. That meant being able to find and play film sequences as quickly as we find page numbers in a book.

The first medium that showed promise was the now obsolete capacitance electronic disc (CED), a pre-digital video disc played with a stylus like an LP. We bought our first player because, in those pre-media study days, we thought our children were watching too much television. CED titles included classics that were also fun to watch, such as *Modern Times*, *City Lights*, *Some Like It Hot*, *Casablanca*, *The Big Sleep*, *The Searchers*, *Henry V*, *Hamlet*. CEDs succeeded because, using the stylus control and the minute counter, we could find and replay sequences we were interested in 15-30 seconds – quickly enough to sustain family discussion. When my eight-year-old daughter wrote out a short list of questions about the narrative of *The Big Sleep*, it seemed the right time to try the Shakespeare discs with my students. An index card with the minute numbers of key scenes provided a means of studying text and video in close conjunction.

After reading descriptions of a Media Lab laserdisc project in which users could simulate the experience of driving through Aspen, Colorado, turning at intersections at will, I began to think of the materials for Shakespeare study not only as a potentially legible text, but as a navigable environment. In 1992, with a seed grant from Steve Lerman's post-Athena educational technology group, I joined with Janet Murray and Larry Friedlander (Stanford) to try to make the dream of a Shakespeare environment in which all materials were linked to corresponding lines of text a reality.

Though we had a unified vision, we quickly found that copyright and technical issues made a mobile, sometimes nomadic strategy for achieving that vision a necessity. In one project, we linked all Shakespeare films published on laserdisc to their respective texts – one link for every three lines or so. Reading a passage in the text of the play on one screen, the student could click to start the corresponding film sequence playing on another. Using stacked players, we were able to compare passages. We also created electronic "notecards" so students could easily insert video citations into their homework and essays. Students used these tools to do remarkable work – systematically discussing Laurence Olivier's hand gestures in *Henry V*, analyzing alternate performances of the same scenes in multiple versions, approaching old fashioned thematic topics (such as "Nature in *Hamlet*") freshly by seeing how twentieth-century directors and performers struggled with the change in meaning this word has undergone since the sixteenth century.

The second project was a prototype archive of texts, images and films, intended at first as a workstation installation, and later migrated to the Web. Here we had no ready published source of images to plug into a disc machine, but were highly reliant on permissions from the rare book libraries that owned the folios, quartos, and works of art and illustration we photographed and digitized. Also, a multimedia archive of this size exceeded the limits of our classroom technology. The Shakespeare Electronic Archive (http://shea.mit.edu) has grown to include several complete electronic texts of all plays, images of all pages and all variants of the Shakespeare First Folio and most early quartos, all extant copies of *Hamlet* First and Second Quartos, 1500 works of art and illustration relevant to *Hamlet*, and several films. It still requires a password, though an impressive subset of the materials are freely available on *Hamlet on the Ramparts*.

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Digitizing Shakespeare

Donaldson, from preceding page

Our current projects continue the tasks of building a large comprehensive cross media archive, as well as creating flexible on-line environments for using multimedia materials.

In order to move ahead on the copyright question, we are gradually populating the archive with materials for which we have permission for worldwide access. The University of Pennsylvania's generous policy of making its materials available free of charge has helped us here, and we are beginning a promising partnership with the Royal Shakespeare Company (RSC) which will add a new dimension to our work. This summer we began a pilot project in which we selected and digitized 200 images from the RSC collections. Publicity stills, photographic records of productions, prompt books, and other materials will enable us to study RSC productions more closely than ever before in our Shakespeare classes, and will be available worldwide on MIT's OpenCourseWare site. This project, in fact, would not have been possible without MIT's lead in establishing a new emphasis on the digital commons worldwide through OCW. Other institutions are impressed and convinced by MIT's example. A second project with the RSC in collaboration with Comparative Media Studies (CMS) and the MetaMedia Project is a new kind of production archive in which the evolution of a theatrical production would be traced from earliest discussions through rehearsal and performance. CMS graduate student Clara Fernandez has completed an impressive prototype for this project, using materials from Professor Janet Sonenberg's innovative deconstructed production, *Hamlets*, performed at MIT last February.

On the on-line environment side, we have developed new tools for using archival materials across all media in the classroom, building support for on-site as well as remote annotation, discussion, and collaboration by students. The iCampus project, XMAS, began as one of the launch projects for the MIT-Microsoft iCampus Initiative. We worked at first in close collaboration with Microsoft engineers and last year our MIT team – a gifted group of former students, current undergraduates, and staff members who are all devoted to working in a unified team of humanists and programmers – took over the development effort. DVDs are the initial medium supported by the system. As with laserdiscs, the computer acts as a more sophisticated remote control, recording start and stop points and weaving these into student-created discussions, commentary, and film/text essays that can be presented in class or shared remotely. The next phase of XMAS will include support for multimedia essay writing as well as discussion, image collections, electronic texts, and urls as well as DVDs. With XMAS we are very close to the goal of combining a multimedia archive with flexible learning and communication tools in one system.

Shakespeare materials constitute the most comprehensive potential multimedia archive in the humanities – not only are print and illustrative materials copious, but there is now a hundred-year film record, culminating in a recent wave of superb productions from Branagh's *Henry V* to *Shakespeare in Love*. Building the archive and devising new protocols for the performance archives of the future are compelling goals for our project. But equally compelling is the goal of using such collections to make possible new kinds of discussion, conversation, and collaboration, enriched by rapid and comparative access to materials across all media.

Many MIT humanities projects, including pioneering work in foreign language and culture and in comparative media studies, share the Shakespeare Project's vision of "the archive in the classroom," combining the creating of digital collections with an intense focus on the use of digital resources in teaching and research. Collectively, we are transforming teaching and research in the humanities. The present moment, in which the d'Arbeloff Fund and the iCampus initiative have nurtured groundbreaking new work, and in which the OpenCourseWare project commands worldwide attention, holds the promise of greatly extending the impact of our work, and extending recognition of MIT as a center of innovation not only in science and technology, but in the humanities as well. ✥

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Enhancing the Graduate Experience

Ike Colbert

Last year, I received an allocation of $200K from the student life fee to be used for enhancing the quality of student life. The timing of this allocation was especially opportune since, for several years, the GSC (Graduate Student Council) had spearheaded an effort to explore the role of "community" in terms of enhancing the graduate experience. Using the student life allocation, I decided to offer funding for creative initiatives for enhancing the graduate experience through a request-for-proposal process.

In June 2002, I appointed a selection panel to develop guidelines and implement a process for collecting and evaluating proposals. In two rounds of proposals (July and December 2002), the panel reviewed 50 entries, of which 23 were funded at a total cost of approximately $67K. Funding for individual proposals ranged from $500 to $12K.

The panel identified some key themes that distinguished successful proposals. These themes, described below, inform the ongoing discussion of "community" and what it means for enhancing the graduate experience.

Socializing

Several proposals focused on bringing people together in a social context. For example, one opportunity was to focus attention on constituencies whose needs for and perspective on "community" might be unique, for example, students living off campus have different needs for getting together socially. Another proposal broadened the outreach for a social program that was already in place.

Integrating academic and social aspects of graduate life

Several proposals acknowledged that social events and activities are often the crucial underpinnings for promoting intellectual exchange among faculty and students. Creating this environment – where students learn to express their ideas, seek connections, and exchange criticism – is the heart of the graduate enterprise. One such proposal, the Physics Pride Campaign, was a departmental effort to develop a vibrant and healthy professional community despite the fact that students are dispersed across campus; the campaign brought together students and faculty for orientations, weekly socials, and weekly colloquia.

Communications/outreach

A wide range of proposals addressed the need to improve communications and outreach – from increased support of the international community, or students' spouses and partners, to encouraging collaboration among student groups in planning and implementing activities and programs. One interesting proposal recommended the use of video to capture and document "the vibrant social medium of graduate life," a unique and important way to reflect what is actually happening in the lives of students.

The arts

Several proposals focused on the arts as an important crucible for enhancing the graduate experience. Proposals sought to acknowledge creative expression, such as creating public venues for graduate student artwork, or to draw students to existing venues, such as receptions held in the List Center for the Visual Arts. Another proposal focused on strengthening communication and collaboration among graduate "arts" students.

Models for community building

A few proposals were instructive on two levels. Although they focused on an activity within a particular organization, they addressed the theme of community building in a manner that might be more broadly applied, for example, to other academic departments, student organizations, or activities. The panel saw the potential for creating models for community building based on such proposals.

Seminal ideas

In this process, I was looking for "seminal ideas," for example, a proposal that would fundamentally change the graduate community and the services provided to the community. Such an idea would be far-reaching and innovative and reflect the best thinking about programmatic change. Although they did not represent original ideas, two proposals were strongly indicative of the community building that I hoped to see.

The proposal Ramadan @MIT, a series of community dinners marking the end of the Islamic holy month, was submitted by the MIT Muslim Students' Association to "foster understanding between the different groups of people that make up the MIT melting pot." The attractive aspects of this endeavor included its appeal to a broad MIT audience (both graduate and undergraduate, faculty and staff); its social and intellectual content; the partnerships formed with campus cultural, religious, and living groups; and the opportunity offered by the dinner forums for "forging fellowship." In the progress report they submitted to me, the Association noted a key theme that students expressed again and again: achieving balance in their lives. In this case, the challenge was balancing spirituality with other aspects of the typical student's college experience.

For many of the same reasons, Weekly Wednesdays was an important idea. Although these get-togethers at the Muddy Charles Pub did not address specific intellectual content, their purpose was to "create opportunity for a diverse cross section of MIT graduate students to come together on a regular basis in an informal and connective setting." The organizers were trying to "orchestrate serendipitous connections among MIT folks who would benefit from knowing one another," students as well as faculty. These Wednesday events attracted crowds of up to 200 students and, significantly, a wide variety of co-sponsors. Funding ensured that food was provided, and that graduate student groups with limited budgets were able to co-sponsor events.

Going forward

In past articles in this newsletter, I've offered a working definition of "community" as "opportunities for priceless encounters." Such encounters

(Continued on next page)

Changes in the Graduate Student Community

Steven R. Lerman

As this issue's article by Ike Colbert highlights, MIT has recently taken major steps to support various aspects of the graduate student community. As other articles in past issues of the *Faculty Newsletter* have pointed out, the graduate student body has grown steadily over the last few decades. It is appropriate that we have been working to provide that growing body of students with a wide range of opportunities that support our broader educational goals.

Much of this work can be traced to the groundbreaking work done by the Task Force on Student Life and Learning. In 1998, that group laid down the foundation for MIT's efforts to view learning at the Institute as resting on the triad of education, research, and community, and to expand the attention we pay to the third element of that triad.

Up until recently, the major locus of graduate activities was the small number of graduate dorms, with the Graduate Student Council playing a cross-dorm role. These community activities left students living off campus largely on their own and those in family housing (Eastgate and Westgate) relatively isolated. The changes we have seen recently result from a confluence of several actions.

- Expanded financial support through the student activity fees administered by the offices of the Dean for Graduate Students and the Dean for Student Life.
- The addition of two new dorms (Sidney and Pacific and The Warehouse), along with the three faculty housemasters who live in those dorms.
- The creation of new positions called Residential Life Associates in the Office of the Dean for Student Life. One of these new staff positions has been working closely with students in family housing.
- A better-funded and more active Graduate Student Council which, when it is at its most effective, works closely with the MIT administration and the Graduate Housemasters who can advocate for graduate student concerns.
- A heightened awareness of the financial pressures that some graduate students face, particularly in times when TA and RA stipends do not grow as rapidly as housing, medical insurance, and other major costs faced by graduate students. This increase in educational costs is a particularly acute problem for students in fields in which research and teaching assistantships are scarce or where stipends are relatively low.

The progress we have made in developing a strong, well-supported graduate student community should be viewed as the start of a larger effort. There are at present several things we need to do to continue making progress in this area, including:

- Moving forward on plans for more student housing at both the graduate and undergraduate level. The short term "Senior Segue Program" that places on the order of 100-150 undergraduates in graduate dorms was a stopgap measure to alleviate crowding in the undergraduate dorms. More permanent solutions now being studied might include one or more new dorms (both undergraduate and graduate) that allow us to return the beds now used for Senior Segue students to the graduate student community as planned.
- Mitigating the effects of budget cuts on graduate student quality of life, particularly moderating how increases in housing and medical costs grow in comparison to stipends.
- Expanding the opportunities and support for involvement of graduate students who live off-campus in the activities of the graduate community.
- Expanding the support for graduate students living in family housing, particularly in areas such as child daycare.
- Continuing the discussion on managing the size of the graduate student body, particularly in a time when small decreases in faculty size are being considered among the options for balancing the 2005 budget.
- Making it easier for more faculty to participate in both undergraduate and graduate community life by finding opportunities for faculty housing on or near the campus.
- Encouraging more faculty to be involved in the residential aspects of student life through opportunities such as the Faculty Fellows Program and involvement in co-curricular activities.✣

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Graduate Experience

Colbert, from preceding page

are the many and varied interactions that prepare students for community citizenship. Taken as a whole, these proposals help us to understand what today's graduate student wants and expects from the graduate experience. By listening carefully to what they say, we have the opportunity to engage in a profoundly different and positive dialogue about a new experience.

This work complements the earlier focus group research conducted by the Graduate Students Office (GSO). While focus group participants talked about the importance of community, the proposal authors offer concrete suggestions about community activities for enhancing the graduate experience. With this process, we've initiated a dialogue and created an effective mechanism for gathering fresh, creative ideas. In a bid to continue this important dialogue, the GSO has announced the third round of request-for-proposals which were due on October 15. For complete details about the proposal process, please see <web.mit.edu/gso> and click on "community building."✣

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MIT Poetry

Mud

It is early in the history of the season of humid freshness, herbs, and mud.
I walk across the sod of the meadow, which is after rain a bitter sponge.

I am almost afraid to see how weighty I feel to the earth, which has suffered me this long time
and still supports, imprinted with corresponding scars.

Many things I have thought and felt I am not proud of and are best not talked about, disgracing the body:
not even with God, who knows them as acts, having witnessed,

and who does not after all demand to be told them as a condition of forgiveness.
Therefore I print them here, setting my feet carefully where my body touches

the softer body of the meadow — as if to make them more exact,
a condition of the dark receptive soil:

as if prayer were a specific longing, as if the forgiveness I pray toward
would be a specific forgiveness and I will know it when it comes.

Better None

The storm passed like a fever. Now the residual snow
fits across Monodnock, a specific abyss: down the Asheolot Valley

to the river's roots, tucks under the ice at the rim of the reservoir
and pulls taut. Strange, that no pine or hawk or printing animal has punctured it,

through a night and a day and a night. I respect its blank
precision. By the end a man I loved also insisted on dying.

Alone in his body, he insisted. Even the snow is warmer
than that rage, that blank page. Now not

even if I had the power. How could I choose
pain for him, to keep the dead alive a little? Better none

than an elegy fed on grief like that, constantly
changing, constantly freshened and greedy.

— Stephen Tapscott

[These poems appear in Tapscott's *From the Book of Changes* (Carnegie Mellon University Press, 2002)]

OpenCourseWare Update

Unintended Consequences

"Notoriously unwired" educator taps into electronic potential of OpenCourseWare

John W. Dower

In the fall semester of 2002, Professor Shigeru Miyagawa and I introduced a new undergraduate seminar titled "Visualizing Cultures." For me personally – notoriously unwired – this was a plunge into unexplored virtual terrain. And, almost serendipitously, it led to an exceptionally fruitful collaborative relationship with MIT's OpenCourseWare initiative.

In recent decades, historians have devoted increasing attention to social and cultural developments at popular levels. Here "texts" tend to be more diffuse and less formal than the documents relied on in traditional histories focusing on politics, institutions, prominent individuals, and "high culture" in general. And one of the most vivid and engrossing vehicles for exploring popular consciousness lies in the visual record – in materials such as prints, paintings, lithographs, engravings, photographs, postcards, posters, advertisements, cartoons, lampoons, and in recent times, films.

As pedagogy, it is difficult to surpass the intimacy and immediacy of such materials. Over the years, many of us have built up slide collections to use in the classroom – and learned, in the process, that the graphics tell stories that words alone fail to convey. They enable us to teach students of the rapid-fire "MTV generation" how to slow down and analyze what passes before them. They facilitate not merely discussion of who is creating any particular image, and for whom, but also analysis of the particular mediums being used (how the "reportage" of a woodblock print or engraving, for example, differs from that of a photograph). Through artful presentation and juxtaposition of historical graphics, we can capture sentiments and nuances and contrasts that, as the old cliché has it, make history "come alive."

Until recently, the great challenge has been how to make such resources available in sufficient quantity and quality to engage students – not only at MIT, but *everywhere* – and enable them (or inspire them) – to develop projects of their own. For Professor Miyagawa and I, OCW was the answer. With essential support from the OCW staff, we designed a pilot project for "Visualizing Cultures" that pushed the envelope for all of us – interweaving hundreds of historical graphics (all in original color) with a substantial analytical text. Students began the semester by developing their own short PowerPoint presentations based on this core exhibition. Then, using the pilot project as a model, they moved on to substantial "visualizing culture" research projects of their own choosing – tapping graphic resources they themselves identified.

The pilot project, developed with generous financial support from the Alex and Brit d'Arbeloff Fund for Excellence in MIT Education, focused on the 1853-1854 mission of Commodore Matthew Perry that culminated in the opening of long-secluded Japan to foreign intercourse. Our project entailed assembling historical graphics from some 30 or more public and private sources in Japan and the United States (intellectual property rights are not so problematic before the twentieth century). It enabled us to visualize the same events from multiple perspectives on both the Japanese and American sides – in ways never ventured before. And it turned out to have an unintended consequence that delighted our Web designers as an unprecedented venture into "reverse engineering." Our OCW site, in short, has led to the creation of a real, solid traveling exhibition titled, "Black Ships and Samurai, 1853-1854."

It helps that this year and next mark the 150th anniversary of the Perry mission. Be that as it may, the planning and design of the OCW site enabled us to create a flexible display of 10 panels (ranging from 8-x-4 feet, to 9-x-3 feet), that premiered in Newport, Rhode Island, this summer and is presently scheduled for display in Los Angeles, Honolulu, Boulder, Minneapolis, and several other potential sites. One of the very special features of this exhibition – also incorporated into the OCW site – is the reconstruction of a 30-foot long "Black Ship Scroll" dating from 1854 that unfolds onscreen and can also be explored interactively. One hundred and fifty years after it was painted, this scroll is now available to the world for the first time through OCW.

In these various ways, vistas have opened that we hadn't even imagined when our collaboration with OCW began.✥

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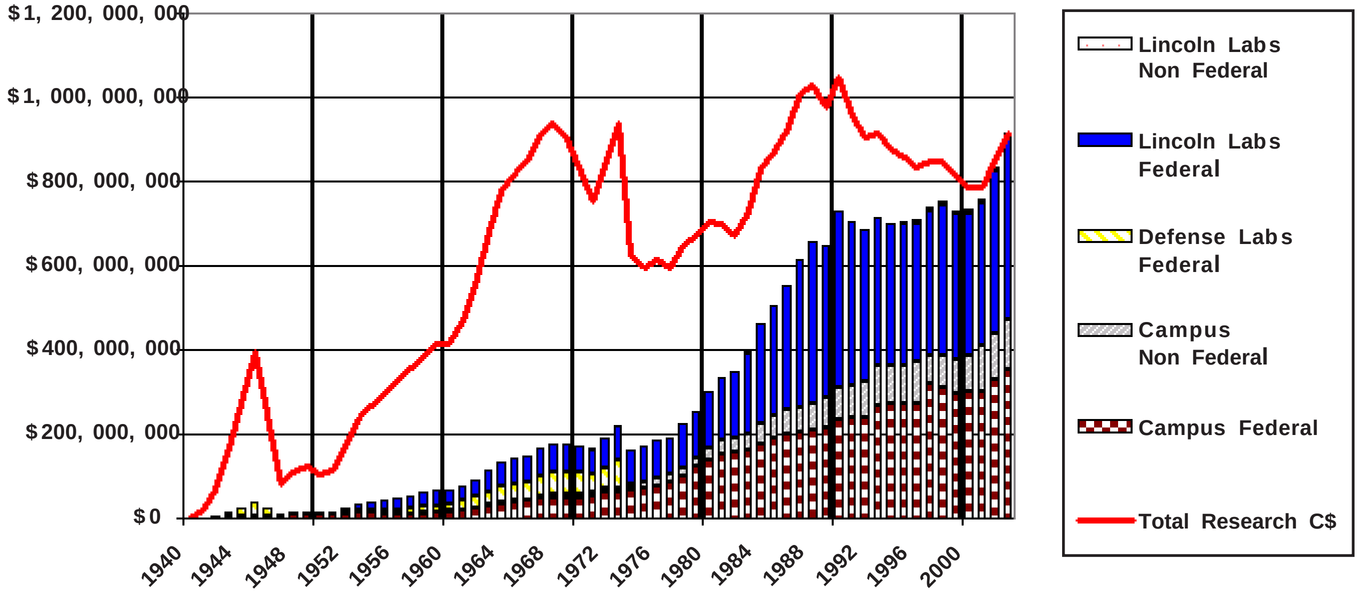
You can see Professor Dower's OCW course, "Course 21F.027J: Visualizing Cultures" online at <http://ocw.mit.edu/OcwWeb/Foreign-Languages-and-Literatures/21F-027JVisualizing-CulturesSpring2003/CourseHome/index.htm>. If you would like to participate in OCW, please contact Jon Paul Potts, the OCW communications manager, at jpotts@mit.edu *or 2-3621.*

M.I.T. Numbers

Historical Research Expenditures



Source	1944	1954	1964	1974	1984	1994	
Campus Federal	$26,587,294	$81,445,935	$204,512,431	$251,174,750	$313,081,444	$337,170,748	$350,897,272
Campus Non Federal	$16,052,706	$18,081,038	$21,534,150	$49,068,675	$83,365,810	$110,792,489	$120,857,180
Defense Labs Federal	$226,462,294	$38,274,917	$221,470,501	$22,841,170	$0	$0	$0
Lincoln Labs Federal	$0	$127,163,196	$326,590,457	$307,098,729	$429,513,744	$421,020,025	$435,264,824
Lincoln Labs Non Federal	$0	$0	$0	$41,206	$769,990	$4,841,867	$7,633,692
Total Research C$	$269,102,294	$264,965,086	$774,107,540	$630,224,530	$826,730,989	$873,825,129	$914,652,968

Source: Office of the Provost