The MIT Faculty Newsletter

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Teach Talk

Active Learning, Part II
Using Active Learning Techniques in the Classroom

Lori Breslow

I was having dinner with a group of my students last week when the conversation turned to the freshman year. The students, most of whom are juniors and seniors, were reminiscing about how they had managed to survive that first year. They talked about the steady stream of problem sets, the course material that seemed at times impenetrable, and the routine of cramming for test after test. When I asked them what they thought they had learned in that year, one of them, I'll call him David, said, "The thing the freshman year taught me best was how to be a passive learner." David's comment was a conversation stopper; I gathered most of the group agreed with him.

The good news is that with Alex and Brit d'Arbeloff's gift to support innovation in the freshman year, MIT faculty and students will be working together to create initiatives that will

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New High School Tests Undermine Inquiry Based Science Education

Jonathan King

Though receiving little attention on campuses, the imposition of high stakes tests as the single criteria for high school promotion and graduation is exercising a major influence in secondary science education. Laboratory experience, hands-on encounters, and project based learning are being set aside by pressure to improve performance on tests that emphasize rote learning and shopping list education. These retrograde curricula changes are already underway in public high schools in Massachusetts, New York, Texas, Florida, North Carolina, and California. (An excellent recent summary is in *Standardized Minds*, by Peter Sacks, Perseus Books, 1999.) MIT and other colleges and universities that train future scientists and engineers draw a significant part of their entering classes from these schools.

Over the past few decades the National Science Foundation, National Academy of Sciences, and AAAS have

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Poem and Image

John Hildebidle

We all know, do we not, how radically dissimilar, even discontinuous (all right, discordant) poetry and science are. How unsettling then to come across this proposition – admittedly, by a poet (Diane Ackerman), not a biogeneticist, but a poet who has written lucidly and learnedly about various aspects of science: "Both science and art have the habit of waking us up, turning on the lights, grabbing us by the collar and saying *Would you please pay attention!"* What I mean to argue here is that poetry undertakes this work in an especially radical way, but one not unparalleled by the best of science. It wants nothing more or less than that we alter the whole way we view the universe. Think of Copernicus or Darwin or Einstein; and then think of, say, Robert Frost or Emily Dickinson or Shakespeare. Colleagues all.

Among the lamentable half-mistaken lessons I learned in high school (Paul Simon's blunt lines come inevitably to mind: "When I look back on all the c**p I learned in High School, it's a wonder I can think at

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From The Faculty Chair

The Mixed Blessings of E-Mail

Steven R. Lerman

In some sense, it is the ultimate irony. We at MIT played an important part in inventing the Internet, yet many of us at times feel overwhelmed by the burden of keeping up with its demands. This is particularly the case with e-mail that arrives incessantly, increasing the demands of everyone to communicate with everyone else. One hears the same complaint both among our faculty and elsewhere that the quantity of e-mail demanding our attention has added to, rather than reduced, the time demands of work.

This dilemma came upon us suddenly, and there has been little time to adapt work styles and customs to accommodate these increased demands. Part of the problem is that e-mail hasn't completely replaced a previous medium of communication; rather, it has mostly been yet another one that is faster and cheaper for some purposes. We find ourselves working on our e-mail late at night to avoid falling further behind the next day.

Yet another aspect of e-mail is the ease with which large numbers of people can be drawn into a correspondence. Given that the university is going to have the infrastructure to support universal e-mail access anyway, the marginal cost of copying large numbers of people on a message is essentially zero. The positive side of this is that each of us is much more informed about various things going on at MIT than we would have been when memoranda had to be photocopied and mailed. The dark side, however, is that we tend to exercise far less restraint when we add people to the copy list on electronic mail. Making matters worse, each recipient may feel obliged to respond to the original message, creating a cascade of e-mail about something that really isn't worth the time and energy.

Lest you view this piece as the work of a technological Luddite, I am a strong advocate for e-mail when used with some restraint. During the 1980's I was deeply involved in Project Athena, which had the side effect of expanding the community of e-mail users at MIT from the small set of computer scientists to the entire community. E-mail has vastly reduced the incessant telephone tag that used to go on, and I am much more aware of research developments in my fields of interest as a result of electronic communications. However, even during the early phases of Project Athena, it became clear that e-mail (and other immediate electronic communications mechanisms such as instantaneous messaging) wasn't the right medium for all communications.

We need to develop social norms and some common sense rules of thumb about how this particular medium can serve us best. As with many things, the development of widely accepted social norms about a new technology takes more time than the spread of the technology requires. Not surprisingly, we find ourselves in an era when cyberspace has much of the feeling of the American frontier; it's dynamic and exciting, but only marginally civilized.

The key to taming this new frontier is for all of us to become more conscious about what works well with e-mail and related media and what doesn't. Based on my own experiences and those of colleagues, I have some concrete suggestions that might help.

Very early during the Project Athena development process, we discovered that e-mail is a terrible medium for resolving any dispute. Over and over again those of us managing the project would observe very minor disagreements escalate into massive electronic confrontations through a series of increasingly inflammatory e-mail messages. This same phenomenon was reported elsewhere and can still be seen almost everywhere e-mail is used. It has given rise to the terms "flame" (meaning the initial complaint) and "flame wars" (meaning the vociferous e-mail exchanges that the initial flame induces).

E-mail generates flame wars, because it in some ways combines the features that probably make it the worst possible way, short of physical violence, for two parties to reach amicable agreement. This happens for three reasons:

• E-mail has a high degree of immediacy. You read a message, write off the first response that comes into your head, and press the send button. In cases where you start out angry, your message often has a tone that, upon more careful reflection, you might have avoided. The recipient, now further enraged, does the same thing. In contrast, old-style paper mail required you to write the message, proofread it, address an envelope, and place it in the mailbox, all of which gave you time to calm down and reflect a bit more.

• In some hard to define sense, the words we write in an e-mail message aren't quite as real to us as those on paper. This perceptual oddity may

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disappear over time, but for those of us raised in the paper-based generations, there is something more ephemeral about words on a screen that makes us take their meaning less seriously. We seem to view words on paper as having permanence, and we therefore take more time in composing them. As a consequence, we often respond hastily and inappropriately to an e-mail complaint in a way that escalates conflict.

• E-mail doesn't communicate any of the nuances of spoken communication and is devoid of any of the subtleties of body language. This often leads us to misinterpret the sender's intent as hostile. This can happen with paper mail, but the time delays involved with older styles of written communication enabled us to be clearer and more temperate.

We may eventually learn to use e-mail more effectively in dispute resolution. However, at least for now, I propose a very simple rule. *Never try to resolve any contentious issue through e-mail. Instead, pick up the phone or, even better, meet face to face with the people involved.* This approach may appear at first glance to be more time consuming, but the truth is that the time needed to resolve a vastly escalated dispute can be many times that needed to resolve the initial dispute without e-mail.

Another entire aspect of e-mail that many are unaware of is its almost complete lack of security. The message you send from your computer is much more like a postcard than something sealed in an envelope. Even someone with little technical skill can install software that examines the contents of e-mail messages as they are transmitted across the Internet. In addition, there is essentially no guarantee that a message you receive purporting to be from someone actually came from them; forging an e-mail message is fairly simple. I propose two simple rules to deal with this. *Never send anything by e-mail you wouldn't want someone other than the recipient to see, and never assume that an e-mail message comes from where it says it does without checking with the purported sender.*

As an interesting aside, the technology exists to resolve both of these problems. While there are some complexities associated with implementing it campus-wide (and even more implementing it for all Internet communications), we could use encryption and digital signatures in a way that would make e-mail more secure than its paper-based counterpart. This would require, however, that we adopt campus-wide standards for e-mail systems, reducing the high degree of flexibility in our software choices.

Another aspect of e-mail is the disturbing tendency of people to send copies of things to large groups. The existence of mailing lists further exacerbates this problem. It is simply too easy to "cc" everyone you know. My proposed rule for dealing with this is somewhat more complicated than my earlier ones. *Remember that the criterion for selecting who should get a copy of an e-mail isn't based on how easy it is for you to send the message, but rather the time needed by the recipients to read it.* We all need to balance the value of the information we are sending someone against the time it will take the recipients to process it. This is the reason I try to limit the number of messages sent to the mailing list that includes the entire faculty.

My final message relates to setting reasonable expectations about turnaround times on electronic messages. The very speed with which e-mail can be sent and received has escalated users' expectations about how quickly a response to an inquiry will be sent. One faculty member cited an instance in which an electronic correspondent was outraged because he failed to respond to an e-mail message by the afternoon of the day it was sent. After all, argued the correspondent, the message arrived in the morning and had been sitting on the recipient's computer for several hours.

In the era of paper mail, no one had any such expectations, and a response within a few days was seen as the hallmark of a diligent correspondent. The unreasonable assumption that every e-mail message will get a response in just hours has led many of us to be constantly checking our e-mail, often several times per day. *We need to restore a more sensible expectation that, except for dire emergencies, e-mail will be answered about as quickly as paper mail messages.*

I do believe that many of the stresses that e-mail intensifies will be resolved over time by emergence of accepted social conventions that better fit with busy schedules. This should allow most of us to see e-mail as less a cause of time-related stress and more as a contributor to real productivity. We might all contribute to the early arrival of that time by acknowledging the limitations of e-mail as a medium and adapting our use of it to serve us better.✣

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High School Tests Undermine Inquiry Based Science Education

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led an effort to modernize science education. The goals have been to produce students who know how to learn, how to inquire, how to identify problems and pursue solutions, as opposed to spitting back lists of facts, or mechanically fitting values into equations. Significant progress has been made in many states. Science curriculum tied to the actual investigations being carried out have been supported by NSF, NASA and the Department of Energy. (Some of these are Web-accessible and easily explored such as Earthkam, Hands-On Universe, and Visualizing Earth <http://www.cesse.terc.edu/PROGRAM.html> developed by Cambridge-based Technology Education Resource Center.)

Unfortunately, these developments have been seriously set back by the imposition of single high stakes tests that must be passed for promotion or graduation. In Massachusetts, these tests are called the MCAS – Massachusetts Comprehensive Assessment System. Presently these are given to 4th, 8th and 10th grade students, in English, math, social studies, and science. By 2003, graduation from public – but not private – high schools will require passing the 10th grade MCAS tests.

They test for retention of selected pieces of information from a very broad list. They exhibit the arbitrary and capricious character found in tests uncoupled from actual curriculum, but designed such that large numbers of students fail. They seriously disrupt a school's authentic educational activities. In efforts to prepare students for the tests, richer activities, such as hands-on investigations, field trips, or writing plays, have to be set aside. Careful analysis of the test questions by independent educators reveal a consistent pattern of age inappropriate questions, ambiguous questions, questions with multiple correct answers, and questions unrelated to curricular priorities (see, for example, <http://www.fairtest.org/arn/masspage.html>). The tests deeply damage children's self image, and dampen their enthusiasm for learning. I have been appalled at the deletions from the curriculum in my children's elementary school, in order to make room for a test prep drill.

The tests are extremely long, longer than the Massachusetts Bar exam, requiring weeks to administer. As a result they are very stressful for the younger students, and even more so for those facing the prospects of failing to graduate. As pen and pencil tests, they cannot assess the most profound aspects of student learning and education, but like most such tests assess test taking ability and test prep. Yet teachers are under enormous pressure to demonstrate improvement on the tests, regardless of correlation with actual educational achievement.

Test construction and scoring has emerged as a lucrative business. Thus the MCAS tests were not constructed by Massachusetts educators, but by an out-of-state company with no educational record in the Commonwealth. Gov. Cellucci just awarded $75 million to a Texas firm closely associated with Gov. Bush for the next five years of test preparation and scoring.

The testing madness has been promoted in the name of accountability and standards. They represent standardization, a very different value from high standards. The watchword "accountability" masks the actual transformation – narrow control from above. The recent (1999) National Research Council Report "High Stakes: Testing for Tracking, Promotion and Graduation" articulates some of these concerns.

Massachusetts parents and teachers and educators have been deeply disturbed over the tests, and frustrated by the insensitivity of the Department of Education to sound criticisms. It is instructive to examine who has brought these high stakes tests into K-12 education. Gov. Weld appointed John Silber, former president of Boston University, as chair of the Board of Education. Silber is a leading proponent of privatization of public education. Weld and Silber engineered the removal of the representative and professional Board of Education, and passed new legislation allowing the sitting governor to appoint a smaller Board, without legislative confirmation.

The new Board is weighted with individuals associated with efforts to privatize education, including a group affiliated with the Pioneer Institute, a Massachusetts think tank aligned nationally with the Heritage Foundation. When Gov. Cellucci replaced Weld, he continued in the same direction, appointing James Peyser, the executive director of the Pioneer Institute, as chair of the Board of Education. The Pioneer Institute is a leading proponent of privatization of government functions including education, and actively promoted for profit charter schools.

In the next few years the damage these testing regimes do will begin to be felt in colleges and universities. It is important that university faculty not sit by while the progress that has been made in K-12 education is dismantled. Education of our children and our students is too important to their future and the nation's future to be left to those who hope to turn education into a private business for their narrow profit.✣

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Using Active Learning Techniques in the Classroom

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offer alternatives to the way freshman subjects are currently taught. This will open up possibilities for students who are not thriving under the current curriculum, and for faculty who are frustrated because they cannot "reach" their students. "The only problem is," warned a colleague of mine from a university with a freshman-year curriculum that extensively utilizes active learning, "once students get into their upper-level courses, they complain like crazy if the class uses the old sit-and-listen-to-the-lectures technique." So we need to get ready!

In the last "Teach Talk," I described a body of research that shows that active learning methods work: In classes that use active learning, students learn more, retain more, and have a more positive attitude toward the subject matter of the course. In this "Teach Talk," I want to describe a few of the specific techniques that are commonly used when instructors move away from the strict lecture format. (To remind readers, I am using the phrase "active learning" to refer to a range of techniques that get students actually engaged in the classroom. The richest definition I have found comes from Richard Hake, an emeritus professor of physics at Indiana University, who writes that active learning is "designed in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors." (p. 65) ["Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics*, 66, 64-74, 1998.])

Active learning can be as simple as engaging students in Q&A during class, or it can be as involved as having them work on semester-long, team-based design projects. Here I would like to focus on three activities that have been used successfully in MIT classrooms: peer instruction, "the muddiest point in the lecture," and in-class group work on problems. An accompanying side bar provides a more complete list of active learning techniques (see p. 9).

Peer Instruction: Active Learning in Large Lectures

Professor Hale Bradt is explaining magnetic energy dissipation to his Physics II (8.02) class. Referring to a diagram of a LR circuit he has on an overhead, at about 15 minutes into his lecture, Bradt stops and asks the students this question: "At Time 0, the energy dissipated in R equals the energy stored in L. True or False." The students think about the answer for a few minutes, then raise their hands when Bradt asks, "How many think true? How many think false?" Next he asks the students to talk to each other about the problem. A low buzz engulfs the classroom. After a few minutes, Bradt asks for a show of hands again.

This technique, called peer instruction, was pioneered and popularized by Eric Mazur, a physics professor at Harvard. Mazur was discouraged about how little his students were learning when he used conventional lectures. As he writes in his book, *Peer Instruction: A User's Manual*, "Analysis of my students' understanding of Newtonian mechanics made it clear: They were not learning what I wanted them to learn. I could have blamed the students for this . . . . [Instead] I decided to change my teaching style and discovered that I could do much better in helping my students learn physics." (p. xiii) The "change" Mazur refers to was to get his students actually working during the lecture itself with the material he was presenting.

Peer instruction works this way: Every 15-20 minutes the instructor stops lecturing and asks the students a question about the *concepts* he or she has been explaining. These questions, which are either true/false or multiple choice, require the students to do very little, if any, calculation. (For an example of a concept question drawn from 8.02 taught by Professor John Belcher, see p. 9.) Students work the problem on their own for several minutes. Then they are asked to give an answer.

(While Professor Bradt has students raise their hands, other lecturers feel more comfortable giving students a way to hide their answers from one another, thereby protecting them from having to publicly commit to the wrong answer. Professor Belcher gives his students flashcards with numbers on them for this purpose. The rule is no one may turn around and look at the card anyone else is holding up. There is also a more technically sophisticated electronic system on the market, called Class Talk, which allows students to use a keypad to record their answers, but it is not available at MIT.)

After the students work on the problem individually, they are asked to talk about it with one or two of their classmates. Then they vote again. Mazur reports that the number of right answers almost always goes up after the students discuss the problem. (Mazur also asks students to report how confident they are about their answers; confidence levels also go up appreciably after discussion.)

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There are at least two advantages to peer instruction. First, *immediately after* students hear the instructor explain a concept, they can work with it themselves. Second, the instructor can get *instantaneous feedback* on how he or she is getting the material across. In fact, if most of the class answers the question correctly on the first round, the instructor can decide to move on to the next topic. Or, if there still seems to be widespread confusion even after students have discussed the question with one another, the instructor can spend more time on the topic.

This technique can be used in smaller classes, too, of course. Course 16 (Aero/Astro) Professor Steven Hall uses it in Unified (16.010). He asks students to work individually on a problem. Following that, students team up in groups of two, and each person explains his or her answer to the other. The team then synthesizes the best possible answer, and either partner may be asked to brief the solution before the class. A typical 50-minute lecture will contain three main ideas – 10 minutes of lecture on each with a concept test in between.

I read all of Professor Bradt's evaluations the semester he began using peer instruction. Almost every one of his students was enthusiastic about the concept tests because they gave them a break from the lecture, and because they helped them gauge their own understanding of the material. A few students (no more than a dozen) felt the concept tests were a waste of time or resented having to do something during the lecture other than listen and take notes.

The thing that worries almost every instructor about peer instruction is the loss of time: If students are spending time talking about concept A, that's time taken away from the instructor covering concept B. There is no getting around that. Professors Bradt, Belcher, and Hall estimate they cover between 10% and 15% less material because they use peer instruction. They also believe that is a small price to pay for an increase in comprehension. As Professor Bradt explains, "I don't feel I lose anything because I know the question is forcing them to think and get the basics down. Giving them another example is just not as productive. I only spend about five minutes on one of these concept questions – so maybe 10% less material covered. But no loss of concepts – just loss of more examples."

"The Muddiest Point in the Lecture"

In 1989 Frederick Mosteller's article, "The 'Muddiest Point in the Lecture' as a Feedback Device," appeared in the journal *On Teaching and Learning.* Mosteller, a statistics professor at Harvard, advocated asking students *in the last three or four minutes of every class* three questions:

"(1) What was the most important point in the lecture?

(2) What was the muddiest point?

(3) What would you like to hear more about?" (p. 10). "This simple idea attracted me," writes Mosteller, "because it might feed into *this* course given *now* and give immediate benefit to *this* teacher and *these* students without the need to wait for next year." (p. 11).

The "muddiest point" has been used regularly in Aero/Astro's Unified to acclaim by both faculty (five faculty regularly teach the subject) and students. The instructor distributes 3x5 index cards, and only asks students to identify the muddiest point. The students can sign their names or not to the cards. After class, the instructor sorts the cards into piles according to the unclear points identified or the questions asked. He can then do several things: talk about the question in the next class; send students an e-mail addressing the issue; make up a handout to give out in the next class period. Sometimes there can be just a handful of students who are confused about a particular point; a TA may be able to help them. And sometimes instructors who use this method report students hand in cards that say, "Everything was perfectly clear!"

Again, there are multiple benefits of the "muddiest point." It allows students to take five minutes at the end of class to reflect on what they have learned; it permits students to ask questions anonymously; it gives the instructor instant feedback; and it permits misconceptions to be cleared up within a class period. This is especially important in teaching the kind of technical material that is the bulwark of MIT classes, since concepts so often build upon one another. According to Professor Ian Waitz, another Unified faculty member and the chair of Aero/Astro's Teaching Methods Team, "The 'muddiest point' has been one of the most successful – if not the most successful – of all the active learning techniques we have implemented. It's an invaluable form of feedback both for the faculty and the students."

In-Class Group Work

Ideally, recitations are an opportunity for students and instructors to work together on material covered in the lecture that may still be troubling or confusing. Too often, they turn out to be lectures themselves with the

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Using Active Learning Techniques in the Classroom

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recitation instructor working problem after problem on the board. But, again, the findings of recent educational research tell us that learning occurs most successfully when the learner is actively engaged with the material. In other words, the recitation instructor may be learning a lot, but it is not clear that the students, sitting passively in class watching problems worked for them, are getting very much out of it!

An alternative is to put students into small groups (two to four) and have them work on problems together. There are several factors to consider when using this approach, and several variations on how it can be implemented. Here are some suggestions:

Who forms the groups? You can put the students in the groups or ask them to form groups themselves. If you opt for self-selection, make sure every student is a member of a group. Some students find it difficult to work with others; while you can acknowledge that group work isn't for everyone under every circumstance, you should explain this will be the norm for the class. Gently encourage students who don't naturally put themselves into a group to do so.

Should the same students work together in each class? There are advantages to forming permanent groups that have to do with teaching students team dynamics. Given that this is usually not an objective of in-class group work, students can form and re-form groups at each class session.

How much time should be devoted to group work? Some instructors spend the first 10-15 minutes allowing students to work on a problem; then they use the rest of the time in recitation to work through that problem and others with the class. Other instructors devote all of the recitation to group work. I believe either format can be effective depending on your objectives. In any case, it is best to spend at least the first five minutes of the period orienting the students to the topic at hand, and the last five minutes summarizing the work that was done that day.

What role should the instructor play? After the team has been working together for at least a short period of time, you can move around the class, making yourself available to the students. At first, having the instructor "eavesdrop" may make the students self-conscious. But when it is clear that you are a *resource* for the students, you should be able to move among the groups naturally. You can also stop the group work and reconvene the class as a whole if you see a common problem cropping up for most of the students.

What happens if one or two students in the group get the answer much more quickly than others, or if one group finishes much sooner than the rest? I believe the group should be encouraged to work as a whole: that is, more capable students should be asked to help their teammates understand the material. If students seem reluctant to do that (and some will), explain that teaching something to another person is the best way to reinforce your own learning! One instructor keeps several harder problems in his "back pocket" for students or groups who finish the assigned problems quickly.

Should students then be chosen to work the problems on the board? In the recitations that I've observed, asking students to work whole problems on the board has not been particularly effective. Students seem to have a hard time re-creating the steps they went through to solve the problem, or they are unfamiliar with speaking in front of a group at a blackboard.

A better technique is to give different students specific questions to answer. You may want to develop the entire solution to the problem step by step. Or, you may want only to discuss the first step in solving the problem, the key idea, or the places where students are likely to have difficulty. This kind of focused discussion keeps the class much more on target, and makes the best use of the available time.

When during the semester should this technique be implemented? The sooner the better. If you intend to use in-class group work, tell the students that this will be the way the class will be run on the first day. (That allows students who may be reluctant to participate in groups to switch sections.) One recitation instructor gave out a sheet the first day of class that outlined the method he intended to use.

Each of the methods described here will require some experimentation in order to work most effectively in an individual subject, with specific material and particular course objectives. Active learning also requires a shift in the relationship between the instructor and the students. As people in education circles say, the instructor has to change from being a "sage on stage" to a "guide on the side." I prefer to think that the instructor can widen his or her repertoire of pedagogical tools to incorporate both. There is much satisfaction in doing so.✣

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Promoting Active Learning

The following is a list of ideas for activities inside and outside of the classroom that can help to promote active learning. Although the list is far from complete, we have tried to provide a wide range of suggestions.

Engaging Students with Subject Material
• Use exercises or problems in class
• Ask questions in class; call on students to answer those questions
• As a homework assignment, have students generate questions to bring into class
• Have students generate their own examples and illustrations
• Have students write short summaries of discussions or lectures
• Require students to keep journals on some aspect of the subject
• Assign students the task of writing homework problems
• Have students give each other feedback on some portion of their classroom performance
• Hand out incomplete notes that students have to fill in during the lecture

Developing Interactions Among Students
• Use an ice breaking activity at the first class (e.g., pair students and have them introduce each other)
• Team students in small groups to work on homework problems
• Provide time in class for students to discuss course material or solve problems
• Set up student panels or debates
• Pair students for problem solving with one student recording how the other solves the problem
• Set up a Web discussion forum for the course

Developing Faculty-Student Interaction
• Learn students' names and have students learn each others' names
• Arrange the classroom so that students face one another
• Describe the kind of interaction you expect in class at the beginning of the semester
• Survey students to find out their knowledge base and expectations for the subject
• Tell short, focused, relevant war stories
• Arrive early to class; stay after class
• Describe some part of your research
• Walk around the classroom rather than just staying at the front
• Recognize and compliment student participation
• Ask for feedback about the subject regularly

Incorporating Engineering Practice
• Use demonstrations
• Use cases
• Pass around hardware
• Plan trips to plants or other field trips
• Use game playing simulations
• Bring in guest lecturers
• Relate current events to class material
• Assign on-paper design contests

Compiled by Benjamin Linder, Ph.D '99
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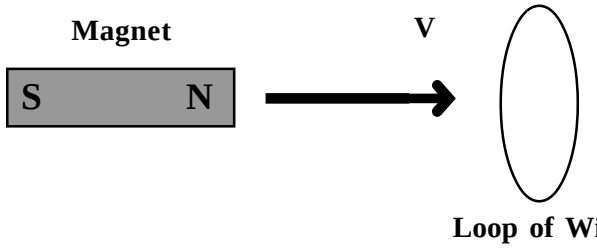
8.02 Concept Question

When we move a permanent magnet through a coil of wire and observe the induced current in the wire



the force on the magnet when it is first moving into the loop of wire and then when it is moving out of the loop of wire is

(1) always attracting the magnet to the loop
(2) always repelling the magnet from the loop
(3) first attracting the magnet to the loop, and then repelling the magnet from the loop
(4) first repelling the magnet from the loop, and then attracting the magnet to the loop

Professor John Belcher

From The Libraries

Digital Information Resources Brought to Your Desktop

Carol Fleishauer

If you haven't visited the MIT Libraries' Website recently <http://libraries.mit.edu/>, you may not be aware of the Libraries' substantial and growing investment to bring digital information resources to your desktop. The Libraries currently provide access to approximately 150 databases and nearly 1000 electronic journals, in all subject areas important to the Institute's curriculum and research programs. There's something for everyone, and we encourage you to explore the possibilities. Even if you haven't visited the Libraries' Website, you may have been using some of these resources by connecting directly to a publisher's or society's Website. Although you may not be aware of it, in many cases the Libraries' payment to the publisher or society has enabled your access to the products.

The purpose of this article is to let you know why we are investing in these resources and how this new type of library "acquisition" differs from our traditional activity of buying books and journals for your use.

Why Are the Libraries Investing in Digital Information Resources?

Networked information resources expand your options for where and when you can work, and often how, and how effectively, you can work. The goal is to enable you to use digital information sources in your office or laboratory, or from distant universities or other sites where you may be working on a temporary basis. Your students can use them in their dormitory rooms or from another state or country within the context of a distance education program. You and your students can use these resources at any hour of the day or night, regardless of time zone. In many instances, digital information resources also offer improved functionality over traditional print resources. For instance, a digital database may enable you to search many years of a reference work much more quickly than you could in the multiple volumes of a print publication. Some of the electronic indexes now provide "hot-links" to journal articles, and most full-text databases provide keyword searching. As digital databases and full-text products develop, we expect that their features will diverge more and more from those of print resources, incorporating multimedia, for example.

The Libraries are investing in these resources because they are the next generation of research tools, providing an improved means to maintain currency in the various academic disciplines, and producing research results within a competitive time frame. In spite of the notable advantages of digital information resources, however, we do expect print resources to survive in tandem, with a natural discrimination developing for the various purposes of scholarly communication.

How Do the Libraries Select Information Resources?

Choice of resources provided is based on pertinence to MIT's research and education programs, size and breadth of the potential user group, price, and functionality. The Libraries have established a separate budget line for expensive, interdisciplinary information products, and decision making is entrusted to a standing committee of librarians from the five divisional libraries: Barker Engineering, Dewey, Humanities, Rotch, and Science. The committee members are responsible for appropriate consultations with faculty and with other librarians. In most cases, there is a trial period for the product before the decision to purchase is made.

As digital products emerge in the marketplace, substantive differences from print publications are becoming obvious. In selecting print publications, librarians have chosen within genre with long histories and established traditions: monographs, journals, indexes, conference proceedings, etc. In the digital marketplace, the product types are still developing and diversifying. Significant changes are evident, however. The way electronic journals are being marketed provides an example.

Many e-journals are sold only within a package of all of the journals of a given publisher, with no option to select only those titles most appropriate for a given institution. In another pattern, an intermediary vendor provides a selected set of journal titles from various publishers, intended to fulfill the needs of a designated group such as undergraduates. Again, there is no option to select only those most useful to the MIT community or to add others that the provider has not selected. The tradition in library collection development has been to select individual titles (books, journals, etc.) that are judged to directly support a university's education and research programs. In the case of digital resources, the selection decisions are based on the advantages and dis-

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Digital Information Resources

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advantages of competing aggregations of content. In addition, the content of some of the aggregated products fluctuates from year to year!

How Do the Libraries Acquire and Manage these Products?

In most cases, digital information resources are not purchased; they are licensed for use by the MIT community for a fixed period of time. The Libraries actively negotiate the terms of the licenses with providers to ensure that all members of the MIT community may use the products in accordance with the customary standards of scholarship, as well as to protect MIT against liability. End-users of the products also have responsibilities, however, and the Libraries try to make users aware of these by screen messages and "clickable" access to use restrictions or to the licenses themselves.

Each of the licenses negotiated by the Libraries contains a definition of the MIT community. The Libraries attempt to ensure that these definitions reflect the array of users who can obtain MITnet accounts. In addition, the Libraries' walk-in users are allowed to use the products from library workstations. However, providers are usually unwilling to include access to users they believe are potentially separate customers. Alumni, for instance, represent a user group that is too broad for providers' interests. Likewise, the inclusion of distance education students whose degrees will be granted by other universities may be impossible to negotiate.

Control of on-campus use of networked resources is managed by IP (Internet Protocol) filtering. The way this works is that the Libraries provide the publisher or vendor with MITnet IP addresses. The server on which the product resides checks the IP address of a person requesting access to the product to determine whether he or she is based at an institution that has paid for the access. Remote access by MIT community members from their homes, their travels, or distance education sites is managed by a proxy server (the "GO" service) which utilizes certificates to authenticate users. Some products are restricted to on-campus use by the terms of the licenses.

The acquisition of digital information sources, then, is considerably more complicated and less standardized than the acquisition of print books and journals. While every effort is made to facilitate the negotiation of licenses, the process can delay access to a product for several weeks. In addition, the Libraries take advantage of purchasing through a consortium of libraries when significant price reductions can be realized. Purchasing through a consortium may affect the timing of product choices and may limit the ability to negotiate licensing language.

What are the Ramifications of Access Rather than Ownership?

A significant unresolved issue related to licensed information resources is the lack of permanent access to the information. In the case of print resources, the Libraries purchase and own the content (although not the copyright). The Libraries may, and usually do, retain the print resources permanently. Books and journals from 20 or 50 years ago provide a rich mine of information for active research in many disciplines, for retrospective research into aspects of a discipline that may have lost and then regained scholarly interest, and for studies of the histories of the disciplines themselves. One might think of the print model as "pay once, use forever."

In contrast, the model for the licensed digital product is "pay for one year, use for one year." In most cases, the license for a product does not transfer ownership of the content to the Libraries. If the Libraries (for reasons of rising prices, budget constraints, or waning scholarly interest) do not renew the license and pay for it on an annual basis, the MIT community will no longer have access to information content licensed in previous years. If the provider ceases to offer the product or goes out of existence, the result will be the same.

Even in those cases where the provider agrees to ensure perpetual access, there are legitimate reasons to be dubious of that guarantee. For one, commercial publishers in the print environment have not typically maintained backlists after they were no longer profitable. For another, few publishers last as long as universities. For yet another, there are many difficult issues related to migrating products while hardware and software develop over time. Libraries have centuries of experience managing the shelving and preservation of print materials (with many problems related to the latter still existing), but libraries and publishers are only beginning to develop standards and gain experience with managing "digital shelf-space." Meanwhile, some trusted third-parties are also experimenting with providing archiving services.

The MIT Libraries' mission includes preserving the record of advances in knowledge in the relevant areas of science and technology, as well as architecture, linguistics, and many other disciplines. In this interim period, while the standards and structures for managing digital collections are developing, the Libraries continue to purchase print resources for that purpose, at the same time carefully monitoring emerging alternatives.✣

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Poem and Image

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all.") one had to do with poems and images. A poem, so I was confidently told, was an arrangement of words that frequently (almost always, until recently) rhymed. But the heart of the poem was its image. Poems were customarily allowed only one image, and it was the job of the poet to define and manipulate that image in the cleverest fashion imaginable. Poems, in short, were more or less images with fins and chrome. This was the Fifties, so fins and chrome were compliments.

It wasn't hard to find poems that fit the definition pretty well. This image of poetic images was one of those dangerous errors that is partly true, and therefore partly provable. Fortunately, its usefulness wears away quickly, once you escape from the anthology. It doesn't do a darned bit of good with Yeats or Wallace Stevens or even Shakespeare's sonnets, which have a nasty way of piling image on top of image, of complicating verbal pictures – that's what an image *is*, isn't it? that's why they call it an image, just like a photograph, isn't it? – with sound patterns and tactile images and Lord knows what all else.

It finally dawned on me one day (I won't say how old I was; I'm a little embarrassed to admit how long it took me to wise up) that poems were insidious little things that took as their work the complete unsettlement of the universe, the challenging of all the consoling presumptions you'd tinkered together over the years. Poems are, often in the quietest way possible (they've figured out, you're a more likely sucker if you're half asleep) complete revisions of the way you think. They have, at their disposal, a whole range of tricks, honed to a fine complexity over the centuries. But mostly they work with only two meager tools: language and imagery.

One problem with language is that it's so shopworn, used by everyone from Shakespeare to children singing nursery rhymes, constantly acquiring new meanings, new implications. That makes it a restless and often awkward tool. I can recall, once, sitting on a faculty committee charged with the work of writing some legislation. One of my engineering colleagues, frustrated by our efforts to find just the right words, lamented, "Can't we just use *algorithmic* language?" He was not in the least mollified to have it pointed out that no such creature exists. Which, of course, is why computer programmers prefer numbers.

Still, that very multiplicity is, in its way, an advantage. Any word worth its salt (or, more to the point, worth its poem) means four or a dozen things. The poem's work is to try to unleash all of those meanings at once. Which is why poems are bad things to read when you're trying to relax yourself to sleep, and impossible things to read fast: they demand that you linger over almost every word, considering the possibilities the way chess champions are supposed to be able to do.

But language (along with its subsidiary pleasures, like sound and rhythm) is really just the raw material of the poem. What makes it a poem (as opposed, say, to a short op-ed piece) is the image. William Carlos Williams said once that:

It is difficult
to get the news from poems
yet men die miserably every day
for lack
of what is found there.

Williams was a doctor, in the slums of Northern New Jersey – no airy-eyed romantic. He knew what "news" is, and how rarely it is found, in the normal course of things, in poems. He also knew, all too painfully, what causes miserable death. But if you take "news" here as, itself, an image, then the proposition at least becomes conceivable. And the result is not the death but the misery, after all.

To the poet, the image – observed or imagined, or when things are working well, both at once – is the germ. To the reader, the image is something else. In fact, that's part of the heart of the matter: the image *is* something else, something unexpected, something unfamiliar, and maybe even (when the poem tackles one of those nagging Big Questions, like death or love or the nature of the universe) something unpleasant. All the poem wants you to do, after all, is look at everything – every darned single thing – in a new way. And the image is the lens it asks – no, demands that you look through (and entices you to look through, too, of course). Williams is a master of this; one of his poems demands that you look scrupulously, and in the end lovingly, at a brown paper bag being blown down a city street. Every poet has his or her favorite pallet of imagery; it's one of the things that makes for a unique poetic "style" or "voice."

But it may be with images that there are really only two kinds, the useful and the ineffective. No, not useful;

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Poem and Image

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necessary, the ones that nag and nag at your mind, as opposed to the ones you can't even remember, ten minutes later – the ones that change the world and the ones that just take up space. Read enough poetry and the images will stay, forming your vision. On a bright December day you will not be able to keep from remembering that:

> *There's a certain slant of light,*
> *Winter Afternoons –*
> *That oppresses, like the Heft*
> *Of Cathedral Tunes.*
>
> (Emily Dickinson)

A month or so earlier, fighting like mad to avoid thinking of age and mortality, still there will come creeping into your mind the thought that:

> *That time of year thou may'st in me behold,*
> *When yellow leaves, or none, or few, do hang*
> *Upon those boughs which shake against the cold.*
>
> (William Shakespeare)

And once you've made it again to the grey days of earliest March, you'll look out the car window at some unprepossessing field full of the

> *reddish*
> *purplish, forked, upstanding, twiggy*
> *stuff of bushes and small trees*
>
> (William Carlos Williams)

and realize that, if you could only look hard and carefully enough you'd be able to see "the stiff curl of wild carrot leaf" as "Spring and All" triumphs again.

The end point of these maunderings is that what poetry intends is a kind of cognitive rearrangement, a restructuring (and no less than that) of the way you observe and understand the universe. But consider Warner Heisenberg's mild-mannered formulation of the importance of Einstein's General Theory:

> *It was among the self-evident presuppositions of science that space and time are two qualitatively distinct schemes of order, forms of intuition, under which the world is presented to us. . . Einstein had the uncommon courage to cast all these assumptions into question, and he possessed the mental power to think out how, upon somewhat different assumptions, one may also arrive at a consistent ordering of the phenomena.*

There is something so insouciant about that formulation, the ease with which Heisenberg contemplates the disposal of fundamental "forms of intuition." I encourage you to look at some of Yeats's poetry – he does this all the time. You've heard of the Second Coming, the final triumph of Good and Right and Justice? Look at his poem entitled "The Second Coming," and prepare for unsettlement. Or read MIT's own Alan Lightman's fine book, *Einstein's Dreams*, and enter a marvelous exploration of the scientific mind playing with . . . metaphor. "What if time is square?" I recommend the book frequently to friends of mine who are, in fact, poets. But always with the acknowledgement that the author is an astrophysicist.

The ecologist and naturalist Edward Abbey puts my case this way:

> *Any good poet, in our age at least, must begin with the scientific view of the world; and any scientist worth listening to must be something of a poet, must possess the ability to communicate to the rest of us his sense of love and wonder at what his work discovers.*

Or, closer to home, the head-note to the section of the MIT course catalog which lists the offerings of the School of Science: "Above all, science is elegant, beautiful, and mysterious; it ennobles the human spirit." My argument is really very simply made – replace the word "science" in that sentence with the word "poetry" and you have a reasonable label for, say, Keats's *Odes*.

If poetry has one great advantage over science, it comes in the area of cost and portability. A good book of poems (and you can find a treasure trove of them, just two stops up the Red Line, at the Grolier Poetry Book Shop in Harvard Square) might cost $12, at the most. And it would surely fit in a pocket. No lab, no Defense Department grants to apply for or administer, no complex computer modeling to keep you up half the night, logged on to Athena. Just careful reading, careful looking, and hard thinking, about the fundamental nature of things. And no proven medical side effects either, although the truth is, for some of us at least, it is a tad addictive.✣

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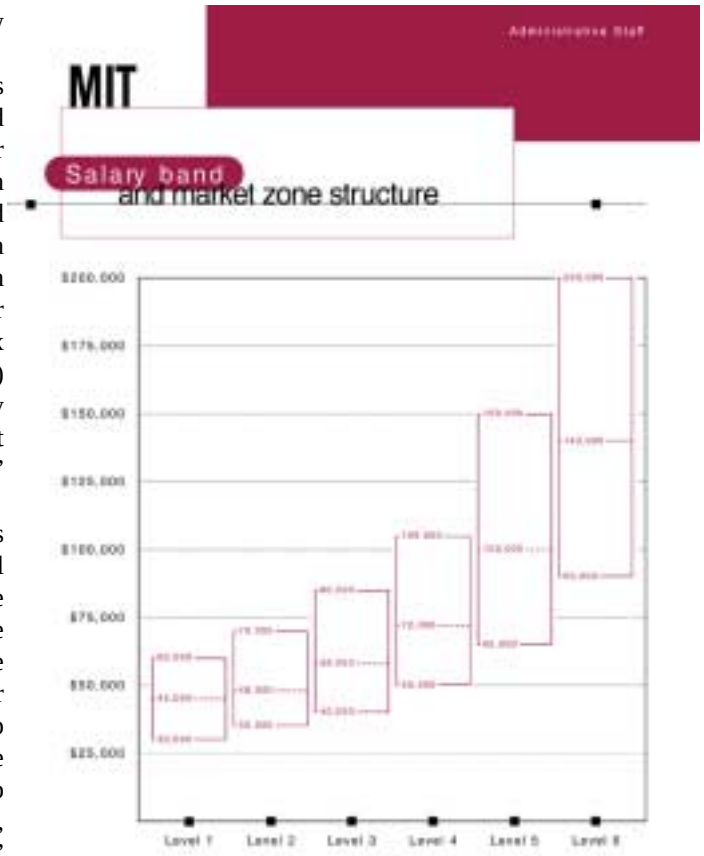
Classification and Compensation System Changed for Administrative Staff

Nora E. Costa

Faculty who conduct the annual performance review for administrative staff members need to know that the classification and compensation system has been changed for this payroll group. The review period will still be in March with pay changes effective July 1, 2000, but the structure of the system has been simplified, and there is some new terminology.

Here are some of the main differences between MIT's new system and the old "point" system that has been used for 25 years. The new system focuses on the qualities of complexity, scope and impact of the job, rather than quantitative metrics associated with the number of people managed or budget size. The new system has six classification levels (rather than 42) and six corresponding broad "salary bands" with "market zones" that replace the old terms of "salary range" and "mid-point."

Every administrative staff job has been assigned to a classification level (salary band) and market zone. The external market and the internal value of the job determine the market zone within the salary band for a particular job. The market zone concept will help managers identify the appropriate "marketplace" salary for a given job within the broad band. For example, the positions "admissions counselor" and "systems programmer I" are classified in Level 1. Data from the external salary marketplace shows that the admissions counselor would be paid on average about $32,000 annually, whereas the systems programmer is likely to earn closer to $50,000. Both jobs are valued at the same classification level within MIT, however the average salaries for the two positions are quite different. By identifying the part of the salary band a particular job should be paid within, the new broad band system will provide individuals with a more realistic view of how they are paid compared with "market" for the kind of work they perform. An illustration of the salary bands, which will be in effect until June 30, 2001, is below.



Six "compensable factors" were used to determine the new classification level for every administrative staff position on campus. These factors include collaboration; communication; influencing and leading; critical thinking and problem solving; knowledge, skills and expertise; and responsibility and accountability. The full classification model is available to view and print from the Compensation Office Website <http://web.mit.edu/personnel/www/compensation/>.

In February, each staff member received an individual letter with their level, salary band, and market zone as well as a packet explaining the new system. The classification level of every administrative position was reviewed by the senior officer or department management head who oversees the position, and no individual's salary will be decreased as a result of the new system.

The factors to consider in determining merit pay increases continue to include the following: fulfillment of job performance requirements, contributions to results, peer comparison/ internal equity, and recognition of superior performance. MIT staff members will be paid within the minimum/maximum boundaries of the assigned salary band. The market zone dividers within each band should be used as guidelines for determining market competitive salaries.

When an employee's salary is above the market zone assigned to the job, the manager may do any of the following when making merit pay allocation decisions.

- Grant an increase to base pay, based on performance, provided that the increased salary does not exceed the salary band maximum;
- Provide a lump sum payment to the employee on the effective date of the review in lieu of an increase to base pay;
- Provide an increase in base pay up to the salary band maximum and distribute the remainder of that increase as a lump sum merit payment;
- Provide no increase or lump sum payment. This option should be used only in the case of significant poor performance, for which corrective action is planned and documented.

Information packets provided to administrative staff are available to faculty through their administrative officer, the Dean's Office, or the Human Resources Department.

Questions about the new classification and compensation system for administrative staff may be directed to me at 3-4279.✣

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Student Leaders Report

In response to a recent request by the president of the Graduate Student Council (GSC), the Faculty Newsletter *has initiated the following regular feature, written by the president of the Undergraduate Association and the president of the GSC.*

Undergraduate Association

A Look at the Freshman Year: The Science Core and Class Size

Matt McGann

The Task Force on Student Life and Learning identified improving faculty-student relations as a big need at our Institute. By and large, students don't know much about the life of a faculty member, nor do most faculty know much about student life.

It is my hope that this column will be the beginning of a regular look into student life issues at MIT. Sometime in the near future, perhaps I'll try to explain why students are so enamored with a residential system which most outsiders see as bizarre, or why some students have recently gotten upset with the athletics department, or how the tradition of hacking enriches student life.

For this first column, though, I'd like to address the perennially hot topic of the MIT freshman year academic experience. This is an issue that nearly every member of the MIT community has an opinion on and feels passionately about. Rightfully so – the freshman year truly shapes the entire MIT undergraduate experience.

Currently, there are a handful of Institute committees examining various aspects of the freshman year. Professor Charles Stewart of the Political Science Department is chairing a committee on the future of Pass/No Record grading and Advanced Placement credit. There's another committee whose task is to implement experimental programs around the freshman core, including those proposed by last year's Educational Design Project.

As I see it, these committees aren't really getting to the heart of the matter. To do that, we must examine the basic causes of our problems.

Some in the faculty have told me that they believe the current P/NR system makes students lazy and inattentive in class, and shoot for the old tradition of the "gentleman's C." Others assert that AP credit is among the reasons students are unprepared for more advanced subjects. Still others say that if we inject some excitement into the edges of the freshman year, around the science core, the ills of the freshman year will be cured.

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Graduate Student Council

Graduate Student Issues are Faculty Issues

Luis Ortiz

When the editors of the *Faculty Newsletter* responded positively to my suggestion for a standing column by the leaders of the undergraduate and graduate student governments, I felt such articles would be valued by both the faculty and the students. I hope to use this first installment as an opportunity to introduce you to the work of the Graduate Student Council (GSC), why those efforts are important to you the faculty and give a glimpse of more focused communications to come in future issues of the *Newsletter*.

The purpose of the Graduate Student Council is to promote the interests and needs of the graduate student body. This is a broad mandate, and historically, we have decided to attack those issues and topics that are brought to the Council by our representatives. Graduate students, as well as faculty, choose MIT because of the quality of the individuals on campus; the opportunity to work together and interact is MIT's largest asset and consequently, a cooperative relationship is natural. Therefore, the needs of your graduate students not only often overlap the needs of the faculty (quality lab and office space, parking, good health insurance, etc.) but also are of corollary importance to the faculty based on the strong relationship between the two populations.

I have had a tremendous opportunity to work with outstanding faculty in relation to my research project as well as on faculty and Institute committees. This experience helped me reach a rather natural observation: faculty and graduate students often share a common world view while having similar aspirations. But of course! However, I do not believe that the faculty as a body and the GSC have worked together to realize our common goals. I hope that this regular column will help initiate a better dialogue about graduate student issues.

Graduate Student Issues

- **Housing:** Are your best prospective students choosing other schools because graduate school at MIT is too much of a financial sacrifice? Are your current students able to

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The Science Core and Class Size

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All of these contentions, of course, have some truth to them. But I believe that we are still only nipping at the edges of the real problems. The real problems, as I see them, are these:

• There is too little coordination in the Science Core.

• The classes in the mainstream freshman curriculum are too large.

A central problem that I hear about from freshmen and upperclassmen alike is the perceived lack of coordination of classes in the freshman core. Part of this means that freshmen don't see how the core subjects influence each other. This is made all the more difficult by the fact that freshmen don't all take the same subjects: some come in with credit for Calculus I, others take biology instead of chemistry, etc. Programs like Concourse attempt to unify the curriculum, but these programs affect only a minority of each year's incoming class.

Another part of this, though, is that freshmen even more often don't see the connection between the core classes and things that they care about. A step in the right direction is the new Media Lab freshman year program, where students have their science core recitations together, with an instructor from the Media Arts & Science program providing context to the material, relating it to technical innovations.

Finally, we run into the somewhat-related problem of these science core classes as doppel-gangers: trying to be both core classes as well as introductory classes for their department. Physics serves quite different purposes for physics majors and for management science majors.

The other central problem is that many freshman classes are just too big. Rooms like 26-100 and 10-250 hold many hundreds of students. Walk into a large lecture class on any given day, and you'll see students asleep, or doodling, or daydreaming, as well as the majority of the students frantically scribbling down everything the professor says or writes on the blackboard.

What's happening here? It's not that MIT is admitting lazy students, or non-interactive students. Rather, it's that we're conditioning our students to be passive learners. We're telling our students to sit and listen, then go home and work through some heavy calculus or chemical structures. This is a suboptimal way to learn. Students who are not engaged in the material do not learn it and retain what they learn nearly as well as in active learning.[See Teach Talk, p. 1.] We owe it to our students – the future leaders in academia, industry and government – to provide the best education possible.

This conditioned passive learning affects more than freshman classes. Students behave in the same manner in upper-level subjects, and even in some small HASS classes. I'm sure you've taught a class where you felt it was like pulling teeth getting most of the students to participate. It's because of this conditioning.

I believe that in the same way, large freshman classes condition for poor student-faculty relations. It's very difficult for students to approach the lecturer in a n-hundred person class. The faculty are seen as intimidating. Often, this is eventually overcome by relationships with UROP mentors (and occasionally in traditional advising settings), but in the meantime relations suffer.

I'm not trying to belittle the hard work put into these classes by such passionate instructors as Professors Don Sadoway and John Belcher. Most of these problems are completely independent of their hard work. Sometimes I have to remind myself how much worse the freshman year could be if these great teachers weren't around.

Currently, we as an Institute have two special opportunities to make positive changes in the freshman year, one of new resources and one of new ideas. Alex and Brit d'Arbeloff's generous gift of $10 million provides us with the financial resources to innovate in the first-year curriculum. And, later this term, a faculty member from your ranks will be appointed the next dean for Undergraduate Education.

Work with this dean. Allow the dean to have true power over the freshman year. Rally your fellow faculty to forget the Institute's "sacred cows" to take advantage of this unique time. The true curricular power at MIT lies in you, the faculty. Let's remake the freshman year so we can truly declare that MIT is the world's greatest educational institution.✣

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Graduate Student Issues are Faculty Issues

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be productive with their current commute or level of poverty?

• **Advising:** What do your students need from you? Is there a clearly communicated set of expectations?

• **Careers:** How well will your students be prepared to impact the world? They know how to do research, but have they been taught to teach or work within an organization?

Housing

Throughout its existence, the Graduate Student Council has been working to improve the housing situation for the graduate student body. This becomes immediately clear just by glancing back through old issues of the publications of the GSC (*The Graduate*, *The Graduate Student News*, and others). We are in a particularly critical time because of the competitive nature of graduate student recruiting nationally. The cost of living in the Boston/Cambridge area has become a competitive disadvantage for MIT in recruiting the best graduate students. (If you have any doubt of this I would be more than happy to share the three-ring binder full of complaints received over the last 15 months about the cost of living at MIT.) Not only does the GSC have to advocate to the senior leadership of MIT for more safe and affordable housing close to campus, but also we have to protect the campus housing that already exists for graduate students. Administrative decisions end up shuffling graduate students around and hasty negotiations often result in costly mistakes (such as the Worthington Place contract, which currently has MIT spending $90,000 a month to rent apartments that are standing empty.) (See *The Tech*, 2/4/00.)

The response of students has been to either attend other schools, move further from campus, or simply pass up graduate studies because the sacrifice is seemingly unjustified. These methods of coping are worrisome to us of the GSC, and I believe that the faculty share our worries. There is much more to be discussed around this issue, and that will be the focus of a future installment of this column.

Advising

As reported in the February issue of the *Graduate Student News*, the GSC over the years has received communication from graduate students who have had misadventures with their advisors and feel powerless to change the situation. The issue is a complex one, and I encourage you to take a look at the article. One lesson to be drawn from this, is that even with the close collaborative relationship graduate students share with individuals on the faculty, there can be chasms that exist in communication. These chasms, and the culture that they expose, are not healthy or desirable for anyone on the campus and can be diminished. Although the apprentice-like relationship is valuable and integral to the graduate student educational experience, the GSC is working to voice concerns about the current nature of that relationship and shape what the relationship will look like in the future. Faculty are the key element in this relationship and as such you will delimit our success.

Careers

In its 1995 report, *Reshaping the Graduate Education of Scientists and Engineers*, the Committee on Science, Engineering, and Public Policy (COSEPUP) (joint committee of NAS, NAE and Institute of Medicine) identified that graduate education produces professionals who are going into an ever widening range of careers. Consequently, they recommended that U.S. graduate education change to "impart a broader range of skills" while "retaining the features, including an original research experience, that have made it a world model." Although much of the rest of MIT has ignored the recommendations of COSEPUP, we at the GSC have been endeavoring to realize this goal. We bring numerous companies to campus with the specific focus of recruiting graduate students with our Career Fair. The GSC has initiated programs for graduate students such as the Externship program (IAP job shadowing), Travel Grants ($10K per year to support student presentations at professional conferences) and a Professional Development Seminar series.

Without a doubt, the faculty ensures that graduate students will have a solid research training upon graduation. But who provides instruction to those interested in academic careers about pedagogy, job placement, and the demands of an academic life? Or about the professional skills (beyond research prowess) that are needed to be effective in the private sector? While there are certainly pockets of excellence on these topics (each year we commend those excellent examples at the MIT Awards Convocation with the Perkins Award), the bulk of MIT's graduate students are failing to receive that "broader range of skills" and have made this known to the GSC. There are many that provide this at a local level, and we thank you. After all, graduate degrees are professional degrees, and preparing students for their future career is critical. Let us work together to provide a graduate education to MIT students that meets the needs identified by COSEPUP so that we can continue to be the undisputed leaders in graduate education.

Conclusion

I hope that the description of these three issues has been informative. These are just part of the work of the Council, but a part that is of particular importance to the faculty. In the next couple of articles, I plan to expand the discussion on issues of competitiveness and advising.

I know that we have common interests and goals and I hope that this will be the beginning step in raising awareness of the needs of graduate students and building a relationship with you, the faculty.✣

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Letters

Overburdening of Faculty and Misapplication of Resources

Faculty Colleagues:

This letter responds to the Chair of the Faculty's "Partnerships and Faculty Governance" article in the November/December 1999 *Newsletter* and what I see as a disjunction in the President's Annual Report between the sections (as phrased on the Web) "Faculty extend role in student life" and "Industry ties increasingly crucial."

Some of the following was originally penned for my contribution to the MIT Class of 1950 50th Reunion Book (but omitted later by me as too negative for that celebratory document). But the experiences which demanded that I "do something" reflect my participation during two IAP meetings, the first of the Mechanical Engineering Department, poorly attended though held in the splendid ambiance of the University Park Hotel, and then the oral examination of candidates for my discipline qualifying for the Departmental Ph.D. Despite pleas by the department head to the faculty, the examiners for my session (out of some dozen full-time faculty) were two emeriti and one adjunct professor, one loyal faculty colleague, and the junior faculty member who had organized the exam but is leaving MIT due to being "burned out."

The bottom line of my remarks are the overburdening of the faculty and the misapplication of MIT resources in the face of demands upon the faculty.

Let me start by reflecting on MIT as I have known it and on how it has changed in recent times. From my first faculty appointment in 1953 through my retirement in 1992, the progress of the individual undergraduate and graduate student could be the be-all and end-all of a faculty person's commitment and focus. One's research program relied on endlessly proposing to external funding sources, virtually all governmental – NSF, NIH, DOE, etc., and winning competitively. Once the federal funds were committed, if appropriate research results were published, one could go back to the well with new proposals with reasonable expectation for further funding. The work-force for the research was composed of graduate students (doctoral and master's candidates), assisted by under-graduates in the S.B. thesis and projects. If a project or thesis task proved more daunting for the student than anticipated, or the student somewhat slower, accommodations could be and were made by the faculty person. Over my academic career, I supervised uncounted pre-UROP and UROP undergraduate projects, 155 bachelors', 104 masters', and 52 doctors' theses. SB and SM graduates mainly went on to industry; for many of those completing doctoral degrees, academia was the goal – about half of my own Ph.D. students are faculty, a former chancellor at Texas A&M, a department head at Caltech, a dean at Penn State, two former heads and four current members of the MIT Mechanical Engineering Department, etc.

For me at least, those fulfilling, intense days have changed and not all for the better. Federal support of research is now significantly complemented by funding from industry. I know from limited experience with industry-funded research, that companies don't just give money and go away; they expect results and regular reports of progress from funded faculty and therefore from the students the funding supports (as well as from the much increased research staff), putting everyone under a lot of pressure to meet deadlines. What's worse, I read in *The Wall Street Journal* and hear elsewhere that faculty-student effort increasingly leads to forming new companies, sometimes *even before the student gets the degree!* Intellectual property issues of who owns what intrude upon traditional academic pursuits and secrecy replaces the prior open publishing practice. The pace gets faster and more complex, and scholarly interests are side-tracked. And too many individual faculty, as part of the contemporary society at large, look to their own interests rather than the common good, here that of their students (e.g., the Ph.D. exam). I appreciate that the university cannot be isolated and that it will reflect – and strive to lead – the greater world of industry and commerce. I am just glad that I retired when I did.

And as the Faculty Chair discusses in the article cited, exceptionally funded major alliances with industry and other universities are the order of the day, negotiated not by individual faculty (charged to implement them) and the sponsor, but by senior administrators.

Then there is the Report of the Task Force on Student Life and Learning, and the issue of "quality of student life." I can't agree more with the President's "...view that faculty do have certain collective responsibilities

(Continued on next page)

Letters *(continued)*

to our students beyond their formal duties in the laboratory and classroom." But achieving that "responsibility" mandates the opportunity for at least some faculty to live nearby. When MIT acquired the Simplex property decades ago (where University Park is now) Ken Wadleigh, then dean of students, and I served on a committee which proposed extensive faculty and student dormitory and fraternity housing along and behind Vassar Street. Shades of the new dorm! The development of Kendall Square, sans any housing, was another lost opportunity.

In the face of these new demands on the faculty, its size remains static, while the total staff burgeons. One small calibration: At a celebration of that marvelous renovation of Baker House, as resident in its first year ('49-'50 as the original "New" Dormitory), I was called upon to make a few remarks. I reminisced that Ev Baker, then dean of students, was supplemented with a freshman dean, and each had perhaps a secretary. Compare that with the current corps in the Office of the Dean of Students and Undergraduate Education!

And not only is the size of the faculty static in the face of new actual and proposed obligations, its funding also seems mired. At that ME Department meeting, in response to questions along the lines of this plaint, the department head noted that the ME budget from the administration is $8.2 million, of which only $200,000 could be considered discretionary – this against what I understand to be an on-campus budget of about $1 billion. Thus the department, with the second largest student enrollment, gets 8.2% of the on-campus MIT budget to run its shop. I ask the *Newsletter* to publish in its "M.I.T. Numbers" an abbreviated but interpretable MIT budget with allocations to departments, administration, offices, faculty, staff, etc.

I repeat my "bottom line" – overburdening of the faculty and misapplication of MIT resources in the face of demands upon the faculty – neither bodes well for the future.

In frustration,

Robert W. Mann, Sc. D.
Whitaker Professor Emeritus
Biomedical Engineering

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Thanks for Your Support

To The Faculty Newsletter:

I am writing on behalf of the MIT Year 2000 Team to thank you for your support of our efforts. We are grateful for the opportunity you gave us to submit articles explaining the Institute's Y2K efforts. I also want to thank the faculty and the rest of the MIT community for their cooperation which resulted in the "boring New Year's weekend for which we all hoped" (to paraphrase President Vest). We salute you and, like the proverbial "old soldier," we will now fade away.

Sincerely,

Rocklyn E. Clarke
for the MIT Year 2000 Team

Re: A Sore Thing
(Letter to the *Faculty Newsletter* from Professor Edwin L. Thomas, November/December 1999)

To The Faculty Newsletter:

After being briefed on the installation schedule for the Libraries' many new photocopiers(1), and updated on the journal circulation policies of the Libraries(2), I believe that Professor Thomas is now sore no more. Indeed, it is clear that Professor Thomas might be downright happy about the Libraries, if only we could afford the journal "Nature" in full text online(3)!

The Libraries welcome faculty suggestions <http://libraries.mit.edu/services/suggested-purchase.html>, comments, and questions (awolpert@mit.edu). Please do not hesitate to contact us.

(1)Please see <http://libraries.mit.edu/docs/copiersfaq.html>.

(2) All the MIT Libraries allow bound journals to circulate, and (excepting only the Lewis Music Library) all the MIT Libraries allow unbound issues to circulate. Only the most recent issue will sometimes be reserved for in-library use in recognition of MIT's limited number of subscriptions and large community of readers.

(3) We're working on it.

Ann J. Wolpert
Director of Libraries

M.I.T. Numbers

Annals of Reengineering

Administrative Staff Headcount
Selected Central Administration Units

Headcount	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00
FSS	0	0	0	0	0	0	0	45
MR	0	0	0	0	0	26	28	0
CAO	76	77	76	68	61	52	67	77
OSP	19	19	19	19	18	25	22	26
Procurement	31	30	34	25	27	20	20	18
Personnel	31	30	32	34	35	40	39	44
Total	**157**	**156**	**161**	**146**	**141**	**163**	**176**	**210**

Change	FY94	FY95	FY96	FY97	FY98	FY99	FY00
FSS	0	0	0	0	0	0	45
MR	0	0	0	0	26	2	-28
CAO	1	-1	-8	-7	-9	15	10
OSP	0	0	0	-1	7	-3	4
Procurement	-1	4	-9	2	-7	0	-2
Personnel	-1	2	2	1	5	-1	5
Total	**-1**	**5**	**-15**	**-5**	**22**	**13**	**34**

FSS=Financial Systems Services; MR=Management Reporting; CAO=Controller's Accounting Office; OSP=Office of Sponsored Programs

Source: *MIT Faculty and Staff Directory*

An unfortunately placed semicolon in the recent e-mail to the faculty was misinterpreted by certain mail handlers. Clicking on the Web address yielded an error message rather than the *Faculty Newsletter* Survey. The correct URL is: http://web.mit.edu/fnl
Please participate if you have not already done so.