Chapter Five

MIT Learning Networks
An Example of Technology-Enabled Education

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Larson envisions a future MIT that is global in scope and a leader in providing life-long learning opportunities via technology. He proposes MIT Learning Networks—virtual communities comprised of students, mentors, alumni, teachers and researchers. Members of the community support and enhance each other's learning through interactive collaboration. Larson's interactive model is quite distinct from routine broadcast variety distance learning; it adds value to the two core strengths of major research universities, namely, on-campus teaching and research. And the model develops a third core activity as well: beyond-campus learning and collaboration.

The world in which research universities operate has changed in many profound ways. The Cold War is over, and a remarkably large fraction of the planet's population has joined or is joining the world economy. Increasingly, corporations operate on a global rather than national basis. New developments in telecommunications have diminished the importance of distance as a parameter in human interactions. Technology is fueling much of the growth in both mature and emerging economies.

Education is increasingly important in this new world. In any country, a shortage of human capital is often the key delimiter of growth and prosperity. Economic success in these times requires professionals who can function creatively in a world

of increasing technological intricacy, professionals who are literate in science and engineering and who, in their later careers, can manage within complex organizations. Increasingly, a country's most important natural resource is the mindpower of its citizens.

At the same time, we are experiencing a great explosion in digital communication technologies. Examples include the internet's World Wide Web, digital satellite television, fiber optics networks, cable modems, and various forms of local wireless communications. Desktop computers linked to these communications networks have capabilities unimagined for mainframes two decades ago. Acknowledging the roles of these technologies in replacing transportation with communication, *The Economist* ran a cover story, "Distance is Dead."

The new technologies are affecting how organizations operate. An increasingly large fraction of corporations are operating more like virtual corporations, in which physical street addresses are replaced in importance with internet addresses and fax and phone numbers. Telecommuters are increasingly common. Professional meetings and even scientific presentations are more frequently occurring via teleconferencing rather than by boarding airplanes and staying at hotels.

Governments during this era are also redefining themselves. Not only in the United States, but also in Europe and elsewhere, federal governments are reducing their roles. With a focus on balanced budgets, federal governments are dismantling welfare states, reducing tax levies, and intervening and supporting less in general. In the United States, this includes federal support for university-based research, anticipated to decline 20% in real dollars between 1990 and the end of the century. Research universities hoping to at least to sustain—if not increase—research support will have to look elsewhere, most notably to the private sector, for increased research funding. And corporations—in this era of increased international competition—are no longer content with largely philanthropic relationships; instead, they are demanding true value added from university partnerships.

Effects of Technology on Research Universities

While every era is unique, we believe that this era is potentially vitally important for the future of research universities, including MIT. Today's trends point to a dramatically different world, a world in which research universities must re-examine and enlarge their core mission. Consider MIT: Born as Boston Tech, MIT was largely a regional technical engineering school during its first decades. It rose to national prominence largely as a result of 'Rad Lab' and related successful activities in the 1940s in support of the World War II effort. With the support of Vannevar Bush and others after the War, the United States federal government recognized the important role of federally supported research and the maintenance of a strong national research capability. This paradigm persisted throughout the Cold War. With the dismantling of the Berlin Wall and subsequent demise of the Soviet Union in 1989, it became history.

Why is all this important to those interested in technology in education? There are several reasons:

Demand. With a global shortage of professionals educated in the sciences, technology and management, the demand for world class education has never been greater. There is a huge market need for superlative educational offerings, a market that is barely being served at present. New technologies make possible quality educational experiences not constrained to campus boundaries.

Need for Growth. To survive and to solve the increasingly complex crisis of overhead containment, research universities need a growth strategy going forward into the next century. Research universities are high tech places. In the private sector high tech world, there is a common verse: "Grow or die." This dictum may now also be true in the academic world. Reduced federal research support only accelerates the need for an alternative growth strategy. Higher education, it must be acknowledged, is a service industry, one of the very few in the United States that has yet to transition to fundamentally new modes of operating made possible by the very technologies that it helped to invent. The private sector sees a large business opportunity here, based on huge potential market size and higher education's old fashioned way of doing business. To thrive, higher education must reinvent itself.

Pedagogy. The new technologies — computers and telecommunications — when used with their full visualization and audio capabilities, facilitate new teaching and learning styles. MIT and perhaps most other research universities, with all their greatness, are still dominated by a chalk-and-talk lecturing style that dates back hundreds of years. At MIT our classrooms are readily recognized by alumni returning with their daughters and sons who are considering applying to MIT.

With technology-facilitated pedagogies, there are important shifts in emphasis:

- Teaching is replaced with learning, with the learner pulling in knowledge from a variety of sources rather than the teacher pushing out material.
- Listening passively to lectures is replaced by active, goal oriented learning.
- Learners traverse knowledge space nonlinearly in a manner that matches their learning styles, interests and prior knowledge.

Contrary to popular belief, interactions between learner and teacher can be enhanced and increased with technologies.

Collaboration. Technology in education can mean much more than computers and multimedia in the traditional classroom, and more than e-mail correspondence between students and faculty. It can open up all sorts of collaboration possibilities. Courses can be co-taught by two or more universities. Some few MIT faculty are doing that now, and they and their students are discovering the multifaceted benefits of such an experience. Students can interact with one another and with faculty both at

MIT and elsewhere. MIT's Professor of Literature Peter Donaldson is conducting Shakespeare research and teaching with faculty and students at Stanford, using digital video indexed archives of Shakespearean plays and communicating over the World Wide Web. Other MIT faculty have also taken the plunge into this new domain, in both teaching and research. Researchers can more easily collaborate with each other and with research sites. For example, given the importance of human body images, use of multimedia computer and communication technology is already standard fare in multilocated medical research efforts.

Leadership. No one institution has assumed world leadership in providing education in a technologically complex world. Such leadership includes education of many of the brightest learners from various countries—but it also requires effort at bringing a much larger segment of the world's population to a point of technical literacy, reducing the fraction of educational have-nots, and creating an environment for economic participation of all peoples—an environment conducive to world peace. MIT is one of a very few institutions that now has the worldwide respect and admiration necessary to assume this role.

The current environment offers tremendous opportunities and equally large risks. Research universities must protect and build their core strengths, yet not ignore the need to create and maintain a dynamic, invigorating environment for its learners, faculty, staff, alumni and partners.

A New Driving Goal for Research Universities

Research universities may have to broaden their scope and purpose, perhaps adding constituencies far from their usual ones. For MIT, one possible goal statement might be as follows:

MIT is to provide global leadership in education and research in a technologically-based world.

One can alter the precise wording, but the focus is leadership, global impact, and recognition of the increasingly pervasive role of technology and science, together with their effective management.

Becoming Global: Learning Networks

If we accept the above goal for research universities going forward, then the technological infrastructure would have to be supportive of world leadership in education and research. This means that much of what is done on campus can also be done off campus, in sites previously considered remote. It also means that the infrastructure should positively impact both traditional core competencies—education and research—and, to facilitate growth, should allow the opening of additional core competencies as well.

Suppose that we put an infrastructure in place that is supportive of worldwide-offered learning and research. How might this change things?

Fundamentally, it makes it possible to redefine our campus community in a global way. It provides for the welcoming of nontraditional learners and teachers within the broader campus, a campus with no physical borders. At MIT we have suggested calling such a new community *MIT Learning*

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Networks (MITLN). MITLN is a virtual community of students, mentors, teachers and researchers, whose shared goal is to enhance the MIT learning experience both on and off campus. Charter members would be the students, faculty and research staff of the Cambridge campus. For any proposed virtual community to join MITLN, the new community should improve the learning standards of all members of the community, as follows:

New Learning Desired. Members of the proposed joining community would seek learning opportunities (e.g., courses, special programs, informal interactions) from the other current "residents" of MIT Learning Networks, including but not limited to on-campus faculty, students and researchers.

Mentoring and Support Offered. Members of the proposed joining community would interact with current residents to enhance and support their learning and/or research experiences within the community.

The second requirement above is what makes MITLN different from more usual *broadcast variety* distance learning programs.

Research universities such as MIT present a unique environment to their residents and an ideal setting for implementation of the structure outlined above. With excellent students and a world-recognized teaching and research faculty, a research university offers to its few thousands of on-campus students a rich and rewarding set of learning experiences that almost always include research opportunities. Given the special nature of the on-campus residents and their experiences, it is unlikely that any major research university will choose to compete in the commodity market of more routine distance learning. Research universities do not have a competitive advantage there, nor would such activity enhance their two core strengths: on-campus teaching and on-campus research. But they might find it attractive to identify potential new "residents" for an extended community, residents who would add value to the campus-based traditional teaching and research. Such new members could benefit from what research universities have to offer in teaching and research, and they would enhance the quality of education for on-campus residents. If those conditions were satisfied, then distance learning would no

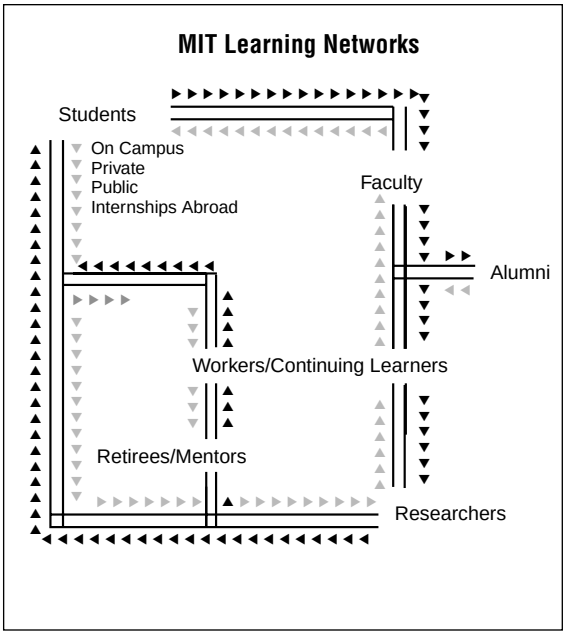

Figure 5-1

longer be viewed as an add-on, or an adjunct activity for a minority of university participants, but rather as a new core activity that enhances all *three* core activities: on-campus teaching, on-campus research, and beyond-campus learning and collaboration.

This learning model is not typical of distance learning today, where the one-to-many, one-way broadcast model prevails. It is not even the model that is quite popular in many places: one-to-a-few, two-way interactive (videoconferencing) mode. It is not even like many subjects currently on the World Wide Web, which tend toward passive, non-interactive, controlled environments in which the teacher is still telling the student what to learn and precisely how to learn. Rather, it is like a virtual town, an open community for learning in which each learner is expected to use the resources in his or her own way, based upon learning style, interests and background. Many people support the learners, including fellow students, faculty, alumni, practicing professionals at affiliated companies, and other friends of MIT. The primary medium of communication is the World Wide Web and related broad band digital communication networks. While rigorous course content will be provided by regular faculty members, it is envisaged that most participants will become both teachers and learners. All will learn from each other.

Ultimately, MITLN would involve many people: MIT faculty, Cambridge-based as well as distant students, alumni, corporate partners, distant researchers, K-12 learners and their teachers, and others in a world wide collaborative learning community. A Learning Network model would allow:

Global Co-ops. Global co-op programs for undergraduates in which a junior year abroad might mean working in a factory in Bangkok or in an office in Copenhagen or in the Amazon Forest. Co-op students would gain invaluable practical experience, would live in other cultures, and would stay connected with their home university through the technological infrastructure. This connectivity could be used for taking home university courses remotely, for continuing dialogue with advisors, and for communication with student peers. It would also facilitate reverse direction seminars back to the home university community to communicate the learning, research and cultural experiences of spending one or two terms in another land. Such co-op programs may be so valuable to potential corporate sponsors, especially multinational firms, that demand for students in the program may exceed supply from the undergraduate pool. Students being supported by their companies also would greatly relieve the tuition burden currently faced by parents. And there is another important advantage: if, for example, at any given time one-quarter of our undergraduates were off campus on co-op assignment either in the United States or abroad, the total on-campus undergraduate capacity could increase by roughly 33 percent without adding to brick and mortar facilities.

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Global Collaborative Research. Research teams now constrained to brick and mortar campuses would function without regard to location of collaborators. Images, text and data can be instantly shared, and face-to-face (electronic) contact could be arranged on a moment's notice. Student teams would be assembled based on strength of the team, not proximity to a physical home place. In that way students would be collaborating with colleagues at other universities, in firms on co-op assignment, and with faculty elsewhere. This is already happening: in the early 1990s, using only e-mail, a two-person research team (one in Cambridge and the other in Australia) wrote and published two scholarly papers together before they ever met in person. But the possibilities go far beyond this. For instance, students studying the Amazon as part of an environmental research project could have monitors set up in various locations in the jungle with live data feeds back to the physical campus. These data could be instantly shared with colleagues world wide. Quality data from a corporate partner's manufacturing line could in a like manner be directed back to the physical campus for real time analysis and feedback. Architecture students could build on the collaborations they currently have with accomplished practicing architects and receive valuable feedback regarding their prototype plans and drawings. We also see in these examples—examples that only scratch the surface—that the boundary between research and education is impossible to pinpoint; often education and research are one.

Enhanced On-Campus Education. Given the appropriate technologies, learning on the traditional campus can transcend the passive listening associated with traditional chalk-and-talk lecture subjects. Students can work collaboratively in goal oriented learning environments located in laboratories and in new learning studios. Faculty members can reduce the lecture component of their work while enhancing mentoring and coaching. Students can be in nearly continuous contact with on-line TAs who can provide homework and conceptual help on a real time, as needed basis. Faculty and TAs can provide better learning at lower costs by compiling FAQs (Frequently Asked Questions) in a video archive available when needed to the learner in the dorm room. Experiments shown live in the classroom can be viewed again at the student's desk drawn down over the network from video archives. The list goes on, building from many of the intriguing experiments currently being carried out at other universities.

Life-Long Learning for Alumni. The reinvented research university would provide continuing education at the workplace, home or on-campus for its alumni, who would now be considered *learners for life*. At a time when well-known CEO's claim that they want engineers not with a 4-year degree but a 40-year degree, universities must respond with appropriate educational products and services, else the competition will. It is estimated today that technology-based knowledge has a half-life of approximately five years, and that profession-

als typically have up to seven different jobs during their career. Professionals at formerly stable firms no longer have *de facto* life-long job security. And many, if not most, engineers make transitions within their first career decade into other areas, most notably management. All this implies the need for continuous education, education that MIT and other research universities can offer. The existence of over 1,000 corporate universities and the expenditure of $100 to $300 billion per year on corporate education and training provide more strong evidence of the need for life-long learning.

The key point of the above examples is to illustrate that extending and strengthening traditional core competencies should guide the choice and use of technology, not the latest faddish announcement from Wall Street, Route 128, or Silicon Valley.

Technology-Enabled Education for Physical and Virtual Campuses

Whether at a distance from the physical campus or on-campus, the technological infrastructure supporting learning and researching are nearly identical. For example, requiring a high bandwidth network for on-campus learners will imply the need for a similar network for off campus learners.

Besides routine transmission of the usual educational content, today's emerging technologies facilitate new pedagogy, new styles of learning, and new styles of teaching. Investing in infrastructure to facilitate global reach thereby provides us with the exciting opportunity to reinvent what we do on-campus at the same time. In designing our technology infrastructure, pedagogy should drive the technology decisions. We should not assume pedagogy as usual, namely chalk-and-talk.

With supportive technologies learning experiences can become

- More participatory
- More goal oriented
- More tailored to a learner's learning style
- More collaborative
- More interactive with faculty
- More compatible with lifestyle constraints
- More timely
- More relevant
- More fun
- More memorable

Technology-facilitated learning can alter many of our traditional points of view. Here are some of the contrasting words:

Old Word(s)	New Word(s)
Teaching →	Learning
Teacher →	Mentor or Coach or Co-learner
Student →	Learner
Synchronous →	Asynchronous
Passive →	Active
Linear →	Nonlinear
Scheduled →	On-demand
Teaching material →	Accomplishing a Goal

Designing a new technological infrastructure on-campus allows these new concepts to be incorporated into the on-campus educational experience. The new infrastructure is much more than ether-networked classrooms in which students can download today's lecture onto their laptops—although such a standard capability would be a vast improvement

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over the typical status quo. The new infrastructure also supports flexible learning studios, in which small groups of students work collaboratively toward the goal of that day's class. It supports laboratories in which nearly all scientific measurements can be downloaded in real time to the student's computer for analysis. It supports on-line help connecting students most hours of the day with TAs, faculty, other students, and with useful databases such as FAQs; eventually much of this interaction can have images and video content. The new technological infrastructure supports asynchronous access to much of the content of a course, including imaging and video content, perhaps some of which is available only from distant sources.

Human Infrastructure

One cannot overstate the importance of faculty support of these new efforts. Without the faculty's enthusiastic participation, efforts at technology-facilitated curriculum innovation are doomed. What does this mean? It means careful attention to faculty incentive and reward structures, with more emphasis on rewarding excellence in educating learners. It means establishing a fair and equitable policy on intellectual property rights for educational materials that are digitized and made widely available. It means spending requisite time in training and educating faculty about teaching and learning in new technology-facilitated paradigms.

Some believe that investment in technology-enabled education will be dominated by human investment rather than capital expenditure in hardware and software. That is, faculty and staff time in revising current subjects and presenting them in new modes will be greater than all the necessary capital expenditures. Time will tell, but other universities routinely take a faculty member off-line for two terms, working with crews of up to four professionals to develop new on-line learning modules. The conversion cannot be done at the margin in real time; a substantial investment is required.

Recent Activities at MIT

During the past five years, two high-level MIT committees have focused on technology-enabled education and how it should affect the MIT learning experience, both on and off campus. The first was the EVAT Committee—Education Via Advanced Technologies—chaired by Professor Paul Penfield. Its final report is a World Wide Web multimedia document located at URL <**http://www-evat.mit.edu/report/**>. The second is the MIT Council of Educational Technology, whose current report is available at URL <**http://alberti.mit.edu/edtech/**>. It is likely that the primary recommendation of the council will be to devote "an effort comparable to MIT's Project Athena" toward technology-enabled education at MIT, both for on-campus and off campus learners. (Project Athena was the intensive program during the mid-1980s that wired the campus with state of the art workstations and educational software. In dollar terms, the level of effort at that time was approximately $100 million.)

Given its emphasis in the council's report, one sees that distance learning most likely will become

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a core component of MIT's educational mission. MIT was an active, early participant in distance learning and distant collaboration. In one sense, MIT become involved in 1969 when CAES (then Center for Advanced Engineering Study) created its first of numerous videotape courses. More recently, MIT is now operating the System Design and Management (SDM) Program, its first nearly virtual masters degree program offered jointly by the School of Engineering and Sloan School of Management. Plans are underway to increase the number of participants in this program and to expand its curriculum. The School of Architecture and Planning and the Department of Civil and Environmental Engineering have become leaders in collaborative design studios using distance learning technologies. CAES (now Center for Advanced Educational Services) is offering MIT courses and educational programs throughout North America via the newly formed Business Channel of PBS and the Williams Companies, and to strategic partners in Latin America located in Argentina, Brazil, Mexico, Chile, Peru and Venezuela.

Some individual faculty members have also been active, following the age-old MIT tradition of "letting a thousand flowers bloom." We cite as examples Professor Hal Abelson's World Wide Web-implemented course on the Internet, privacy and the law; Professor Peter Donaldson's collaborative work with Stanford on his Shakespearean video archive; Sloan efforts at teaching negotiation over the Internet; and four subjects from the Mechanical Engineering Department that have been "webified," with much multimedia content for MIT on-campus students, but which could be offered at a distance as well.

Much of the recent council report on educational technologies encourages collaborative learning and research, in the spirit of the MIT Learning Networks (MITLN). Proposed efforts include:

Alumni Initiative: Life-Long Continuing Core Courses

All MIT undergraduates takes core subjects, both as freshmen and later in the department of their choice. As part of MITLN, these subjects would remain available and be updated in perpetuity for all MIT active students and participating alumni.

For example, a 31-year old "Course 6" engineer—let's call her Sally—has to determine the stability of a feedback control system she is designing for her employer. She could consult the updated World Wide Web location for core subject 6.003, "Linear Systems Analysis," and find the contents of the current version of 6.003. The location would include all the discussions she so fondly but vaguely recalls about Nyquist criterion, stability, root locus plots, Bode diagrams, and more. But she would find much more. She would find a conversation zone, a World Wide Web directed thread, where all others who have taken or who are taking 6.003 can initiate and continue discussions on any aspect of linear systems analysis that they deem interesting and informative. Alumni who have become accomplished practicing engineers may share their wisdom and insight here. A full word search engine would allow Sally to locate any contribution on a

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particular targeted subject. Alumni can help younger students, even on-campus students with their questions. Those alumni who have contributed to the literature in linear systems analysis would post their contributions in the library section of the 6.003 MITLN web site. They would also post other articles, papers, URLs and reports that they have found interesting and useful for carrying out linear systems analysis at the professional level. Each copyrighted entry will be available for downloading, with required copyright charges being automatically logged onto the user's accounts.

Using this collaborative learning environment, Sally has access to other MIT alumni as well as current undergraduates who may help her. The current faculty are also available by e-mail. There would also be an Expert Consultant's Corner, where those who provide professional consulting services in linear systems analysis would post their resumes and related information.

To use this service, Sally or her employer would be charged a fee, either on a per use basis (*a la carte*) or on an annual fee total membership basis. Active MIT faculty who participate would receive extra compensation from MIT.

The 6.003 MITLN web site would offer all the multimedia learning exercises now available and deemed pedagogically useful for our learners. The textbook—revised on an as-needed basis, perhaps annually, perhaps weekly—might be the central core of the learning space. Around that core are the hypertext linked multimedia learning objects: videotaped experiments (showing, for instance, inverted pendulums that are both stable and unstable); a system simulator that allows system configuration by pointing, clicking and dragging; virtual oscilloscopes linked to simulated systems for showing ringing and other phenomena in impulse responses; homework problems that have parameterized animations; goal oriented challenge problems that require a deeper expertise to solve, not unlike that required in industry. For the deeper learning assignments, undergraduate teams might be linked up with cooperating MIT alumni experts from industry or similar professionals from MIT's Industrial Liaison Program (ILP) member companies. In that way, our undergraduate experience becomes enriched from the larger community residing off campus in MIT Learning Networks.

Periodically, perhaps once or twice weekly, there would be town meetings in which live conversations would take place. Most likely, the initial set of planned meetings would have the faculty member be the moderator of the town meetings. But the learners—both on-campus and alumni—would be given the facility to set up their own town meetings as well.

As the site is developed over time, an updated set of FAQs would be created and maintained, first as text only, then with audio and ultimately video options.

Eventually, new services may be created for the town. For instance, we may invent Pointcast™ services for alumni and/or degree-seeking students, where the Pointcast identifies newly breaking developments in that learner's select set of interests or specialties, and directs them to her computer screen, perhaps in the form of a screen saver.

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Creating this environment for many MIT subjects gives us the advantage of economies of scale, quality control, and creation and maintenance of a unified or branded MIT look and feel, while also allowing extreme flexibility for each subject.

Access to the World Wide Web pages of the 6.003 site would be defined and controlled. Faculty would have access and change rights to all the MIT content pages, and to pages dealing with this semester's offering of the on-campus subject. MIT degree-seeking students would have access to most of the pages, but not those for faculty monitoring, change and control, and not those reserved exclusively for alumni. Similarly, the alumni would be excluded from certain of the degree-seeking students World Wide Web pages.

Eventually it might be desirable to enter a third category of "citizen" in this town: collaborative researchers. In the case of 6.003, such a citizen would be one conducting research involving some aspect of linear systems analysis. The research could address of myriad issues, for example, the stability of airplane auto pilots during potential icing situations, or audio frequency response of a newly proposed CD, or input-output analysis of a factory floor. The researcher would gain value from access to the current 6.003 subject content and to the team of experts who reside in the town. MIT undergraduates would have one more possible source of educational enrichment, and the MIT alumni in the town could see how current research is being conducted in linear systems analysis. This third type of citizen would have his or her unique World Wide Web page access limitations.

In the future, other types of citizens may also be invited in to join in. Or, communications could start with adjacent towns, such as other universities having similar learning environments, perhaps Stanford or Cornell or Princeton. Perhaps eventually we could have teams of learners from each town compete against those from other towns. The competition could be in the form of design contests, advanced testing, science fairs, and/or new product invention. Or, we may wish to form collaborative alliances with citizens of other towns. It will be possible to do so many things not done today: to add new important sets of learners to the extended MIT community, to have these new learners enhance the experiences of all, and to utilize all the pedagogically relevant new technologies in pursuing these goals.

Professionals at Affiliated Companies

MIT has over 200 ILP member companies and organizations. Professionals at ILP member companies have a special relationship to MIT: they are interested in one or more areas of MIT research, they hire many of our graduates, they often financially support research in areas of mutual interest, they sometimes offer summer internships to our on-campus students, and occasionally they present a rich environment in which to undertake graduate research leading to a thesis. All these aspects of a pre-existing relationship would seem to encourage their joining MIT Learning Networks.

The ideal ILP member company joining MITLN would: (1) have its professionals take MIT courses and

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educational programs at a distance; (2) offer learning experiences for our degree-seeking students, including summer internships, co-op placements, thesis opportunities, distance mentoring of on-campus students; and (3) support on-campus research. Because many of these activities are in place now, their entry to MITLN would be most natural.

Students and Faculty at Partner Universities

Other universities participating in MIT Learning Networks would be viewed as partners in education, research, mentoring and discovery—not as competitors. MIT already has a limited number of such partners, including Stanford University collaborating with MIT's Professor Peter Donaldson and his students on Shakespeare, and Gabriella Mistral University in Santiago, Chile collaborating primarily on management, operations research, and environmental issues. We have a growing queue of other universities, both in the United States and abroad, that wish to collaborate with us.

K-12 Students and Teachers

Many MIT faculty and students have over the years been involved with K-12 education, and the interest among our on-campus students seems to be growing as an increasing number seek to become certified teachers and spend part of their post graduate career teaching the nation's children.

Institutionally, MIT has deep interests in K-12 education. Narrowly, MIT would like to maintain and enhance the caliber of high school students who will eventually attend MIT. More broadly, in a democratic society where majority rules, MIT and other universities have an interest in increasing the scientific and technical literacy of all citizens. If we do not do so, the national priority placed on science and technology may fall, and with it ultimately our nation's standard of living.

One may imagine a variety of ways to introduce high schoolers (and even perhaps younger students) into MIT Learning Networks. MIT could assist in the teaching of college-level advanced placement subjects, especially in regions having no qualified teachers for such courses. Or, following what many MIT faculty currently volunteer to do, faculty could provide guest lectures via telecommunications technologies to participating schools. MIT students can, as they do now, participate as apprentice teachers—both live and virtually. More interesting than these one-way examples would be collaborative exercises: joint design contests, shared humanities subjects, shared research projects, joint science fair projects, etc.

The K-12 arena is fraught with potential problems of scale and implementation feasibility, and will require considerable design work to bring to fruition. But the notion of a sample of K-12 schools joining the MITLN is appealing.

Conclusion

Universities can be strengthened by embracing the broad and rich possibilities of distance learning as a core institutional activity, supplementing today's standard of on-campus teaching and research. By approaching technology-enabled edu-

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cation as more than just an adjunct activity, institutions can preserve their quality and integrity while adapting to today's new world and successfully positioning themselves for the 21st century.

The following fictional account of student life at MIT in 15 years conveys a vision of the future that could well become reality for forward-thinking institutions.

A Fictional Account of Student Life at MIT Operating as Part of MITLN

A Day in the Life, 2014

Tuesday, March 15, 2014
Cambridge, Massachusetts

5:15 A.M.

Carl is awakened in his Baker House dorm room by his beeper. Groggy, at first he thinks it is a signal from his VCR, perhaps unable to download the video lecture of 6.003 that he missed yesterday. But it is more serious: the weather balloon that his team launched from Bangkok last Friday has veered off course and is headed into a typhoon. Via the Motorola world wide satellite network, the GPS receiver had been programmed to alert him and his junior year teammates Nancy and Paul at MIT in Cambridge, Bish in Bangkok, and Alicia in Johannesburg of any sharp deviation off course. Both Bish and Alicia are away on their overseas co-op assignments. (Like most MIT undergrads, they are five-year MEng candidates participating in international co-ops.) Data downloaded to date are being used by the team to build and test a revised world weather model on the CRAY 330000, located on Carl's desktop. Carl, after clearing his eyes from sleep, activates the video monitor on the balloon to witness live via compressed video the last hour of the balloon's lofty existence. He will share that video with his four colleagues and their UROP faculty advisor before reporting the event to class later today in E90-350, which will tie into six other sites on three continents. (The weather modeling project is being sponsored jointly by the U.S. Meteorological Association and American Airlines.)

7:20 A.M.

Nancy, awakened by Carl's e-mail to her wristwatch, is disappointed to learn of the balloon's demise. But she must prepare for an exercise later today for her international negotiation class. This "class" will pit skilled student negotiators from MIT in Cambridge, Stanford in California, and the U.K. Open University at random points on the global net. Each team is representing a side in a three way business/government/university negotiation to establish a more accurate and profitable satellite monitoring system to anticipate weather's effects on crops in South America and Africa and ultimately to tie that to commodity price forecasts. She has to bone up on her statistical forecasting methodology, as she is estimating value of alternative satellite data sets for one side of the negotiation.

7:22 A.M.

Paul, also awakened by Carl, is getting ready for a video phone conversation with his older sister, Ingrid—an MIT Ph.D. EECS student now resident in

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Beijing. Carl establishes contact with her at 7:30, over coffee in Cambridge and noodles in Beijing. Ingrid reports on her on-going EECS TA experience, providing learning and mentoring support to 18 of the practicing engineers who are charged with expanding and upgrading the electrical power grid over China. Via satellite and fiber network, the engineers take graduate courses from the MIT Cambridge campus two days per week, six hours each day. Only two of the 12 hours per week are live with the Cambridge-based professor, while the remainder are asynchronous, downloaded over the Global Digital Pipeline (once known as the World Wide Web). Ingrid explains that power grid expansion has become especially critical now that the power from the Three Gorges Project has come on line and cities growing in the interior of the country are desperate for additional electrical power. Ingrid reports that her faculty research advisor, Professor Comp.edu on the Cambridge campus, is quite satisfied with her thesis progress on optimal distribution network redesign in the presence of geographic and political constraints. She will meet with her advisor in about an hour via videophone. Ingrid hopes that the thesis will be of direct use in China and perhaps also in Nigeria, where the newly elected democratic government is using oil monies to build a cross country world class highway system.

7:25 A.M.

Paul and Ingrid's mother, Amanda (MIT, '83), join the video call from Dover, Delaware. Amanda proudly reports that she just received a "95" on her MIT mid-term exam on Operations Management from Professor Dimitris Bertsimas at Sloan/virtual/campus. Amanda, educated at MIT as a Chemical Engineer, is now in management at Dupont and is finding the MIT EMO program invaluable in her continuing lifelong learning. The EMO (Educational Maintenance Organization) program was put into place by MIT in 1999. Since then, scores of other universities have followed suit. Not unlike an HMO, with an EMO, actuarial tables are used to determine the monthly employer fees necessary to keep an employee graduate of MIT in the EMO. The program serves both preventive educational needs (e.g., scheduled yearly upgrades of domain-specific knowledge) and emergency needs (e.g., as one needs to learn about business negotiation strategies). Paul and Ingrid, after telling their mom how proud they are of her performance, recount the day's activities at MIT, the global campus.

Paul reminds both his sister and mother to tune in tonight to Turner Channel 1865 on their video consoles to see the "Sweet 16," that is the 16 nation finalists in the 6.270 competition. Each year at this time excitement builds as the best students worldwide compete for the Super Bowl of robot competition. This year's worldwide contest— with teams from 72 countries originally participating— is being sponsored by a consortium of 12 companies, each of which has donated components for the micro-robot creation contest. The robots this year are so small that the video will be shot through a microscope.

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9:05 A.M.

Alicia reports in live via videophone to Professor Ron Latanision's weekly meeting of MIT undergrads serving K-12. There are 30 students present in the MIT Cambridge classroom and 15 others reporting in from 5 countries. Alicia reports that the new math curriculum proposed for 14-18 year olds is taking hold in sub-Saharan Africa. She shows videos of learners in Zimbabwe using the new interactive learning tools. The multimedia interactive curriculum is a product of the MIT undergrads serving K-12 and their sister groups at Stanford, Oxford, and the new Federal University of Hong Kong. The project has been supported in part by the U.N. Annually, more than 50 MIT grads seek their first careers as high school teachers, perhaps switching later to industrial careers.

During the past several years, two high level MIT committees have focused on technology-enabled education and how it should affect the MIT learning experience, both on and off campus. The first was the Education Via Advanced Technology (EVAT) Committee; its final report is a multimedia document located at http://www.evat.mit.edu/report. The second committee is the MIT Council on Educational Technology, whose report is available by request from the author at rclarson@mit.edu.

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