MIT's strategy for educational technology innovation, 1999-2003*

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Abstract

This paper discusses the institutional framework and the strategic decisions the led the launch of several major major educational technology initiatives at MIT between 1999 and 2003. It describes how MIT's central administration provided strategic support and coordination for large educational technology programs, and it traces how strategies evolved as work progressed through 2003 to a point where major projects had been launched and were ready to proceed as ongoing concerns. The history recounted here provides a snapshot of a world-class university confronting the changing environment for higher education engendered by information technology at beginning of the 21st century.

> "People who didn't know better might think we had a strategy."
> – MIT Provost Bob Brown[1]

Beginning in 1999, the Massachusetts Institute of Technology launched the most extensive array of coordinated educational technology innovations it had embarked on in a quarter-century. Activities ranged from single-semester experiments by individual faculty members and small student groups, to sweeping institutional commitments with global scope, to major alliances with university and industrial partners.

This paper discusses the institutional framework within which these initiatives were undertaken and the key strategic decisions that that led to specific activities. It describes how MIT's central administration provided strategic support and coordination for large educational technology programs, and it traces how strategies evolved as work progressed through 2003 to a point where major projects had been launched and were ready to proceed as ongoing concerns. The history recounted here provides a snapshot of

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* Portions of sections 4-5 of this paper, dealing with the launch of MIT OpenCourseWare, appear in [1].

[1] Robert A. Brown, now President of Boston University, was MIT Provost (chief academic officer) during the period described in this paper and the member of the top MIT administration most personally involved in the activities described here. The remark quoted here was made at a meeting of the MIT Educational Technology Council in spring 2001, upon reviewing the work the Council was engaged in.

a world-class university confronting the changing environment for higher education engendered by information technology at beginning of the 21st century:

- The possibility of putting into place significant pedagogical shifts towards active learning, and the role of technology in contributing to this shift
- The tensions between the desire to expand the university's global reach via the Internet, versus the fear of weakening the residential experience
- The threats and opportunities provoked by increasing commercialization of scholarly materials, prompted in part by the dot-com boom and the availability of the Internet as a distribution channel.
- The potential for fundamental change in the nature of the university community through enhanced roles for off-campus participants and the ability to harness the Web for sharing resources among institutions
- The challenges of infrastructure upgrade and renewal in a climate of rapidly evolving technology

Finally, we assess the current state of these projects from the vantage of 2007 to describe the challenges ahead.[2]

1. A slew of institutional initiatives

For most MIT faculty, the administration's heightened interest in educational innovation first became apparent in the spring of 1999 with the announcement of a $10 million gift by MIT Corporation Chairman Alex d'Arbeloff and his wife Brit. This established a fund whose goal, as Brit put it, would be to stimulate "whole new ways of looking at teaching and whole new ways of looking at learning." In Alex's words, "MIT is already known for innovation and for new ideas in how to educate scientists and engineers. In the light of new technology, we have a tremendous opportunity to go further. We can add value to the residential experience by stimulating innovation in teaching. The Institute is already churning with new ideas. This is a chance to bring them into the light of day." [2]

The inauguration of the d'Arbeloff Fund for Excellence in MIT Education not only unleashed pent-up enthusiasm for educational innovation, but it would also set the tone for the period that followed, with its clear articulation of two themes. First, there was a strong focus on MIT residential education and a belief in MIT's future as a residential university. Second, while the d'Arbeloffs were not funding educational technology as an end in itself, there was an expectation that technology would be a

[2]This narrative concentrates on initiatives coordinated centrally by MIT and the Council on Educational Technology, and does not include dozens of other MIT educational initiatives – including major ones with global impact – that were done independent of central funding. For example, one particularly important cluster of projects has been the work on K-12 education centered in Media Lab, including Mitchell Resnick's Computer Clubhouse Network, and the community that grew up around computing as a vehicle for intellectual empowerment of children, starting with work of Seymour Papert in the 60s around the Logo computer language, and becoming visible most recently through the world-wide One Laptop Per Child initiative.

critical enabler of educational transformation, and a belief that a key reason for mounting a large effort *now* was the presence of technology as an enabler.

Yet for all its significance in focusing the attention of the Institute on educational innovation, the d'Arbeloff Fund was only one of five ambitious education and technology initiatives that the MIT administration was to unveil that year – there were also university partnerships with Singapore and the United Kingdom, and industry alliances with Microsoft and Hewlett-Packard. Together, these initiatives formed the setting within which a strategy for educational technology would unfold.

1.1 The Singapore-MIT Alliance

The Singapore-MIT Alliance (SMA) had already been announced in November 1998. SMA was the result of an approach to MIT Provost Bob Brown by Singapore's Deputy Prime Minister Tony Tan early in 1998, suggesting that MIT consider creating "an MIT of Singapore". The Institute declined to do this, largely because it did not want to be viewed as competing with existing top Singaporan universities, and also because of a belief that such a venture would distract MIT faculty from a commitment to the main Cambridge campus. After further discussion, the proposal was modified, and SMA emerged as a partnership with the National University of Singapore and Nanyang Technological University, two of Singapore's leading research universities. The program would be funded by the Singaporan government, initially for five years at $18-20 million per year.[3]

SMA was designed as a graduate-level collaboration in teaching and research. It began by offering Master's degree programs in Advanced Materials and High-Performance Computation for Engineering, which included student and faculty exchanges, and also lectures by faculty from all three institutions, delivered synchronously via high-speed internet connections (Internet2).

The Alliance was lauded at its announcement as "a bold new model for global university collaboration." (MIT Associate Dean of Engineering John Vander Sande, quoted in [3].) MIT administrators spoke of a leadership role in globalizing science and of the benefits to MIT education that would accrue from global interaction. From the MIT perspective, the goals of SMA were to create new graduate subjects and curricula, develop new research programs, establish a larger MIT connection to Asia, and experiment with distance interaction for both teaching and research. [4] Broad impact on MIT on-campus education, however, was not a primary goal of SMA.

1.2 Microsoft iCampus

The idea for collaboration between MIT and Microsoft in educational technology was born in a conversation between MIT President Charles Vest and Microsoft Chairman Bill Gates in the fall of 1998, during a taxicab ride to the airport. Details were hammered out over the following months in discussions between a group of MIT faculty led by Dean of Engineering Tom Magnanti, and a team from Microsoft Research led by Rick Rashid,

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[3] An additional agreement to extend SMA and include dual-degree programs was signed in March 2003, and a second extension is currently being discussed (spring 2006).

Microsoft Senior Vice President for Research. These meetings led to the signing of a memorandum of understanding in the spring of 1999, followed by the public announcement in October 1999 of the launch of "iCampus," a $25 million 5-year Research Alliance in Educational Technology between MIT and Microsoft Research.[4]

In contrast to SMA, iCampus was designed to have broad educational impact on the MIT campus. The Alliance would "focus on methods and technologies that could set the pace for university education in the next five to 10 years." In Vest's words,

> "Education-focused research supported by Microsoft will lead to new learning environments for our students and will make us an even better university. Still more important, the MIT-Microsoft alliance will help create knowledge and information-based services that can improve higher education worldwide." [4]

iCampus was directed by a Joint Steering Committee consisting of three members from MIT and three from Microsoft Research.[5] At its first meeting in August 1999, before the public announcement, the Committee set out strategic directions that would shape the Alliance. Microsoft emphasized that it was more interested in the effect of iCampus on education rather than the potential to develop hot technology for its own sake. Funding would be awarded in response to annual requests for proposals from faculty, with the expectation of funding a few large, high impact projects rather than many small projects. There would be funding set aside for projects proposed and carried out by students. In making funding decisions, the Committee would be particularly concerned with the potential scale of educational impact and the chances that a project would be sustained after its iCampus funding ended.

1.3 The Cambridge-MIT Institute

The October 1999 launch of iCampus was followed only a month later by the unveiling of a still more ambitious initiative: the Cambridge-MIT Institute (CMI). CMI originated when UK Chancellor of the Exchequer Gordon Brown contacted the MIT School of Engineering late in1998 with an invitation that MIT should open a campus in the UK. As in the case of Singapore, MIT forewent that opportunity, and after discussion of several alternative options came to an agreement to partner with the University of Cambridge.[6] With a projected budget of $135 million for five years – of which 80 percent was backed

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[4] See [5]. The duration of iCampus alliance was subsequently extended until December 2007. Initially, both MIT and Microsoft intended for iCampus to grow to include more similar scale alliances with other academic and industrial partners, but this did not happen, largely because Microsoft Research's university relations strategy shifted away from large strategic alliances, in favor of more limited engagements with faculty from a broader array of universities.

[5] Initial steering committee members were, from MIT, Dean of Engineering Tom Magnanti, Assistant Provost for Educational Technology Vijay Kumar, and Prof. of Computer Science and Engineering Hal Abelson; and from Microsoft, Microsoft Research General Manager Peter Pathé, Research Manager Anoop Gupta, and University Relations Manager William Vablais.

[6] This background was provided courtesy of Prof. John Vander Sande, who also played a key role in the creation of SMA. Vender Sande was Acting Dean of Engineering at the time of the UK contact and subsequently served as the first MIT Director of CMI. Associate Dean Daniel Roos, Chancellor Larry Bacow, and Dean of the Sloan School Richard Schmalensee also played major roles in the early CMI negotiations with the UK Department of Trade and Industry.

by the U.K. Treasury – CMI's programs were to include "undergraduate, graduate student, and faculty exchanges; a program of integrated research; the adaptation to Britain of professional practice programs developed at MIT; and the creation of a national competitiveness network in Britain." [6]

The public announcement of CMI echoed the words of the Singapore Alliance in presenting a vision of a global university. "What we are about to do is potentially historic. It could transform both institutions and truly create a new model for the global research university in the twenty-first century," proclaimed MIT Chancellor Larry Bacow. And with an explicit nod to SMA, the MIT New Office explained that the programs for distance education with Cambridge "will be based in part on experience gained in MIT's distance learning alliance with the National University of Singapore and the Nanyang Technical University."[7]

While the CMI launch evoked images of educational technology, CMI was not itself an educational technology program, or even primarily an educational program. The majority of funds earmarked for research collaborations and activities focused on entrepreneurship, with only about a quarter of its budget was reserved for education. And the "distance learning," plans turned to be not technology-based at all. Instead, they revolved around an exchange program through which undergraduates from MIT and Cambridge could spend a year abroad at the other institution and experience the distinctly different educational styles of the two universities.

1.4 DSpace and the MIT-HP Alliance

The final educational technology-related initiative to emerge during the 1999-2000 academic year was the Alliance with Hewlett-Packard, which was announced at the June 2000 commencement exercises, coinciding with HP CEO Carly Fiorina's appearance as commencement speaker. The MIT-HP Alliance, like iCampus, was a $25 million, five-year initiative governed by a steering committee consisting of three members from MIT and three from HP. The goal of the Alliance would be to "investigate new architectures, devices and user interfaces in information-rich environments and explore novel services for commerce, education and personal use." [7]

Unlike iCampus, which consisted completely of new projects, the HP Alliance was in large part a formalization of existing research relationships between HP and MIT, including HP's sponsorship of research at the MIT Media Lab, the Laboratory for Computer Science, the Sloan School, and – most notably for educational technology – the DSpace Digital Archive project with the MIT Libraries.

DSpace had originated from a conversation in the summer of 1999 between Director of Libraries Ann Wolpert and Computer Science Professor Hal Abelson, about the challenges for university libraries in managing digital information, in view of the fact that fact that educational and research works were increasingly being "born digital." Abelson, a consultant to HP Labs' digital publishing program, suggested that HP should work with the MIT Libraries to create an open-source digital archive platform that would

[7] *Ibid.* Despite this intent, CMI, unlike SMA, never implemented much synchronous delivery and sharing of lectures over the Internet. Instead, it focused on small group collaboration between MIT and Cambridge, often facilitated by videoconferencing.

support publication and dissemination of university works. HP Labs executives were supportive of the idea. The project was publicly announced in March, 2000 after several months of planning, and assimilated into the MIT-HP Alliance shortly afterwards. [8]

2 World-Wide University or zip code 02139?

These initiatives of the late 1990's – the d'Arbeloff Fund, SMA, iCampus, CMI, and the MIT-HP Alliance – didn't spring from a vacuum. Educational technology was receiving increased attention from higher education globally, especially in view of the explosive growth of the World Wide Web, with its intriguing new possibilities for online learning and global campuses. In the university community, this attention took the form of conferences, debates, and, of course, faculty committee reports. Three reports in particular would set the stage for MIT's moves over the coming decade.

2.1 The EVAT Committee (1994-1995)

MIT's interest in the Web had borne fruit as early as early as 1993, when the Laboratory for Computer Science invited Tim Berners-Lee, creator the Web, to move from CERN in Geneva to MIT and establish the World Wide Web Consortium. In October 1994, President Vest commissioned the formation of an ad hoc committee led by Paul Penfield, Head of the Department of Electrical Engineering and Computer Science, "to study the opportunities for MIT of advanced technologies such as the World Wide Web."[8] [9] In contrast to the educational innovation planning to come later, the charter of the "Committee on Education via Advanced Technologies" (EVAT) was narrowly focused on technology. Indeed, the committee's final report, issued in summer 1995, devotes almost a third of its length to an exposition of the Web in a way that today seems utterly quaint, taking pains, for example, to explain that the report itself should not be printed and read sequentially, but rather browsed online and traversed by "active links, known as hyperlinks".

Fascination with the Web notwithstanding, the EVAT report included what for the time were ambitious technology infrastructure recommendations, such as upgrading the MIT network so that every faculty and teaching assistant desk, and all classrooms, would be wired with high-speed Ethernet connections. Another recommendation was for the Provost to establish a "visible and prestigious Institute-wide competition among faculty for support of curriculum development projects that make effective pedagogical use of advanced technologies" that would support five to ten projects annually as a cost of $1M per year, a scale of investment that might have seemed extravagant, but was almost precisely what the d'Arbeloff fund would subsequently enable.

The EVAT Committee report also proposed activities for the longer term, including using the Internet to collaboratively teach subjects with other universities, offering subjects that could be taken by MIT students while on co-op placements, giving alumni access to MIT online resources, and offering special subjects to high school

[8] Committee members were Hal Abelson, Peter Donaldson, Gregory Jackson, Robert Jaffe, Chris Kemerer, Richard Larson, William Mitchell, Edward Moriarty, Anthony Patera, Paul Penfield, Vera Sayzew, and Brian Zuzga.

seniors admitted to MIT. And in a section on "Lifelong Learning," the report envisioned that "advanced technologies may permit effective distance education so that education in mid career become more feasible," particularly for alumni, and evoked an analogy between "educational upgrades" and the product upgrades issued by software companies. This lifelong learning image would haunt MIT strategy throughout the next five years, finally emerging – with a radically different twist – in the OpenCourseWare project.

2.2 The First Council on Educational Technology, 1995-97

The EVAT report had barely been completed in summer 1995 when President Vest chartered a follow-on committee, to "consider the potential benefits that MIT's educational mission might derive over the next decade from effective application of emerging computer and telecommunication technologies." The charge to this "Council on Educational Technology," chaired by Laboratory for Computer Science Director Michael Dertouzos and Dean of Architecture and Planning William Mitchell, was to "explore alternative strategies for achieving the most important of these benefits, to describe a vision for the future, and to make a concise, concrete set of recommendations for action."[9] [10]

While the EVAT Committee began with a narrow focus on the Web and proceeded from there, the Educational Technology Council, which met over the 1995-96 academic year, jumped immediately to consider the fundamental worldwide changes stimulated by information and communications technology, and the consequent challenges to the leading universities:

> "…we expect that the MIT of the twenty-first century will operate in a highly competitive environment, where 'business as usual' strategies will not suffice for maintaining its leading position. Pervasive use of advanced information technology may reduce some of the advantages of being at a leading institution, and institutions with particularly attractive locations and climates may become increasingly competitive as other considerations become less important." [10]

In its final report, Council recommended undertaking an ambitious project at a cost of $100 to $150 million over five years "that will make the Institute the recognized leader in the creation and effective application of advanced educational technology and that will create an exportable model for higher education." The project, to be under the direction of a steering group chaired by a senior member of the administration, would focus on educational uses of computational tools such as advanced simulation and visualization, information management and sharing, synchronous and asynchronous collaborative learning. In an echo of the EVAT report, the project would provide lifelong learning for alumni, MIT-bound high-school students, and industrial partners. The report envisioned new strategic alliances with industry and other institutions, a new "MIT Information Infrastructure" that included not only networks and systems, but also newly designed

[9] Council members were William J. Mitchell, Michael Dertouzos, Hal Abelson, John Belcher, Tim Berners-Lee, Peter Child, Peter Donaldson, Julie Dorsey, Anne Drazen, M. S. Vijay Kumar, Richard Larson, Steven Lerman, Nicholas Negroponte, Alex Pentland, Bruce Tidor, Rosalind Williams, John Wilson, and Ann Wolpert.

classroom spaces and dormitory rooms, and even MIT extension campuses in Europe, Japan, and Washington.

The Committee report was a wide-ranging, future-oriented, grandiose blueprint – and one that the Institute was by no means ready to embrace in 1997.

2.3 The Task Force on Student Life and Learning (1996-1998)

Even as this first Educational Technology Council was auguring a technology-pervaded future, MIT was preparing a fundamental review of its educational mission, with discussions beginning in the spring of 1995 between President Vest and Dean of Students and Undergraduate Education Rosalind Williams. These discussions led in July 1996 to the appointment of the "Presidential Task Force on Student Life and Learning", whose charter was to "undertake a comprehensive review of the Institute's educational mission and its implementation."[10]

Appearing in spring 1998, the Task Force's final report called for a rearticulation of MIT's mission and principles around "an integrated educational triad of academics, research, and community." This included not only a reaffirmation of MIT's traditional emphasis on research as part of the student experience, but also explicitly championed the importance of community activities and the residential campus in preparing students to function as leaders in an increasingly global economy, much of which was being stimulated by information technology.

But where the Educational Technology Council trumpeted this "death of distance" as an opportunity for leadership and expansion, the Task Force seemed to view it as a threat to the residential community. As Williams recounts:

> "You would think that the educational version of change talk would be welcomed at future-oriented, technology-oriented MIT. You would think that MIT faculty members and students would love the idea of leaving behind the academic city on the hill for a globally reaching, technologically nifty educational model …
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> But this is not at all what happened. The task force, a group of future-oriented technophile, students and faculty members alike – came to the conclusion, strongly and unanimously, that the future of MIT depends not on promoting technological change but on maintaining a beloved community in Cambridge, Massachusetts 02139." [12]

In fact, with all its emphasis on recasting MIT education in light of global challenges, the Task Force's recommendations are decidedly conservative towards educational technology, saying only that the Institute should "conduct carefully designed experiments in distance learning and educational technology," with the proviso that

> "It is important that MIT develop distance learning methodologies in a rational and controlled way, of the quality commensurate with MIT's principle of excellence and limited objectives. In view of the still rapidly evolving

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[10] Members of the Task Force were Jesus del Alamo, Sallie W. Chisholm, Iddo Gilon, John Hansman, Hermann Haus, June Matthews, Mario Molina, Luis Ortiz, Jeremy Sher, Robert Silbey, Charles Stewart, Marcus Thompson, J. Kim Vandiver, and Rosalind Williams.

technologies, a committed, yet cautious, process of experimentation, evaluation, and dissemination is the proper course of action." [11]

3 Fall 1999: Seeking synthesis

Of the programs launched during 1998-2000, only the d'Arbeloff fund and iCampus were strictly limited to education, but all five programs had major educational components. Taken together, they were an enormous amassing of resources allocated for educational innovation and educational technology. Yet these initiatives were unfurled with the Institute faced with two very different recommendations, which pointed in opposite strategic directions – one view boldly expansionist and ready for global adventuring, the other oriented firmly on zip code 02139. And these two perspectives hardly even acknowledged each other's existence. The Educational Technology Council's final report notes only that "there is a Task Force on Student Life and Learning charged with developing a comprehensive vision," while the Task Force's final report doesn't mention the Council at all.

The Task Force report received wide publicity throughout the MIT community, acclaimed for its emphasis on the community and the importance of residential education. In contrast the Council report slipped comparatively from sight, and when people spoke of it, it was often with a dismissive undertone of technological determinism run unchecked. Even so, this was the height of the dot-com bubble, when university administers worldwide were both charmed and alarmed by the implications of burgeoning information and communications technology for the future of the academy. It seemed ironic for MIT, of all places, to embrace a vision for its educational future that barely gave nod to this technology. Some sort of synthesis was called for.

In spring 1999, the administration began discussions about creating an MIT-wide steering group for educational technology. This resulted in September in the formation of a second MIT Council on Educational Technology, which was established "to provide strategic guidance and oversight of MIT efforts to develop an infrastructure and initiatives for the application of technology to education." The goal of the Council would be "to enhance the quality of MIT education through appropriate application of technology, to both on-campus life and learning and through distance learning." [13]

The wording of the Council's charter reveals the role it was expected to play in balancing the messages of the prior studies. The Council's objective would be to enhance education: technology would be an enabler, but fostering technology would not be an end in itself and "on-campus life and learning" language was a nod to the priorities set by Task Force. Even so, the explicit mention of distance learning – despite the Task Force's clear focus on residential education – revealed how enticingly the opportunities presented by communications technology beckoned to university administrators in that dot-com bubbly year of 1999.

Unlike the 1995 first Council on Educational Technology, whose job was to produce a report, this second Council's function would be to coordinate and advise. The Council itself had no formal management role, but as testament to the priority the MIT administration gave to these issues, the Council would be co-chaired by the Provost himself, along with another faculty co-chair. Council members included top members of the administration, chairs of major faculty committees, and directors of major services involving education and technology. It also included members chosen at large to represent alumni, student government, and the faculty of MIT's various schools. Among the Council members were leaders of the key initiatives: the directors of the Singapore-MIT Alliance and the Cambridge-MIT Institute, two of the three MIT members of the iCampus Steering Committee, the Director of Libraries (DSpace), and Alex d'Arbeloff.

The Council met for the first time on October 5, 1999 – the very same day as the public launch of the Microsoft iCampus alliance – to adopt an initial agenda and mode of operation. The full Council would meet in plenary session only rarely, perhaps once a semester, with most of the work done in subgroups. A Grants Group would make awards from the d'Arbeloff Fund. An Assessment Group would monitor the effectiveness of MIT-funded educational technology programs and serve as a quality control board for evaluations of particular initiatives funded by the Council. An Infrastructure Group would provide technical oversight on behalf of the Council for MIT-wide educational technology activities. A Strategy Group would maintain a strategic framework for MIT-wide initiatives in educational technology and make initial recommendations, both about broad directions and specific initiatives.

3.1 Funding the initial projects

Towards the end of 1999, both iCampus and the d'Arbeloff Fund issued requests for faculty to submit proposals. The iCampus solicitation called for technology-based innovations, while the d'Arbeloff fund – with a nod toward the Task Force report – was pointedly not limited to technology. Both programs were prepared to support a few initiatives with multi-year awards of up to a few hundred thousand dollars per year.

The response to the solicitations was enthusiastic: MIT faculty were well used to solicitations for research funding, but this was the first time there had been a widespread call for major educational proposals.

The d'Arbeloff call received 40 submissions, from which the Grants group selected seven projects for funding. Three of the seven dealt with advising – the Task Force report had cited the importance of undergraduate advising and its role in strengthening the MIT community. There were two awards to the Office of the Dean for Undergraduate Education aimed at improving residence-based advising, and an award to the Department of Health Sciences and Technology to support a "career-based advising" program for students planning to major in biology and biological engineering. Two more awards established special programs for freshmen: a seminar that combined technology studies with visits to local industries that used those technologies, and an exploratory design subject where student teams carried out ambitious cross-disciplinary projects in response to a challenge. (The first year's challenge was to plan a mission to Mars to search for evidence of life.) The sixth award was a planning grant to the Math Department for revising the introductory curriculum to incorporate computer simulations.

The seventh award, given jointly with iCampus, went to the Physics Department for "Technology Enabled Active Learning." TEAL was an ambitious multiyear effort led physics professor John Belcher to completely transform the teaching of freshman physics by eliminating all lectures in MIT's largest lecture subject and replacing them by "studio instruction." Studio instruction, pioneered at Rensselaer Polytechnic Institute, replaces lectures by interactive sessions where students work in small groups, with brief instructor presentations alternating with opportunities for students to use simulations and hands-on experiments.[11] The MIT version included not only a teaching format change, but also design and construction of a special multimedia classroom, and the creation of an extensive suite of simulations and visualizations in electromagnetism. TEAL was by far the most ambitious the projects, receiving fully half of the total d'Arbeloff funds awarded that year, and a similar amount from iCampus. TEAL would continue to obtain major funding over the coming years, and emerge as MIT's most ambitious effort in active learning, not only for the d'Arbeloff Fund, but for this entire period of MIT educational innovation.

The iCampus call for proposals received 75 applications, of which eight were funded, several with co-funding from other MIT sources. Projects included a development in the School of Architecture for an online community to support the School's professional degree program. There was also a project in the Literature Department to develop a multimedia authoring system, later to be called XMAS – "Cross-media authoring system" – for use in teaching Shakespeare. iCampus added an equal amount of funds to the d'Arbeloff award for TEAL. The other five iCampus awards went to departments in the School of Engineering, with the School provided co-funding. One of the five was for a School-wide initiative to develop simulation technology in fluid mechanics. Three more focused, as did TEAL, on transforming large lecture subjects in favor of more active learning environments: desktop experiments, online lectures, and simulation modules for the introductory course in Mechanical Engineering; computer-based simulations and active learning in Civil Engineering and Aeronautical and Astronautical Engineering; and online lectures with automated tutoring in Computer Science. Finally, there was an award to a group of faculty, led by Prof. Jesús del Alamo of Electrical Engineering, to Web-enable laboratory instruments and create a suite of laboratories that students could access remotely. This "iLabs" initiative would receive considerable additional funding over the next five years, eventually becoming the largest single iCampus initiative.

The iCampus and d'Arbeloff programs issued separate calls for proposals and had separate decision-making procedures, because Microsoft had equal say with MIT in deciding iCampus awards but was not involved on the d'Arbeloff decisions. The two processes were kept coordinated by three MIT members of the iCampus steering committee: Engineering Dean Tom Magnanti, and Vijay Kumar and Hal Abelson, who were also members of Council's Grants Group. One direct result of this coordination was the co-funding of TEAL between the two programs. Another was the preponderance of funded iCampus projects aimed at developing alternatives to traditional lectures, which reflected the Council's desire to find a balance between the "technocentrism" and "life and learning" perspectives of the two previous task forces: The Task Force on Life and

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[11] The term "studio physics" was coined in 1993 by RPI Dean Jack Wilson, who later became President of the University of Massachusetts. MIT's implementation of studio physics was directly inspired by the SCALE-UP project led by Robert Beichner at North Carolina State University. [14, 15]

Learning Report had cited the impersonality of large lectures as an issue for MIT education, but, in keeping with its general silence about technology, it had not suggested that educational technology might provide ways to address this impersonality.

Overall, the first-year funding for projects coordinated by the Council amounted to about $6 M – $1 M from the d'Arbeloff Fund, $3.6M from iCampus, and $1.3 M from the School of Engineering – with equal amounts designated for the second year of these two-year awards.[12]

3.2 Infrastructure priorities

As the grants activities were proceeding bottom-up by soliciting proposals from individual faculty and departments, the Educational Technology Council's Infrastructure Group was taking a top-down look at MIT's technology requirements. The job of the Infrastructure Group was to "advise the Institute on choices of platforms and architectures, with a view towards maintaining the coherence and supportability of MIT's educational technology infrastructure."[13] Its initial task as laid out at the first Council meeting would be to articulate "choices of platforms and architectures, with a view towards maintaining the coherence and supportability of MIT's educational technology infrastructure."[14] One of the group's first recommendations addressed the need for better coordination of information technology architecture and design for the Institute as a whole, not just in educational computing. This recommendation resulted in the February 2000 chartering of the MIT Information Technology Architecture Group, which maintained (and still maintains) oversight of the MIT I/T infrastructure and application design.

The other immediate concern of the Council's Infrastructure Group was wireless. Campus wireless networks were generally regarded as future technology in 1999 university computing circles, but at MIT there was a special urgency to act now. Several groups on campus had already started implementing their own local wireless networks, and incompatible standards were being deployed.[15] MIT Network Manager Jeff Schiller argued that it was imperative for MIT to quickly and publicly commit to deploying a campus-wide wireless network. Otherwise, the local wireless activities could produce a balkanized infrastructure, and more and more local installations camping out on the spectrum would make it difficult or impossible for MIT to ever deploy a central wireless service. This led to a recommendation in December 1999 that MIT should create a

[12] The iCampus contracts were charged MIT research overhead, while the d'Arbeloff and School of Engineering awards were exempt form overhead. A better comparison would set the iCampus funding at about $2.5M "post overhead."

[13] The Infrastructure Group was co-chaired by Hal Abelson and Vijay Kumar. Other group members were MIT Network Manager Jeff Schiller, MIT Registrar Mary Callahan, Steve Lerman, Stuart Madnick, Gary Zacheiss, and Helen Samuels.

[14] From a presentation by Bob Brown and Hal Abelson at first meeting of the MIT Educational Technology Council, October 5, 1999.

[15] The IEEE 802.11 standard permitted both Digital Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS). These were incompatible, and in the late 1990s, it wasn't clear which would become dominant. Eventually DSSS won out, due largely to the appearance of low-cost equipment from Lucent and Apple.

wireless network to cover the entire campus, which was estimated to require installing 1000 access points at an estimated cost of $3 million.

The wireless recommendation was approved by MIT's Academic Council, and the Infrastructure Group was asked to try to identify an industrial partner to work with to help defray the cost. This led to discussions with Lucent Corporation about providing MIT with equipment at low cost, coupled to a research partnership to explore new wireless applications. The discussions dragged on for months and were complicated by Lucent's impending reorganization.[16] The anticipated research partnership was never realized, but MIT was able to purchase access points from Lucent to begin experimental deployment of the network in July 2000. By July 2001, the campus wireless network included over 200 access points covering most classroom and library spaces. Full coverage of the campus, including classrooms and residence halls was eventually completed in September 2005, with a network comprising 3000 access points. The total cost of the project from its start in summer 2000 was $4 million, not far from the original estimate, even though the density of access points tripled from the original plan.

Besides wireless, a second issue the Infrastructure Group turned to in fall 1999 was student-owned computing. MIT had staked out a leadership position in student computing in the 1980s by establishing the Athena distributed computing environment in a multi-year implementation effort that created the networked computer. [16] That position had eroded by the late 90s. Most students at leading universities – including almost 90% of undergraduates at MIT – now owned personal computers as powerful as the Athena workstations that were MIT's official educational computing resource. From an institutional perspective, however, these personal machines were an invisible resource. They did not run a standard software suite, and they did not easily share files or applications with the Athena system, and so faculty could not count on them in planning the curriculum. In fact, the literature the Dean's office regularly sent in the spring to the entering class emphasized that students entering MIT need not purchase personal computers because Athena would handle all their computing needs.[17]

In educational computing circles nationally, there was great interest in whether universities should require students to own computers. Rose-Hullman Institute of Technology, Seton Hall University, and Wake Forrest University had pioneered this approach by mandating student-owned computing in 1995, and other universities were beginning to follow, with Rensselaer Polytechnic Institute implementing this policy for the fall 1999 entering class. After examining these initiatives, the Infrastructure Group decided not to recommend that MIT should mandate student-owned computing. In view of the Task Force's conservatism on educational technology, the Group feared that such a recommendation would spark criticism from students and faculty as technology-centric

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[16] Lucent spun off its enterprise business systems business in fall 2000 to form Avaya Systems, and spun off its microelectronics business in 2002 to form Agere Systems. These plans confused the negotiations by making it unclear which of the three emerging companies would be supplying the equipment, or whether the equipment purchase and the research partnership would even be with the same company.

[17] This statement was modified starting in 2002 as a consequence of the Infrastructure Group's unfolding plans. The Dean's literature still says that student need not own computers, but advises that if students do plan to purchase computers, then they should purchase wireless laptops, and recommends configurations on which MIT has negotiated discounts.

adventurism that would needlessly increase the cost of an MIT education. Subsequently, when Duke University announced plans in 2001 to seriously consider mandating student-owned computing – and declared a year later that it would not proceed with the program, this was viewed as a vindication of the Infrastructure Group's conservative approach.

Rather than mandating student purchases, the Infrastructure Group laid out a path in spring 2000 to transform Athena from a system of networked workstations to a system of networked services that could be accessed by student-owned machines, services such as authentication and authorization, access to shared file space, backup services, and the planned initiative on wireless networking. The strategy was to gradually enhance the utility of student-owned machines and let them become informally integrated into the campus infrastructure, without issuing a mandate. In conjunction with this, MIT would support experiments to assess the utility of computers in the classroom, including some of the experiments approved for iCampus and d'Arbeloff funding.

Steps toward student-owned computing unfolded much as planned, and with the infrastructure starting to emerge the following year, the Educational Technology Council began to encourage experiments with classroom wireless laptops. In spring 2001, the Council drew upon its links with the MIT-HP Alliance to approach Hewlett-Packard with a request to donate laptops for classroom experiments that had been funded by that year's iCampus and d'Arbeloff Fund awards, citing these awards as evidence of the Institute's commitment to the efforts. This resulted in a grant in summer 2001 of 65 advanced notebook computers with a subsequent grant of another 30 machines the following summer.[18]

4 2000-2001: A strategy takes shape

While the Council's Grants and Infrastructure groups were starting their initial programs, the Strategy group began a more comprehensive look at MIT's educational technology opportunities. This group was chaired by the Provost himself, and its charter was to "develop and maintain a strategic framework for MIT-wide initiatives in educational technology, including priorities for initiating programs, collaborations, guidelines for investing Institute funds, and a strategic investment process." One of the Group's first decisions was to work with an outside consulting firm, and in December, it selected McKinsey and Company to lead a study aimed at defining and evaluating MIT's strategic options in a changing educational environment.[19] The work was to be carried out by a joint McKinsey-MIT team over the next three months, leading to a report to the Educational Technology Council in April.[20]

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[18] Two HP employees who were instrumental in making the awards happen, and throughout the MIT-HP Alliance were Sheri Brodeur, HP University Relations Campus Manager for MIT, and William Wickes, who served as HP's manager for the initial DSpace implementation effort.

[19] The idea of working with an outside consulting group was suggested by Prof. Sanjay Sarma. Sarma's wife worked for Booz Allen Hamilton, and his discussions with her about MIT issues had convinced him that getting a professional consulting team to take an MIT-wide look at strategic planning issues would be highly valuable.

[20] Members of the group were (from MIT): Hal Abelson, John Belcher, Jim Bruce, Juliane Cho, Vijay Kumar, Fabien Naud, Tony Patera, Helen Samuels, Diana Strange, Glenn Strehle, and Dick Yue; and

December 1999 was still full-fledged dot-com euphoria time, and the possibilities for a world-leading university like MIT seemed limitless – and daunting. Three years earlier, the eminent management consultant Peter Drucker had famously predicted that "thirty years from now the big university campuses will be relics … The college won't survive as a residential institution,"(quoted in [17]) and anxieties about the displacement of the traditional university were reverberating in academic circles. Packs of startup suitors were courting top universities, offering to usher them – and their famous brands – into the world of internet distance education. Some of these ventures were already making offers to MIT: UNext (which had begun to work with Stanford, Chicago, Columbia, and CMU), Pensare (working with Harvard Business School and the Wharton School of Commerce), Caliber Learning (working with Georgetown, USC, Wharton, and Johns Hopkins). Other institutions were forming commercial ventures of their own: the Princeton-Oxford-Stanford-Yale $12M "POSY" Alliance for Lifelong Learning to create distance education courses for alumni, Columbia's "Fathom" Knowledge Network for online learning, and eCornell.[21]

In this boom-town atmosphere MIT, which after all was a leading *technology* institution, seemed like a disorganized straggler. One of the McKinsey consultants sketched an image depicting the various initiatives – Singapore, Cambridge, iCampus, and so on – as a collection of sailboats drifting whichever way, rather than moving in formation.

The joint MIT-McKinsey strategy team's first activity was to conduct interviews on campus to better understand how the community might react to various proposals. The result, as reported by the consultants, was a list of MIT "core beliefs":

- *MIT has a dual research and educational mission*: Faculty time is the limiting resource in innovation. At the same time research and teaching should continue to be linked and synergistic. Any expansion of the faculty would need to adhere to MIT's relatively tight definition of faculty, in which all faculty participate in teaching, research and service.
- *MIT's role as a residential institution is paramount:* Improving the quality of the on-campus experience is a high priority – maintaining the quality of the MIT community is critical, and strengthening it is desirable. Intimate student/faculty interactions should be preserved and enhanced
- *MIT is unwilling to compromise on student standards for enrollment in degree programs.* MIT's core advantages are its reputation and its ability to bring together world-class students and faculty

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(from McKinsey): Tom Anderson, Simon Blackburn, Lukas Ruecker, Michael Skoler, and Jack Welch.

[21] Looking back from 2007, it appears that eCornell is the only one of these efforts to have survived the dot-com bust. The Caliber Learning Network and Pensare both filed for bankruptcy in 2001, UNext came under financial pressure that same year, renegotiated its university agreements and morphed into Cardean University, which offers online graduate and undergraduate programs. Columbia's Fathom consortium, which at one point had 14 partners and won awards in 2002 and 2003, closed down in 2003. Princeton withdrew from the POSY Alliance, which had been launched February 2000, less than two year later in Nobember 2001. The remaining Oxford-Stanford-Yale venture carried on but struggled to attract enough students to meet its costs, and eventually closed its doors in March 2006. [18]

This list was hardly surprising to the MIT members of the team. But as the McKinsey consultants noted, the emphasis on a single-class faculty, the links between teaching and research, and the unwillingness to compromise on standards meant that proposals for distance education programs, where students don't generally participate in research, and which are often taught by non-regular faculty, would be greeted with intense skepticism, if not outright hostility.

The team also sketched a few broad themes for how MIT might take advantage of Internet opportunities, each one identified by a caricatured label:

- "Forever-tech": Create a lifelong extended community of faculty, staff, students, and alumni who interact both on and off campus, and establish a continuing education program for alumni to pursue advanced degrees and update their skills.
- "Ed-tech:" Establish a leading center for research and technological innovation in education, and use MIT as an experimental lab to test new educational technology.
- "Flex-tech": Offer a flexible and more customized educational program, including off-campus learning, to both enhance the educational experience and offer MIT education to students who would not attend a standard 4-year residential program.
- "Global-tech": Create a degree-granting program with physical presence at multiple locations to reach MIT-quality students who normally would not come to MIT.
- "Tech-tech": Become a leading educational provider to MIT's corporate partners, delivering customized courses based on MIT's strengths in inter-disciplinary knowledge and technological development.
- "Venture-tech": Create a joint venture with other top universities to support and market on-line continuing education courses to a mass market

In February, the Strategy Group met to review these options and to pick directions for the consulting team to flesh out. The result was to place highest priority to forever-tech, with the group citing the benefit to the MIT community. Ed-tech was second, again because of its potential benefit to MIT's current educational mission. Flex-tech was an intriguing third possibility, although it should not be pursued as a priority in itself, rather as a part of Forever-tech.

Lowest priorities went to activities that would expand MIT beyond its current communities: For Global-tech the Strategy group felt that MIT should be learning from the Singapore and Cambridge experiences, but was not ready for a more comprehensive strategy. For Tech-tech, there were several individual programs that addressed opportunities with particular industry partners, and there didn't appear to be a need for a centralized effort. For Venture-tech, there didn't seem to be much support anywhere in the MIT community. As Chancellor Larry Bacow remarked, "MIT is not a profit-making institution."

The options presented here posed the classic industry strategic choice of expanding ones market versus focusing on core constituencies. In MIT's case, this amounted to, on the one hand, expanding MIT's reach and influence: offering MIT education globally to top-tier students, and creating educational offerings for the corporate and mass markets; versus improving the experience "at home": enhancing the quality of MIT's current education, and engaging and leveraging the MIT community. And here, the strategy group opted clearly for the latter. In a sense, this was another endorsement of the priorities of the Task Force on Life and Learning: community was crucial, and internet efforts should focus on the MIT's educational mission in serving its community of students and alumni. But the reaffirmation came with a realization that serving the community might require venturing beyond zip code 02139, and that technology could be a key enabler here.

4.1 Setting priorities

Taking its priorities from February 2000 Strategy Group review, the MIT-McKinsey team spent the next month sketching five possible programs to consider for implementation:

- "educational technology research" (based on the Ed-tech vision),
- "flexible educational options" (based on Flex-tech),
- infrastructure (as an enabler for all programs),
- "alumni connections to MIT's core educational programs," and
- "lifelong learning" (both based on Forever-tech).

These were presented to the Council at its April, 2000 meeting. In response, the Council chartered summer activities that would investigate ways to get started on each program and report back in the fall.

Steve Lerman and Hal Abelson were asked to look into issues around Ed-tech and Flex-tech, respectively. Neither summer investigation yielded much. For Ed-tech, it wasn't possible to identify enough senior faculty members who would want to make a career commitment to educational research to justify an Institute-wide initiative leading to a major research center.

The Flex-tech theme was described in the April recommendations as:

> Over time, MIT will build flexibility into the academic schedule, allowing students and faculty to take advantage of the most compelling research and learning opportunities available on and off campus. Advanced telecommunications will maintain links to campus work, while MIT groups visit peer institutions, industry partners and research sites.

With this came a recommendation to get started by creating off-campus opportunities for students during the semester. The suggested initial experiment here was to work with the Cambridge-MIT Institute to introduce remote collaboration technology into the undergraduate exchange program that CMI was developing, so as to permit MIT students resident at Cambridge to participate remotely in MIT courses. But CMI wasn't interested in doing this, and no other immediate steps seemed apparent.

The Alumni Connections theme, spawned from Forever-tech, flipped the typical notion of involving alumni through educational technology on its head. Rather than regarding alumni as consumers for distance education programs, the idea here was to engage alumni as a resource to improve MIT core education by involving them as mentors and project supervisors. This could be done either by bringing alumni to MIT or, as the technology matured, through telecommunications. As the MIT-McKinsey report envisioned:

> MIT will harness the experience and intellectual curiosity of alumni by drawing them into the core educational experience of students. Students will benefit from the experience of alumni; alumni will benefit from exposure to on-campus ideas; and faculty will benefit from additional resources.

The resulting summer study was sponsored by Bob Redwine, MIT's newly appointed Dean of Undergraduate Education, who had joined Bob Brown and Hal Abelson as Council co-chair. The summer study group was asked to stimulate some initial projects and recommend an administrative home for these activities.

The Alumni Engagement Team's report to the Council in October recommended that the Dean for Undergraduate Education establish an Alumni Engagement Office with a full-time director and support staff.[22] This office was to collaborate with the Alumni Association in identifying opportunities for alumni to become involved in undergraduate and graduate educational activities, putting faculty members in contact with alumni volunteers, and promoting the value of alumni engagement throughout the MIT community. The team also reported that it had launched a few pilot activities during the summer, including identifying alumni volunteers for the iCampus-funded Aeronautical Engineering project and the d'Arbeloff-funded Mission to Mars project.

The Council was receptive to the report, but the Dean was reluctant to fully staff an office before more concrete activities were underway. The Provost agreed to fund a scaled-down operation for alumni engagement, to be housed in the Office of Academic Services under the leadership of Associate Dean Andrew Eisenmann, and the initiative was announced in March 2001. [19] The program got off to a good start, focusing on alumni involvement in the d'Arbeloff-funded projects, with over 600 alumni eventually participating overall.

The next phase of the work would have been a broad program of alumni interactions across the curriculum, but financial pressures in the Dean's office led to the withdrawal of funding for the program. In 2003, the operation became the responsibility of the Alumni Association, but as external funding dried up, the Association reduced its attention to the project, explaining that this really activity should be the responsibility of the academic side of the house, and the program languished, with Alumni Engagement to become an element of the strategic vision that remained untapped. One reason for the lack of strategic follow-through was that, in the meantime, the Council's attention and its energy had been captured by another initiative: OpenCourseWare.

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[22] Unpublished report, October 2000. Team members were Duane Dreger, Andrew Eisenmann (chair), Jennifer A. Frank, Robert Ferrara, Jagruti Patel, and Diana Strange.

4.2 From Forever-tech to OpenCourseware

Lifelong Learning and Alumni Connections were the MIT-McKinsey team proposals for moving ahead on the Forever-tech theme. In the vision of the April 2000 report, Lifelong Learning became:

> MIT will be a valued source of education for members of its community throughout their lives. This includes knowledge update courses designed for MIT alumni and others with a solid technical education, as well as more extended offerings, such as mid-career admission to postgraduate degree programs. Programs will involve both on-campus and on-line elements, and will be adapted to the needs of working professionals.

As a near-term step, the report proposed "Knowledge Updates" – mini-courses and current hot issues and emerging fields, with content based on MIT's strengths in technical and interdisciplinary studies. These would be delivered largely on-line, but there could be on-campus elements as well. Overall, this was not very different from the vision of the EVAT Committee five years before.

In response, the Council chartered a Lifelong Learning summer study team to plan *Knowledge Updates@MIT*, a project that would proceed as sketched in the MIT-McKinsey report. In keeping with the Task Force on Life and Learning's emphasis toward "focus on 02139," the Council added the stipulation that Knowledge Updates should demonstrably benefit MIT's on-campus students, not only alumni and other off-campus participants. The team was asked to recommend an organizational structure for the operation, conduct a marketing study and analysis, and draw up an implementation plan. The Knowledge Updates program would be authorized to request up to $2M in startup funding, but it would have to be completely self-funding after the first two years. In the words of summer study team's charter "This plan should be presented to the MIT Educational Technology Council and the MIT Administration early in September, with the presumption that it will be approved for immediate implementation."[23] The study would be sponsored by the Provost together with Engineering Dean Tom Magnanti and Sloan School Dean Richard Schmalensee, and it would be led by Associate Dean of Engineering Dick Yue. To help drive the analysis, the Council had arranged for the work to again be done with a professional consulting group, this time from Booz Allen Hamilton.[24]

The summer work was an intense effort in analysis and business planning, which drew heavily on the Booz Allen group's expertise in those areas. The team surveyed 2,500 MIT alumni on their attitudes towards continuing education. They interviewed 50

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[23] Unpublished memo from Hal Abelson and Helen Samuels to the MIT Educational Technology Council, May 2000.

[24] The Council had initially contacted MIT alumnus Reggie van Lee, a Booz Allen associate, as part of the investigation that led to the McKinsey engagement. The contact was renewed in planning this new study, and Van Lee acted as Booz Allen's coordinator with MIT for this work. MIT members of the summer Lifelong Learning Study team were Greg Anderson, Jeff Chi, Stefano Falconi, S.P. Kothari, Shigeru Miyagawa, Abel Sanchez, Toby Woll, Esther Yanow, and Dick Yue (chair). Booz Allen Hamilton team members were Reggie Van Lee (co-leader) Kyung Han (co-leader), Erfan Ahmed, Anna Kemalow, Charlotte Khoo, Marian Mueller, Anthony Nichtawitz, and Gita Swam

external organizations – corporations, government agencies, universities, and e-learning companies. They surveyed all members of the MIT faculty and conducted 50 individual follow-up interviews. They analyzed the capabilities of seven internal MIT organizations to deliver on various aspects of the knowledge update effort. They developed detailed financial models for ten different scenarios, each with sensitivity analyses and implementation plans.

The upshot of the analysis was that a financially viable knowledge updates program seemed achievable in the near term, and that it could have significant on-campus and off-campus benefits. On the other hand, the team found that "the technology-enabled lifelong learning field overall is complex, highly competitive, rapidly evolving, and often not profitable." A financially viable program would require at least 25,000 participants – a model market would include 25 corporations, 5 professional organizations, and 5,000 alumni. In essence, a program like this could be sustainable, but only if it expanded significantly beyond the target audience of students and alumni. At the expanded scale, a workable knowledge updates program could produce about 100 modules per year. The financial models predicted that the effort would require an up-front investment of $2M and that the program would break even in about five years.

The team's report recommended that a new centralized organization should be established to implement and manage an initiative of this scale, while cautioning that there were significant policy issues around faculty intellectual property and revenue sharing that would need to be addressed and that "this project places us in a non-traditional MIT business for which we have little or no existing capabilities."

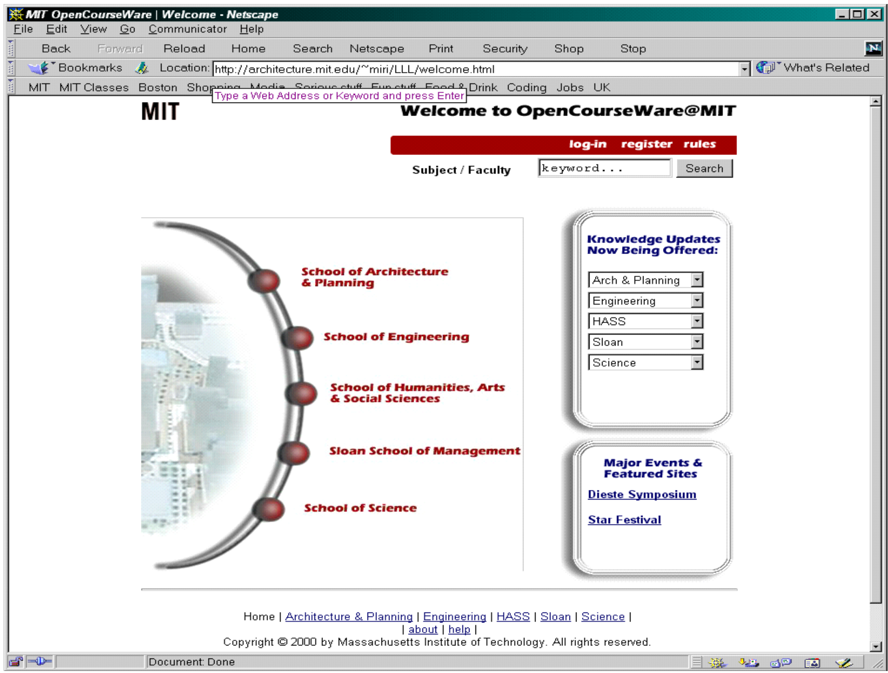
The summer team had met its charter, but as September drew to a close and the final report was being prepared, some of the MIT members of the team, including Dick Yue, who was tasked with preparing the executive summary, began feeling that after all the work, the results were uninspiring. After all, even if MIT were to successfully implement the knowledge updates plan – something that was far from certain – the outcome would not make a large difference in terms of MIT influence or leadership. [25]

Over the summer, while discussing alternative business models, the team had briefly raised the possibility of distributing not-for-profit educational materials on the Web, but without pursuing any concrete plans. As Yue struggled to pull together the final report, he decided to resurrect this idea and include it as part of the committee recommendations. The Booz Allen team was cautious: the existing recommendations were the result of painstaking research and analysis, and here was a major, counterintuitive, last-minute addition, based on no analysis at all. Nevertheless, they agreed to include it in the report, and the team hurriedly crafted some rationales for the initiative: the enhancement of MIT's leadership and reputation, the possible contribution to initiatives like Flex-tech, the benefits to on-campus intellectual life, and the recognition that "MIT is really about dissemination of knowledge." The team also noted that the existence of the free material could give MIT a competitive advantage in pursuing Knowledge Updates.

The final report to MIT's Academic Council and to the Educational Technology Council had a split personality. The recommendations and conclusions about Knowledge Updates were carefully crafted, complete with charts and financial models and backed up by attachments. And then there was a final, tentative addition, which appeared almost as an afterthought, with only the hastily crafted justifications and no analysis or attachments whatsoever:

> A revolutionary notion of OpenCourseware@MIT could radically alter the entire lifelong learning and distance learning field and MIT's role in it and should be seriously considered. [25]

This section of the report concluded with a mock-up of an OpenCourseWare home page, showing how the free material could attract people to the (non-free) Knowledge Updates. As the OpenCourseWare plan matured, the link to a for-profit venture diminished. By the time OpenCourseWare was presented to the faculty or to foundations for discussion a month later, any mention of Knowledge Updates had disappeared from the envisioned home page. (See Figure 1.)



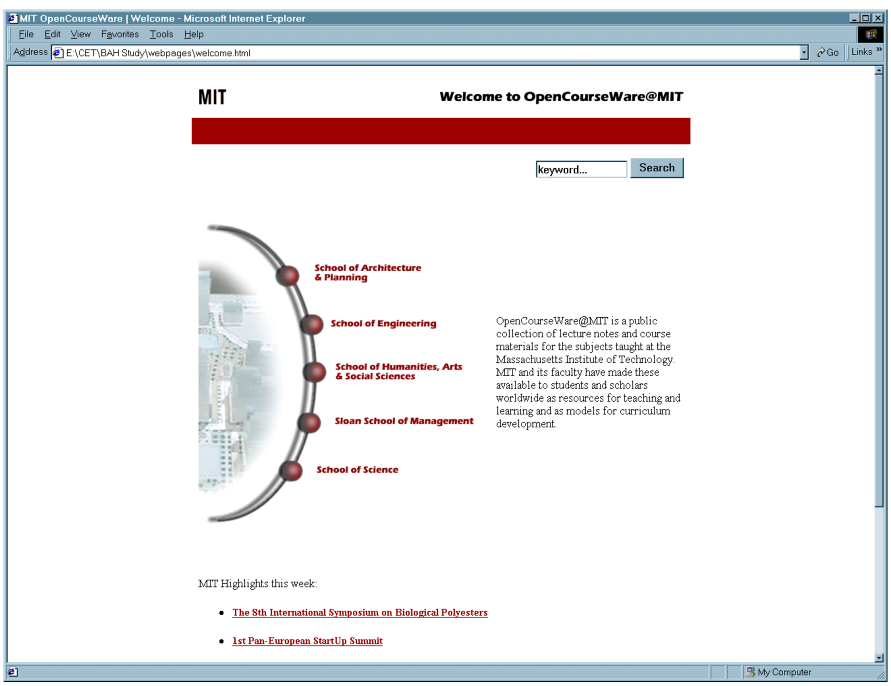


Figure 1

Top: Initial conception of an MIT OpenCourseWare home page, showing the potential for OCW to attract people to knowledge updates offerings. (From the report of the Lifelong Learning Study Group to the MIT Academic Council, October 17, 2000.) Bottom: The MIT OpenCourseWare home page used in presentations to faculty and to foundations beginning in November 2000 was derived from the original conception, but Knowledge Updates had been removed.

Lack of analysis and tentativeness of the recommendation notwithstanding, MIT's administration was enthusiastic about the OpenCourseWare concept. Chuck Vest contacted Bill Bowen, President of the Mellon Foundation who, together with program officer Ira Fuchs, were receptive to the idea and asked to hear more, and Yue, together with Abelson and Steve Lerman were asked prepare more information. The week before Thanksgiving, Yue and Abelson, accompanied by John Wilson of the MIT Foundation Office, met with Bowen and Fuchs at the Mellon office in Princeton, bringing with them a demo they had pulled together of an OpenCourseWare site with materials from five courses. Yue presented careful financial projections of expected costs for the project, which he had developed using the modeling techniques from the summer study. His results indicated that am OpenCourseWare project could publish essentially all MIT undergraduate and graduate courses over a period of 8 years at a total eight-year cost of \$93 million, and a steady-state annual cost of \$6.2 million (not counting inflation). Bowen and Fuchs were interested in hearing more, and suggested that Vest also approach Paul Brest, President of the Hewlett Foundation and Hewlett Program Director Marshall Smith to discuss joint Mellon-Hewlett funding.

Three weeks later, Lerman, Abelson, and Wilson met at Mellon headquarters in New York with Bowen, Fuchs, Brest, Mellon staff member Sarah Levin, and Brest's wife Iris – an attorney with expertise in intellectual property. Both foundations were impressed at how MIT had taken care in working with McKinsey and Booz Allen while other universities had been jumping into distance education ventures without even developing business models – although Bowen and Levin, who had carefully studied Lifelong Learning report, criticized the work on the grounds that the analysis of the alumni survey did not take sample bias into account and that the monetary projections for Knowledge Updates were consequently over-optimistic. The Brests noted that the intellectual property issues of dealing with third-party material in OpenCourseWare would prove to be "interesting." The outcome of the meeting was an assurance that both foundations, whose boards would make funding decisions in the spring, would consider an OpenCourseWare proposal from MIT very seriously.

4.3 Launching OpenCourseWare

Despite the positive signals from the foundations, Chancellor Larry Bacow cautioned that MIT could not announce this initiative before having extensive discussions within the community. Following his advice, the OpenCourseWare planners distributed a slide presentation together with a "frequently asked questions" memo to all academic department heads, introduced by email from Provost Bob Brown:

> I am sending this email to make sure you are aware of the discussions that have started with respect to a potential initiative at MIT in the use of web-based technology in education. The initiative has been called OpenCourseWare@MIT. As described below and in the attachment, OpenCourseWare could radically transform technology-enhanced education at MIT and change forever MIT's role in dissemination of education material to the world

> I am writing you to start an intensive discussion with the faculty about the Open Courseware idea so that we can reach a conclusion on whether we should move ahead. This email to you is a prelude to a mailing to the entire faculty that will occur after the first of the year.

The memo went on to say that Brown, Yue, Lerman (as Chair of the Faculty), and Abelson (as co-chair of MITCET), would be conducting individual discussions with each department during January and February, leading up to an MIT faculty meeting vote at the end of February.

The associated FAQ provided basic information, making it clear that participation would be voluntary, and that copyright of the materials would continue to rest with the authors, rather than with MIT. And the very first question addressed in the FAQ revealed the planning group's sensitivity towards any perceived conflict between OCW and the Task Force of Life and Learning's emphasis on residential education and "02139":

> *How does OCW support and enhance MIT undergraduate education?*
>
> - OCW is based on principles that are consistent with MIT's mission of the highest quality residential based undergraduate and graduate education.
> - OCW will provide support for faculty time as well as TA's and production staff to produce the materials.
> - OCW will provide a vehicle for institute-wide modernization of MIT education using educational technology.
> - OCW will enhance on-campus intellectual life: serve as a common repository and channel of intellectual activity; stimulate interdisciplinary research
> - OCW creates opportunities for major innovations of on-campus education.[25]

The ensuing meetings with 33 individual departments and major administrative units were – to the relief of the anxious planning group – reassuringly positive. The most widespread reaction was that OCW would help with course content modernization, providing resources and unburdening faculty from technical production chores. There was also recognition that MIT faculty were putting course materials on the Web anyway, and that doing this on a large scale would be more efficient in terms of technology and in addressing policy issues. And there was a strong positive reaction, but only from a minority, that OCW would be a way for MIT to take the moral high road and exert leadership. As a faculty attendee at one of the department meetings advised:

> [You] need to sharpen the message of what this is all about. You were the one who mentioned the word "grandeur": a grand project deserves a grand idea. The grand idea here is that MIT is reminding everyone of the democratic and civilizing possibilities inherent in the information age, and our desire to fulfill those possibilities by making our information public and free. We should be quite up front about the way we are bucking the trend towards privatizing information for personal or corporate gain. [21]

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[25] OpenCourseWare@mit.edu: Background information for the Faculty, January 2001 (unpublished MIT internal memo to faculty)

There were also negative reactions. A significant one was that the resource estimates were not well developed and that the resulting effort could end up costing much more than anticipated, or that MIT would end up creating a cumbersome bureaucracy to implement the program. There was also a worry that the OCW materials would be low quality – it was one thing to publish textbooks that had been carefully reviewed and edited, but exposing semi-formal and unfinished lecture notes to world view might reflect badly on the reputation of faculty and of MIT. Another, less widespread concern was that the program was not technically or pedagogically ambitious and that OCW would divert energy from more innovative educational technology efforts. And a very small number of faculty had the strongly negative view that OCW would devalue the MIT curriculum, or deprive MIT of revenue opportunities. In the words of one comment:

> The idea that this “Takes the Moral High Ground" is misguided. This initiative takes the wealth of MIT (created by hard work and toil over several generations) and devalues [it] to zero. [21]

Overall, however, the faculty reaction was supportive. The discussions culminated in a general presentation by Lerman and Abelson at the February faculty meeting, at the end of which, President Vest

> … expressed his personal opinion that MIT should take advantage of this current brief shining moment in which the web is still being used to make information available for free. The trend in higher education, he continued, is shifting towards a model of selling information. MIT could be a disruptive force by demonstrating the importance of giving information away. He noted that in the 1960s and 70s MIT had a big impact on education, not only from textbooks that were published by the faculty, but also from the course notes, problem sets and other materials our graduates took to other institutions where they used them in their teaching. OCW, he stated, gives us another chance to make such an impact. [22]

At the beginning of March, the administration decided to proceed. MIT returned to Booz Allen and chartered an “OCW Implementation Task Force” under Yue to create the OCW initial organizational model, production processes, and business plan.[26]

OpenCourseWare was formally announced at the beginning of April 2001 in a front-page article in the *New York Times*. Within four days, the News Office had received over a thousand messages, congratulating MIT on its vision and its generosity. Brown, Lerman, and Abelson prepared a final proposal to the Mellon and Hewlett Foundations, requesting $11.5M to support an initial publication phase that would mount 500 courses within 27 months. These were submitted at the end of April and approved at the foundations’ board meetings in June.

At the end of June the Implementation Task Force returned its final report, outlining the structure of a new OCW organization and an initial production plan. The

[26] Task force members were, from MIT: Hal Abelson, Greg Anderson, Donna Harding, Joseph Hoffman, Laura Koller, V.J. Kumar, Steve Lerman, Jim Mullins, Anthony Patera, Helen Samuels, Frank Urbanowski, Toby Woll, Ann Wolpert, and Dick Yue (chair); and from BAH: Kyung Han, Reggie Van Lee, Prashant Mupparapu, Anna Pettersson, and Robert Steinberger.

outcome was to appoint an interim project management board and a transition team that would launch the project and begin a search for a permanent executive director.[27]

5 2001-2003: Implementation begins

OpenCourseWare's launch was the MIT news event of spring 2001. But the canvas presented by the Educational Technology Council's planning was much broader. Fueled by resources from iCampus and the d'Arbeloff fund, MIT was able to launch a raft of ambitious educational technology activities over the next two years, as well as continue to support the major projects that had started in 1999. As these projects got underway over 2001-2003, they revealed an institutional picture that was unfolding along three dimensions: promoting active learning, contributing to the information commons, exploring new modes of institutional collaboration

5.1 Active learning

MIT's signature initiative in active learning was Physics Professor John Belcher's TEAL project to transform the freshman subject in electromagnetism to studio-mode instruction. TEAL was stimulated by Belcher's dissatisfaction with the effectiveness of his own highly regarded freshman physics lectures. Although rooted in his physics teaching experience, Belcher's dissatisfaction reflected a general concern that too much of the MIT educational experience, particularly in the freshman year, was in the form of large lecture courses characterized by a general lack of active intellectual engagement. This same concern had been highlighted in the 1998 report of the Task Force on Life and Learning:

> The large lecture format of many subjects, combined with the small amount of interaction between freshmen and faculty, means that many students have few opportunities to overcome the initial perception that MIT is about drudgery and requirements rather than the thrill of discovery and progress. [11]

In keeping with its conservative stance towards educational technology, the Task Force report gave no hint that technology could play a role in addressing the issue, but the potential of technology to be an enabler for active learning had been in the Educational Technology Council's sights from the very beginning. Indeed, Alex d'Arbeloff later remarked that it was he and Brit hearing about Belcher's initial ideas that originally encouraged them to create the d'Arbeloff fund. In addition, Belcher had been a member of the MIT-McKinsey winter 2000 study team, and a persistent force on the team for focusing on MIT education, often reacting to visions from the consultants about distance education opportunities with a down-to-earth, "I don't know about that – I just want to teach physics."

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[27] The Transition Team was led by Laura Koller from MIT and Kyung Han, who had co-led the Booz Allen summer study team, and then subsequently worked for MIT as an independent consultant. The members of the interim management board were Vijay Kumar, Marc Kastner, Steve Lerman (chair), Ann Wolpert, and Dick Yue.

When the initial year-2000 funding allocations were made, TEAL received major support both from iCampus and the d'Arbeloff Fund, and the central administration expended significant additional resources in identifying and remodeling the space to create a large new multimedia classroom. Educationally, this was an exceptionally ambitious undertaking, because TEAL aimed to replace lecture courses – as the Task Force had encouraged – starting with MIT's *largest* lecture course, second-semester freshman physics, taken by virtually all undergraduates. Belcher ran an experimental prototype for 150 students in fall 2001, and repeated this in fall 2002 before moving to full scale (700 students) in spring 2003. By fall 2003 TEAL was becoming a major fixture in MIT education and the cornerstone of the Institute's active learning initiative. 24]

TEAL was the most visible of MIT's active learning projects, but it wasn't the only move away from passive lectures. In a second large effort, the Mechanical Engineering Department used iCampus support to transform its introductory solid mechanics subject to integrate active learning into the lectures, redesigning the lecture hall so that students could perform desktop experiments at their seats, to physically explore phenomena before they were formally presented by the lecturer. 24]

A third active learning project, funded by iCampus and the School of Engineering, the Department of Electrical Engineering and Computer Science created a Web-based delivery system for lectures, called XTutor, which used slides with audio narration. The system also included online tutorial homework assignments that provided students with immediate feedback. XTutor was deployed in several large subjects, starting in fall 2000, including eliminating most live lectures in the introductory computer science course, a subject taken by about a third of all MIT undergraduates. Subsequent subject evaluations indicated an equal preference among students between the live and the online lectures, and an assessment study performed in 2002 found that the online presentation of course material appeared to result in better academic performance than auditorium-style lecturing. [25] Nevertheless, the Department resumed offering live lectures in the introductory subject in spring 2004 to accommodate the students who preferred these, while retaining the online lectures as an alternative. It also continued using the online tutor as a regular vehicle for homework.

A fourth large-scale active learning project, carried out in the Aeronautical and Astronautical Engineering Department, was not as visible across campus as TEAL, but it was in larger in scope, and included a thorough reworking of the entire Department curriculum, based on a framework for engineering education called CDIO (Conceive-Design-Implement-Operate). CDIO is a comprehensive philosophy of engineering education, motivated by the observation that in order to be effective engineers, students need not only the traditional "content" skills, but also skills in teamwork, critical thinking, and social awareness. [26]. CDIO-style instruction features extensive interpersonal interaction and collaborative design exercises, as well as innovative techniques for making lectures more interactive, such as heavy use of personal response systems and peer interaction during lecture. Even so, the project echoed the report on the Task Force on Life and Learning in taking a conservative stance towards technology, preferring to "monitor those currently breaking ground in new media, with the intent to build on their successes, and avoid their mistakes, in order to allow MIT to invest resources in this area prudently.” [27,28] The CDIO work was partially funded by one of the first iCampus awards in 1999 and again in 2000, but it was enabled mostly by extensive fundraising by the Aero-Astro Department and the School of Engineering, including a multi-million dollar renovation of the Aero-Astro building to create new learning spaces tailored for CDIO education. In 2000 MIT, with funding from the Wallenberg Foundation, joined with three Swedish Universities to form “The CDIO Initiative,” an educational framework that stressed engineering fundamentals in a context of real-world systems and products.

So overall, by the end of 2003, MIT was making major investments in active learning and transforming the pedagogy and learning spaces in some of its largest courses. The alignment of strategy and funding that made this possible was a direct response to the 1999 Task Force Report, yet with an educational technology spin that evoked the technophile (First) Council Report of 1997. In a way, the Institute had found its synthesis between the two conflicting perspectives.

5.2 The information commons

The active learning theme was focused primarily inward, at MIT’s own educational practices. In contrast, the second strategic theme – contributing to the information commons – looked outward and spoke to MIT’s leadership role in making educational materials freely available to the world. The term “information commons,” as introduced by Boyle and others, refers to common pools of knowledge that everyone is free to draw from and build upon. [29] The very possibility of the modern university relies on a commons of scholarship, and universities have a significant self-interest in keeping the commons strong. One way to strengthen the commons is to use the Internet as a vehicle for free and open dissemination of educational and scholarly works.

OpenCourseWare was the centerpiece of MIT’s information commons efforts. The irony here was that openness played little role in the strategic planning of 1999. It appeared almost at the last minute in fall 2000, as described above, in reaction to the prospect of a much more standard plan to create distance courses for sale to alumni and industry. But once the OpenCourseware idea was broached, it resonated with the ideal of the university as a supporter of the commons, leading to the project's public launch in spring 2001 under an interim management team. By October, the team had produced an internal testing site that included materials from 30 courses. In April 2002, Anne Margulies, a former director of Information Systems at Harvard and CEO of a communications consulting firm, came on as OpenCourseWare Director.[28] She arrived at MIT with the daunting charter to build a permanent organization and course publication system that would publish 50 courses by September and expand this to 500 courses by September 2003.

The organization Margulies created met both deadlines with a success beyond even what the original OpenCourseWare planners had hoped. The 50-course launch in September 2002 sparked email from around the world with praise so hyperbolic as to be almost embarrassing, comments like “It’s the Big Bang in the Knowledge Universe,” and

[28] “OpenCourseWare director named,” MIT News Office, April 24, 2002, at <http://web.mit.edu/newsoffice/2002/ocw-0424.html>, visited Sept. 4, 2007.

"one of the few beacons of enlightened thinking in an age where the darkness of oppression and proprietary small-mindedness threatens the liberties of free thinkers."

One result of this publicity was the emergence of offers to translate MIT OpenCourseWare material into other languages. The original spring 2001 proposal to the Mellon and Hewlett Foundations had focused almost entirely on activity at MIT, saying only "We will encourage other institutions to post their own freely accessible course materials." But with the encouragement of the Hewlett and Mellon Foundations, OpenCourseWare began to take on an expanded external agenda, concluding agreements for Spanish and Portuguese translations with Universia, a consortium of universities in Spain, Portugal, and Latin America; for simplified Chinese translations with China Open Resources for Education (CORE), a consortium of leading Chinese universities; and for traditional Chinese with OpenSource OpenCourseWare Prototype System (OOPS), a volunteer organization based in Taiwan. The formal announcement that OpenCourseWare had met its September 2003 deadline for publishing 500 courses was in fact made at CORE's inaugural meeting in Beijing. (The early phase of OpenCourseWare is also discussed in [30].)

Meanwhile, DSpace, the other major MIT intellectual commons activity, was also blossoming. The initial concept for DSpace was that MIT would demonstrate a university repository – a Web-based facility maintained by the libraries for hosting and preserving faculty papers and other publications. The implementation was developed jointly by the MIT Libraries and HP Labs beginning in spring 2000, under an agreement that all code would be released under an open source license. The first 18 months of the project were heads-down implementation with a development team from HP Labs resident at MIT.[29] By April 2001, the team was able to demonstrate a prototype system to the Library Visiting Committee, but DSpace was still very much an internal effort.

DSpace's visibility began to increase over 2001, along with a general interest in institutional repositories and open-access publishing on the part of leading university research libraries, an interest driven largely by a decade of extortionate rises in academic journal prices that were straining library budgets.[30] MIT Director of Libraries Ann Wolpert, who was President-elect of the Association of Research Libraries, and MacKenzie Smith, the Libraries' Associate Director for Technology, publicized DSpace among their colleagues in the library community. In January 2002, MIT and HP participated in a workshop sponsored by the Cambridge-MIT Institute with members of the Cambridge University Libraries, planning for Cambridge to partner with MIT in installing DSpace at Cambridge. By July, DSpace was in beta release, MIT had received inquiries from 35 institutions, and an article on institutional archives in the *Chronicle of Higher Education* revealed that

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[29] On the HP side, the developers were Mick Bass and David Stuve. MIT manager for the project was Eric Celeste, MIT Library System's Assistant Director for Technology Plannning and Administration. Celeste left MIT in May 2001, and Bass took over management of the project until MacKenzie Smith came on as the new Library Associate Director for Technology in January 2002.

[30] Between 1986 and 2002, the per-unit cost of serials to research libraries increased by 230% - an annual rate that was 2 ½ times the rate of inflation over the same period. [31]

> "The most ambitious and closely watched superarchive is being developed by the Massachusetts Institute of Technology. It is called DSpace, and its goal is to collect research material from nearly every professor at the Institute."

Under a grant from the Mellon Foundation, MIT constructed a plan for a small-scale rollout of DSpace through a small federation of a few carefully selected initial partners.[31] But burgeoning interest in institutional repositories and the effectiveness of open-source distribution overtook these modest plans. DSpace was officially released in November 2002 at a MIT Library public symposium on scholarly communication. [33]. By summer 2003, while the "official" federation was still launching, there had already been over 5,000 downloads of DSpace software, 125 research institutions were evaluating or implementing DSpace repositories, and 15 sites were in full production.

Both with DSpace and OpenCourseWare, what had started in early 2000 as purely MIT-centric projects, had by 2003 engendered MIT leadership positions in significant international movements, an agenda not at all foreseen in the initial strategic planning, and quite a distance from the notion of a plan rooted in "zip code 02139."

5.3 Institutional collaboration

Institutional collaboration was the third theme in the strategic picture. Like many research universities, MIT was exploring new ways to collaborate with other universities and with industry. The major initiatives – the Singapore-MIT Alliance and the Cambridge-MIT Institute – had preceded the development of an educational technology strategy, and were not inherently technology-based. Nevertheless, the Singapore program did make extensive use of Internet 2 to support synchronous transmission of lectures between MIT and Singapore, and the relationships both with Cambridge and Singapore provided useful synergies with the other technology initiatives, as in Cambridge University's early involvement with DSpace.

Two other projects, iLabs and iMoat, were pioneering forms of institutional collaboration – both funded through iCampus - that were fundamentally technological. Where OpenCourseWare and DSpace demonstrated sharing and collaboration around content, these two projects went further, showing how the Internet could be the foundation for widespread sharing of laboratory equipment and educational services.

5.3.1 iLabs: A Web of shared laboratory equipment

iLabs was born in microelectronics classes taught by Professor of Electrical Engineering Jesús del Alamo. In 1998, he rigged up a system to let students in his microelectronics class test transistors over the Internet, rather than requiring them to come to the lab to use the test equipment. The obvious benefit for students was more convenient access to labs. But del Alamo could see potentially more significant benefits for MIT. With a networked system, the university could schedule access to expensive equipment more efficiently. A

[31] The initial DSpace Federation members were Cambridge University, Columbia, Cornell, MIT, Ohio State, University of Rochester, University of Toronto, and University of Washington.

traditional laboratory for a class of 50 students might require 25 stations, each with expensive equipment. With network access, a single station could fulfill the needs of an entire class. Suddenly, there was the possibility of using real laboratories in many classes that could never before accommodate them because of the expense of equipment and the difficulty of scheduling. One could imagine that, with the Internet, laboratories could become a resource of abundance, not scarcity, almost like the impact of the Internet on libraries. It was a fitting innovation for MIT which, in the nineteenth century, had pioneered making science laboratories available to undergraduates.

In the spring of 1999, del Alamo piloted an improved version of "WebLab" with a class of 90 students, an experiment supported by the MIT Alumni Fund for Educational Innovation and equipment donated by Hewlett-Packard. The success of this experience led him to apply to the first iCampus funding solicitation in late 1999 with a proposal to develop additional web-enabled laboratories, together with a software framework that would simplify development of new "I-Labs" in several engineering departments. The iCampus Steering Committee received the proposal enthusiastically, agreeing to allocate a million dollars in funding for it for the next two years, with an additional $120,000 coming from the School of Engineering.

The iCampus iLabs project was initially organized as a collection of separate experiments put online by faculty in several departments across the School of Engineering: remote instrumentation on one of the main flagpoles in MIT's Killian Court so that students could study its vibration modes, a mechanical shake table, a chemical reactor, a heat exchanger, and polymer crystallization experiment. The microelectronics experiments were particularly successful, becoming a regular part of del Alamo's classes and attracting interest from engineering faculty outside MIT almost immediately. Beginning in fall 2000, in a collaboration encouraged both by iCampus and the Educational Technology Council, the equipment in del Alamo's lab at MIT was used by students in at the National University of Singapore, in classes coordinated by the Singapore-MIT Alliance.

By 2000, the computing world was becoming interested in Web Service Architectures – distributed computing systems that communicated in standard ways using Web protocols, and Microsoft was making a large investment in this technology through its .NET initiative. iCampus, particularly Hal Abelson and Dave Mitchell, Microsoft's on-campus manager for iCampus, became interested in the potential to harness Web services as the foundation for an extension of iLabs built on a "shared architecture" that would supply underlying central services for remote labs, such as scheduling and authentication. The goal of the shared architecture was to ease the task of maintaining iLabs software over the years by centralizing key functions, and to encourage sharing labs among institutions by making it possible to separate, possibly to locate in different institutions, the administrative tasks involved with class use of a remote lab from the provision of the lab equipment itself. In the spring 2001, they initiated a small iCampus project, where a group of students used .NET to develop a prototype of this architecture and a simple demonstration lab, which they demonstrated at the Microsoft Faculty Summit in July 2001, coordinated with a major presentation on iLabs by del Alamo and the other MIT iLabs faculty.

The student-developed prototype encouraged del Alamo that future development of iLabs could adopt a more aggressive multi-institutional goal, but he felt that his own Laboratory at MIT was not well-suited to take on an extensive educational software development project. In response, the iCampus steering committee suggested that he team up with Prof. Steve Lerman, whose Center for Educational Computing Initiatives (CECI) had been established to undertake just these kinds of mixed research and development projects. In 2002, iCampus approved a follow-on to the original iLabs project, now under the joint direction of del Alamo and Lerman. The goal of the project, in addition to extending the WebLab work, was to create the "kernel of a major new programmatic MIT institutional initiative to promote shared access to laboratory equipment by educational institutions around the world." [34]

It would be 18 months before the new architecture would be ready for deployment. In the meantime, teaching experiments using the original software continued apace, for example, with major use of WebLab at Chalmers University in Sweden in 2003 and 2004. In the meantime, iLabs had become imbued with much the same emphasis on sharing as OpenCourseWare. The project exited 2003 with a global vision – albeit a vision confronted with a major software development challenge.

5.3.2 iMoat: A Web of Shared Learning Services

MIT's online essay evaluation system traces its origin to the fall of 1995 and a conversation between Hal Abelson, then Chair of MIT's Committee on Undergraduate Admissions and Financial Aid, and Writing Program Director Les Perelman who was administering the Freshman Essay Evaluation to the incoming class. Like many universities, MIT assessed entering students' writing ability with an *en masse* timed test, where they were given a short passage to read, and then asked to write a short essay with blue book and pencil. Abelson, who was a member of the EVAT committee, and thinking about institutional applications of educational technology, suggested that the writing assessment could be better done on line during the summer, since most entering students were accustomed to writing with word processors. Students could get email telling them what to read and what the essay question would be, and they would have a short period of time to compose their response and email it back to MIT.

Perelman was enthusiastic about the idea, because he believed that such an assessment could be both more valid and educationally more valuable than the current method. It would give students time to write thoughtfully, and give the Writing Program time to do more careful evaluation and provide students with better feedback. He proposed a program to several academic administrators, who were intrigued and referred it to the Committee on the Writing Requirement, which took up the idea – and then set it aside for two years. Finally, in the spring of 1998, the Dean's office assigned an undergraduate to create an email-based "Online Essay Evaluation System" as an option that a few incoming students might want to try over the summer. The response was much higher than expected, with more than half of the incoming students opting to use it that first year.

The next year more than three-quarters of the incoming class used the system, and by early 2000, Perelman, who has been talking about the online system with colleagues from other universities, began getting requests to disseminate the MIT system. Unfortunately, the program couldn't be used at other universities because it was too closely tied into MIT's idiosyncratic registration system, a system that MIT was finding increasingly difficult to update. Perelman told Abelson about his concern that the essay system would soon become unmaintainable, and Abelson, who had been thinking about iLabs and Web Service architectures, was struck with the thought that a new essay grading implementation could be built based on .NET, as an additional example of using Web services for shared educational infrastructure. In fall 2000 he assigned two students in his Web programming class to work with Perelman to produce a .NET-based prototype as a term project, and the results were so successful that Abelson encouraged Perelman to apply for an iCampus grant to create a full implementation.

In September 2001 iCampus awarded Perelman a two-year grant of $350,000 to partner with a few colleagues in writing instruction at other universities to create a new implementation ready for use in summer 2002, followed by a year to be spent improving the system and creating a consortium with a sustainable business model for collaborating on writing assessment. The consortium, under the name of iMOAT (MIT Online Assessment Tool) launched in fall 2001 with MIT, CalTech, DePaul University, Louisiana State University, and the University of Cincinnati as the initial partners. The implementation project met its 2002 target date and was used by all five institutions that summer – over 4000 essays submitted online, including 90% of MIT entering freshmen, and the partners anticipated that 25 schools would be participating within two years.

5.4 Consolidation

By the end of 2003, the planning begun four years earlier was having a major impact. Several of MIT's largest subjects were being transformed with active learning methods, two projects with global were reach were beginning to attract international collaboration, and the campus wireless network was rolling out. The consensus on the Educational Technology Council was that this was about as much in the way of new initiatives as the Institute was ready to absorb for few years, and that it was time to let things consolidate. Even the d'Arbeloff and iCampus funds were conservative in starting new activities, with most of their allocations after 2003 going to continuation funding of ongoing initiatives, although there were some major new projects launched, including research in educational video games, collaborative design in mechanical engineering, multimedia resources for arts and humanities, and an extension of TEAL's studio-mode instructional format from physics to introductory programming, experiments with tablet computing, and a Web-based lecture transcription service based on automatic speech recognition.

Overall, the program put into place reasonably satisfied the desire to balance educational goals of the 1998 Task Force report and the earlier technocentric visions. With respect to the strategic positioning of 1999-2000, the biggest surprise was the transformation of a standard plan for distance education into a leadership position in Internet-based sharing through OpenCourseWare, reinforced by DSpace and iLabs; while the biggest unseized opportunity was the lack of follow-through on alumni engagement. In any event, the end of 2003 marked a hiatus in the central initiation of new projects and a chance for the existing efforts to evolve.

6 The view from 2007

MIT's decade of educational technology investment, some $50 million, began in the euphoria leading up to the Internet bubble and came to a close as the collective focus of the institution shifted to a more measured period of taking stock.[32] Perhaps there's a natural cycle that gives research and teaching organizations a chance to breathe and reflect, as other factors in the ecology of higher education rise to capture the collective attention of the institution.

The greatest challenge facing any university educational innovation is sustainability – institutionalizing projects so that they persist after the novelty has worn off and original developers have turned elsewhere. So it's encouraging that most of the innovations whose birth was described above are still active. This section gives a brief synopsis of their progress since 2003.

Active learning: TEAL

TEAL reached full-scale deployment in MIT's second-semester freshman physics by the end of 2003. Beginning in 2004, the studio-mode format was expanded to include first-semester physics, an expansion that required additional investment to construct a second large multimedia classroom. TEAL is a project that has fully traversed the innovation cycle, from experiment to pilot to widespread adoption. It is now the default format by which introductory physics is taught at MIT. Significantly, TEAL teaching in physics no longer relies on the original innovator John Belcher, but is now the shared responsibility of several faculty leaders within the Department. By all measures, this educational innovation has become assimilated into the physics curriculum as the new standard. [35] TEAL's influence has extended beyond MIT, with TEAL classrooms now operating in universties in Taiwan, Australia, and Japan. There is also a significant amount of evidence beginning to accumulate about the educational effectiveness of TEAL, as compared with more traditional approaches. [36]

Active learning: XTutor

The MIT introductory computer science subject reinstituted live lectures in fall 2004, but the online interactive homework tutor remained a major component of the course. The tutor system was adopted by three other large subjects in the Electrical Engineering and Computer Science Department, and a second implementation of the system is under development. Currently, the Department is undertaking a major revision of its undergraduate curriculum, which includes replacing the introductory subject; the new replacement subject is also using the tutor system. Like TEAL, XTutor has become a regular part of the educational infrastructure. It is not as far along in the innovation cycle, though, because the initial innovators are still heavily involved in the system's use and development.

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[32] An estimate of $50 million is conservative if one counts $10M from the d'Arbeloff Fund, $25M from Microsoft iCampus, $11M from the Mellon and Hewlett Foundations toward OpenCourseWare, and funding for the Aero-Astro Department's CDIO initiative.

Active learning: CDIO

The Aeronautical and Astronautical Engineering Department's CDIO activity, strongly underway in 2003, has by now passed through the "innovation" stage and is thoroughly embedded into the Department's curriculum. Beyond MIT, the CDIO Initiative has remained strong and has grown, now with 22 active members, and a major book on CDIO and engineering education published in 2007. [37,38]

Information Commons: OpenCourseWare

OpenCourseWare continues as a major focus of MIT's strategic outlook, just as it has since 2001. It's publishing schedule is on track, and in fall 2007 it met its original objective of publishing "virtually all" MIT undergraduate and graduate courses – 1800 courses in all, with material contributions from over 4800 individuals, including 90% of MIT's tenured and tenure-track faculty. The significant challenge for MIT OCW going forward is sustainability. OCW's foundation funding will run out in 2011, and the Educational Technology Council is working MIT's administration to implement a sustainable model to keep OCW functioning as a permanent MIT activity. The external collaboration around OCW that was just emerging in 2003 has greatly expanded. There is now an OpenCourseWare Consortium, launched in 2004, with over 160 university members working together on open publication of their course materials. Even more broadly, the Hewlett Foundation, stimulated in part by their funding of MIT OCW, launched a major initiative in Open Educational Resources in 2001. This is sparking a worldwide OER movement, in which MIT plays a major leadership role.

Information Commons: DSpace

Like OCW, DSpace has thrived and taken on an increasingly important external and international role since 2003. The impetus toward open-access publishing and concern about costs of traditional journals has become even greater, and this is accelerating interest among universities in institutional publishing repositories. A 2006 survey by the Association of Research Libraries showed that about half of ARL institutions maintained repositories, and that among these, DSpace was the by far the most commonly used system. Overall, as of summer 2007, there have been more than 40,000 downloads of the software, putting DSpace within the top 2% of all open source projects in the widely used Sourceforge repository; and there are over 500 live repositories in full production, located in 47 countries. In July 2007, MIT and HP launched the DSpace Foundation, an independent non-profit corporation being incubated at MIT, to take over ongoing direction and development of the software and coordinate the DSpace community.

iLabs

The iLabs remains an area of active development with the Center for Educational Computing Initiatives. In 2003, the CECI team was beginning to implement a new architecture based on Web Services, in order to better support sharing of online laboratories among universities. A first implementation was released in 2004 together with a redesigned version if the original microelectronics experiment. The team also deployed a public version of the microelectronics lab on OpenCourseWare, which let anyone on the Web run demonstration experiments using the MIT equipment. Since then, the iLabs team has extended the core architecture to support experiments where students can interact with the equipment as the experiment is being run, rather than just getting the data afterwards. The team has also established ongoing relationships with Dalian University in China, with a consortium of Australian universities led by the University of Queensland, and with universities in Nigeria, Uganda, and Tanzania. Overall, there are currently 18 iLabs in operation and under development, supporting experiments in chemical engineering, electrical engineering, materials science, physics, power generation, and nuclear science. This includes use of iLabs in about half a dozen courses at MIT. On the other hand, the project is still being funded a research enterprise: developing a sustainable model for outside collaborations and integrating remote labs into MIT's own infrastructure have yet to be addressed. (For a in-depth look at the iLabs architecture and current activities, see [39].)

iMOAT

The iMOAT project is similar to TEAL in following the full-trajectory of the innovation cycle. It is now a free-standing consortium, fiscally self-sustaining and nine universities integrated into the freshman admission process of nine U.S. universities.[33] Nearly 17,000 students wrote essays and receive evaluations on their work from IMOAT in the 2006-07 academic year. A key factor is in the successful transition to autonomy of iMOAT as a "service" and not just a "project" was the design criteria at the outset. The iMOAT program at MIT sought out writing program directors for their advance and suggestions on MIT's writing evaluation process, thus making a design good for MIT easier to spread to other institutions, as well. The broader vision of the requirements gathering process helped lay the foundation for wider dissemination later, and the iMOAT consortium continues to seek new membership. Equally important, the historical data on rhetoric from student essays submitted in the admissions process is creating a repository of essays that can become a valuable academic resource for the study of writing in the future.

7 Looking back

Strategic planning for university educational technology verges on the oxymoronic. If asked about educational strategy, most faculty members will probably say that the best strategy is for the administration simply to provide funding and get out of the way. Even so, there are major themes that can be evoked and synergies that can be encouraged and – especially in the case or technology – shared infrastructure that can be developed. And the strategy process itself is a tenuous one. At the first spring 2000 meeting of the McKinsey-MIT strategy team, one of the consultants explained to the MIT group what strategy setting was like: You pick some visions and start moving towards a goal. In all likelihood you'll end up somewhere else, but the critical thing is to start moving. That's not a bad description of what happened at MIT: an impetus born in large part out of

[33] Current iMOAT consortium members are: MIT, University of Cinncinatti, SUNY Stony Brook, Lousisana State University, Albany College of Pharmacy, Rice University, California Institute of Technology, Drew University, Des Moines Area Community College and the University of Massachusetts at Amherst.

higher education's dot-com fascination with distance learning was transformed by a deep concern for residential education, and this drew from within the MIT community visions and plans that were more inspired and more consequential than the original.

Strategy aside, none of this could have happened without a major commitment from MIT's top administration: in obtaining funding for this work, in being actively involved through the planning and implementation, and in vocally promoting the results. Sustaining the attention of the institution for a decade is itself a remarkable achievement. And yet, a major realization gained from this period in MIT's history is one of the paradoxes of educational technology development – technology innovation can happen with breathtaking speed, but achieving innovation across an institution takes years of sustained effort.

Postscript on Knowledge Updates (2001-2005)

While MIT administration was enthusiastic about OpenCourseWare in the October 2000 Lifelong Learning report, the response to the recommendation on Knowledge Updates was more tempered. Perhaps Dick Yue's original concern that a Knowledge Updates initiative would be relatively uninspiring was justified, or perhaps the preparations for OpenCourseWare monopolized the energy available to devote to distance education. In any event, the Educational Technology Council played only a minor role in continued Knowledge Update planning, and left it to the School of Engineering and the Sloan School of Management to prepare a detailed program plan. This was presented to the Provost in December 2002, but the Provost was skeptical and decided not to allocate central MIT funding to the effort. The Sloan School then withdrew, also declining to allocate their own funds. The School of Engineering continued the effort alone and, aided by a grant from the Lord Foundation, developed a prototype Knowledge Update module featuring the work of Prof. Robert Langer on localized drug therapy. This led to the approval by the School of Engineering of three-year pilot project beginning in May 2003.

The Engineering Knowledge Updates project produced 20 modules in the area of life sciences between May 2003 and September 2005.[34] Each module – topics offered included Systems Biology, Microfluidic Devices, and Electronic Control of Biomolecules – consisted of 30 to 100 web pages with a topic overview, references, and information on key companies and people, together with 5 to 20 minutes of video presentation. Modules sold for $75 to $450 depending on the length. Production costs for a module were between $15,000 and $20,000, which was right in line with the analysis of the Lifelong Learning summer 2000 study. But the summer study's market projections proved to be wildly optimistic: the initial offering between October 2005 and January 2006 garnered only a few dozen requests for further information and only about a dozen sales.

Perhaps MIT could have done a more aggressive marketing effort for Knowledge Updates. But the real factor, according to a follow-up marketing analysis conducted by

[34] The School of Engineering Knowledge Update project was directed by Jennifer Stine, Executive Director of the School's Professional Education Program.

the School of Engineering, was that the world had changed immensely between 2000 and 2005. Few survey respondents were willing to pay $450 for these kinds of materials, and most said that, of different types of educational products and services, they were most satisfied with free Web-based resources. In 2000, the dot-com conventional wisdom held that selling educational content on the Web could be a gold mine. By 2005, collections of quality educational content were becoming increasingly available for free, including through efforts like OpenCourseWare.[35]

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[35] In hindsight, this phenomenon of decreasing ability to monetize content on the Internet might have been predicted. In fact it was, by Andrew Odlyzko in [40].Odlyzko’s insightful analysis, seemingly contrarian when it appeared, has proved to be increasingly on target.

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