By Charles M. Vest

Open Content and the Emerging Global Meta-University

There are many questions familiar to all who ponder the role of the university in the modern world. Among them are the following:

- What is the appropriate use of "educational technology" in teaching, learning, and scholarship?
- What will be the nature of globalization of higher education?
- Will the Internet fundamentally reshape higher education?
- Are residential colleges and universities dinosaurs or the wave of the future?

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As I have thought about these and related questions, I have had a recurring nightmare in which students all over the world are sitting in front of a box, all viewing the same lecture. This vision is more or less what many assumed would be the case as the digital revolution broadly began to influence higher education. Entrepreneurs would hire the best lecturer that they could find in each subject area, record his or her lectures, and sell the lectures to self-learners and educational institutions.

MIT's adventure in providing an alternative to this nightmare began in 1999 when Provost Robert Brown launched a committee of faculty, students, and administrators to consider how MIT should position itself in the use of educational technology and distance learning. At issue was whether there was a large-scale program we should undertake. Frankly, like others, we entered this discussion assuming that we would find a market niche for distance education in some form and that revenue streams would be generated to cover costs—perhaps even to exceed costs and be plowed back into the program. The committee's initial questions were frequently about what the right constituency would be.

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MIT is good at teaching very bright, highly motivated students in an intense, rigorous, and frequently "hands-on" environment. It was not clear that our role should be the production of courses for wide dissemination in other educational environments. We generally teach at a rapid pace, one that would not easily translate into many other important contexts. Many thought that the answer would be to provide further education to two of our most natural constituencies: our alumni; and industry researchers and practitioners with whom we partner. Consultants provided pro bono by Booz Allen Hamilton assisted the committee. In addition to deliberating, members of the committee studied the business plans for several for-profit educational entities. The broad conclusion was that in the context of advanced-level education of the type conducted at MIT, distance education was likely to be complicated, highly competitive, and unlikely to make money. This led Brown to visit me in the president's office.

Brown told me that the committee was ready to report back and asked whether I was prepared to receive its recommendation. He alerted me that the committee would recommend that "we give away all of our course materials by putting them on the Web." Now, my proclivity is to think about important issues for some time before coming to a conclusion. In this case, however, I immediately grasped the elegance of this idea, as well as its consistency with MIT's history and values. Let me explain.

In the late 1950s through the 1960s, MIT played the prominent role in launching the "engineering science revolution." The origins of the revolution lay in the Radiation Laboratory, which MIT operated for the U.S. Army during World War II. The "Rad Lab" was charged with developing radar, a British invention, into practical systems for use in the war effort. The Rad Lab was a joint U.S.-British effort that brought together a remarkable group of physicists, mathematicians, and engineers to work in a concerted manner on this project, which was extremely important to the Allied victory.

When the war ended, the government did something that seems unimaginable today. It closed down this successful lab, whose mission was then complete. But before the government turned off the lights and locked the doors, it funded key staff members for six months to record the technical essence of their work. The twenty-eight volumes that resulted did document the work, but they also had a greater significance. These volumes formed the basis for a new approach to the practice of electrical engineering and, indeed, engineering more broadly. This approach moved engineering away from being primarily a phenomenological and experience-based "handbook" profession to being one more centrally based on scientific first principles.

This stimulated an educational revolution, particularly under the vision and leadership of Gordon Brown, dean of the MIT School of Engineering. Subjects were redeveloped on a base of science, and new teaching materials were generated throughout MIT—lecture notes, problem sets, and experiments. In due course much of this was formalized as published textbooks and textbook series. But what really propagated the "engineering science revolution" was that many of the rapidly increasing numbers of engineering PhD's educated at MIT joined faculties of universities and colleges all across the country, bringing with them their lecture notes, draft textbooks, problem sets, and laboratory experiments.

These faculty moving throughout the country adapted their teaching materials to their new environments. They added to, subtracted from, and used the materials to teach at varying paces. This merged into developing programs in many colleges and universities, and before long, the nature and quality of engineering education was elevated across the country. Of course, many fine institutions like Stanford University, the University of Illinois, and the University of California–Berkeley contributed greatly to this rapid evolution.

All this sprang to mind as Brown told me about the committee's recommendation, because although I had not been educated at MIT, the work there had directly influenced my undergraduate engineering education at West Virginia University and my graduate engineering education at the University of Michigan. So it seemed instantly clear to me that in

1999, a well-developed initiative could have a similar impact worldwide—at "Internet time" and without the random movements of MIT graduates as intermediaries to other institutions.

Thus I had the privilege of working with many others to promote the development of MIT OpenCourseWare (OCW). MIT OCW is a Web-based publishing venture, not teaching at a distance. It offers materials for teachers and learners, not degrees or credits. Metaphorically, it puts the books on the library shelves. Our goal is to provide free access—in a well-organized, searchable manner—to materials for the almost 2,000 subjects we teach. To date, the William and Flora Hewlett Foundation, the Andrew W. Mellon Foundation, and MIT itself have provided most of the financial support for OCW. New contributors and partners have recently come on board, most notably the software company Ab Initio. But above all, OCW exists through the generosity of the MIT faculty who choose to share their approach to pedagogy, organization of knowledge, and educational materials in this way. It is a voluntary activity for faculty, and their response has been so positive that we have had no doubt about accomplishing the OCW mission.

OCW is an adventure. This can be quickly discerned by visiting its Web site (http://ocw.mit.edu) and perusing the reactions from around the world. We know a lot about its use because it is highly instrumented, especially by user surveys that receive remarkably high response rates. Students at peer universities are augmenting their learning by using OCW. A group of unemployed Silicon Valley programmers used OCW to master advanced languages while they were between jobs. A university in Ghana has used OCW to benchmark its computer science curriculum and revise its courses. An underground university uses OCW as a primary resource to educate its 1,000 or so students, who are members of a repressed minority in their country and are not permitted to attend college or university. A professor in Baghdad has based his research on data available in an OCW subject. The stories and unusual paths are almost as numerous as our users.

At this stage, we have mounted the materials for about 1,250 subjects from 33 academic disciplines in all 5 of our schools. Visitors are located on every continent and average over 1 million visits per month, with the average visitor using almost 10 HTML pages per visit. Educators make up 15 percent of MIT OCW traffic, students represent 31 percent, and self-learners form 48 percent. Of users surveyed, 96 percent would recommend OCW to others, and 88 percent say that it has helped them to learn. In addition, almost 70 percent of MIT's on-campus students make heavy use of OCW. They review subjects they took in the past, reinforce subjects they are currently learning, and sample and explore other areas of study.

In addition, as we had hoped, MIT OCW is contributing to an emerging global open courseware movement. We know of fifty OCW initiatives in the United States, China, Japan, France, Spain, Portugal, and Brazil. Thirty more initiatives are being planned in South Africa, the United Kingdom, Russia, and elsewhere. Consistent with our open philosophy, MIT OCW has actively worked to encourage and assist this movement.

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I find particularly visionary the Sofia (Sharing of Free Intellectual Assets) project of the Foothill–De Anza Community College District in California, for which the Hewlett Foundation has provided important support. Modeled on MIT OCW, Sofia extends the open courseware movement to a different, extremely important sector of education: community colleges, which serve highly motivated populations, many of whom have quite focused interests and modest budgets of time and money. The project is still in a pilot phase. A very different example is CORE (China Open Resources for Education), which is translating MIT OCW courses into Mandarin and making them available across China. In return, CORE is beginning to make Chinese courses available and to translate them into English. Another partner, Universia, a consortium of 840 institutions in the Spanish-speaking world, translates MIT OCW subjects into Spanish and makes them available. Finally, Utah State University's Center for Open and Sustainable Learning (COSL) is a partner that does outstanding research on open learning, materials, and software.

How will OpenCourseWare evolve in the future? Will it continue to evolve largely by replication in other institutions? Will it grow, Linux-like, into a single entity with continual improvements being made by educators and learners around the world? Or will it be replaced by other developments? I do not know the answers to these questions. I do know that under the outstanding leadership of OCW Director Anne Margulies and several faculty leaders, OCW has flourished and appears to be fulfilling its vision. It has helped to stimulate a broader open-source movement for scholarship and education.

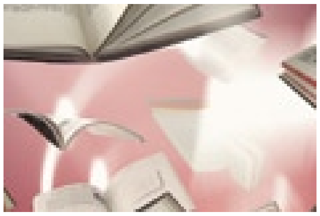
Open Resources for Scholarship and Education

I admit to using the word *open* in a loose manner here. *Open*CourseWare refers to educational content that is available on the World Wide Web free of charge. *Open* software generally refers to software whose source code is readily available and can be modified by users for their own purposes or to software whose continual development is assisted by a volunteer community of code writers, such as

Linux. In the following discussion, I use *open* also to describe nonprofit electronic content and archiving initiatives that make materials widely available on the Web through some form of institutional user charges.

The Andrew W. Mellon Foundation has played a major role in developing programs that use the Web to make large volumes of materials available to scholars, students, teachers, and institutions, many of which would have little opportunity to access them otherwise. Mellon's widely admired JSTOR was the first such major initiative. Its launch in 1990 was seminal in the evolving world of providing digital materials for research and teaching. JSTOR makes available digital copies of scholarly journals in the arts, sciences, and humanities. Generally, the JSTOR archiving begins three to five years behind the current issues of most journals. JSTOR is a nonprofit organization that charges fees scaled to the size of user institutions. It currently serves 2,600 institutions, almost half of which are outside the United States, and archives 580 journals from more than 360 publishers. Like MIT OCW, JSTOR has been an adventure: its uses are frequently wonderful and perhaps unanticipated. For example, access to its wealth of scholarly content in electronic form has allowed professors in very small departments and colleges to participate and collaborate in fields of scholarship and teaching that otherwise would have been closed to them.

ARTstor, launched more recently with the initial backing of the Mellon Foundation, makes available high-quality digital images of works of art for use by scholars, teachers, and students. Its operating and charging frameworks are similar to those of JSTOR. The collections in its archives are approaching 500,000 images.



NITLE works in collaboration with consortia of liberal arts campuses to advance economical and pedagogically appropriate uses of digital collections and tools.

In 2000 Mellon launched Ithaka, whose mission is to incubate innovative projects that focus on the use of digital technologies in higher education and that hope to evolve into sustainable not-for-profit enterprises. It also provides shared administrative and technological services to affiliated entities and advice to other organizations, based in part on Ithaka's own research into cost-recovery models. In short, Ithaka aspires to create new scholarly uses of digital archiving and also to serve as a catalyst for the effective infrastructure building and acceleration of not-for-profit entities to serve the global scholarly community while upholding its values.

Ithaka has three initial projects: Aluka, NITLE, and Portico. Aluka works with scholars worldwide to develop digital scholarly resources from the developing world, starting with Africa. NITLE (National Institute for Technology and Liberal Education) works in collaboration with consortia of liberal arts campuses to advance economical and pedagogically appropriate uses of digital collections and tools. Portico, established in 2005 and built on the base of its predecessor, the Electronic-Archiving Initiative, maintains digital archives of scholarly journals that were initially published in electronic form (as opposed to JSTOR and ARTstor, which digitize printed materials).

One of the largest endeavors in indexing and archiving is the Google Books Library Project. Google has engaged the libraries of Harvard University, the University of Michigan, the New York Public Library, the University of Oxford, and Stanford University. Google's stated goal is to "digitally scan books from their collections so that users worldwide can search them in Google."[1] This is a book-finding initiative, not a book-reading initiative. If a book is out of copyright, the entire book is accessible. Otherwise, one can view snippets of the book, or a few of its pages, online and can obtain information about purchasing it.

Other major digital archiving activities include the Million Book Project and DSpace. The Million Book Project is a collaboration of Carnegie Mellon University, the Online Computer Library Center (OCLC), and government and academic institutional partners in China and India. The U.S. National Science Foundation has provided important support for this project. The goal is to create a free-to-read, searchable digital library. This initiative is notable for its highly international collection. As of fall 2005, it included more than 600,000 books, of which 170,000 are from India, 420,000 from China, and 20,000 from Egypt. Of the total number of books, 135,000 are written in English.

DSpace at MIT has a different goal from those of the archiving projects discussed above. Its goal is to develop a platform to make available the digital scholarly output of a single university. It includes such material as preprints, technical reports, working papers, theses, conference reports, and images. These materials are at the opposite end of the spectrum from out-of-copyright books and journals; this is the stuff of working scholarship. MIT has joined with Hewlett-Packard (HP) to create this archive and to establish a DSpace Federation to promote and enable such repositories using freely available open-source software. Because DSpace is an open-access software platform, those who use the code are not obligated to register or otherwise identify themselves as users. Nonetheless, 150 institutions located on every continent except Antarctica have voluntarily registered installed sites using DSpace software.

Open-Access Journal Publication

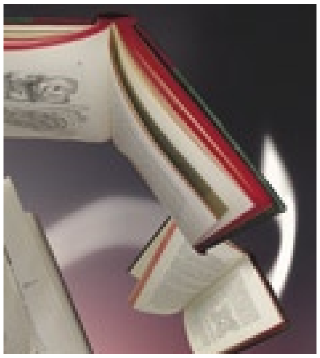
The various projects noted above provide open access (or nonprofit, shared-cost approximations thereto) to teaching materials, archives of digitized journals and books, collections of digitized art images, near real-time collections of the scholarly output of institutions, and archives of back issues of electronic journals. But there is an additional and potentially very important dimension to the open movement: open-access journal publication. The Public Library of Science (PLoS), founded in 2000, made the first major foray into this domain. Harold Varmus, president and CEO of the Memorial Sloan-Kettering Cancer Center, Patrick Brown of the Stanford University School of Medicine, and Michael Eisen of the University of California–Berkeley spearheaded this initiative, which publishes open-access journals in biology and medicine and promotes open access within the scientific community.

PLoS utilizes a broad definition of *open access:* "Everything published in PLoS journals is immediately available online for free. Read it, host it, print it, copy it, distribute it—all use is fair use, so long as the original authors and source are credited."[2] Currently PLoS publishes five journals: *PLoS Biology*, *PLoS Medicine*, *PLoS Computational Biology*, *PLoS Genetics*, and *PLoS Pathogens*. The vision of PLoS is very similar to that of the open courseware movement: we should utilize the empowering properties of the Internet and the Web to make scientific information quickly available as a public good. The PLoS Web site states:

The huge expansion of the Internet means that:

- *Original research can now be distributed at minimal cost online*
- *Barriers to access such as subscription fees and restrictive licenses can be removed*
- *Peer-review can be swiftly conducted online*[3]

In addition to PLoS, the Howard Hughes Medical Institute and the Wellcome Trust have encouraged the open-publication movement by covering the publication costs for researchers whose work the institutions have sponsored—if the work is published in open-access journals.



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A Next Stage: Web-Based Laboratories

I believe that iLab, a project initially conceived and implemented by Professor Jesus del Alamo of MIT, is a harbinger of the next stage of open content: the online laboratory. The principle is simple. Most experiments today are controlled by computers. Therefore, the experiments can be controlled from any distance through the Internet. This is not new in the world of research. Higher education has much experience, for example, in operating telescopes and other research instruments from great distances. The new idea—and the idea behind iLab—is to apply this concept to experiments used in teaching.

The iLab project was developed in part through the support of iCampus, a joint initiative of Microsoft Research and MIT. It was designed to enable MIT students to operate experimental equipment from their dorm rooms or from other study venues—that is, when they wanted and where they wanted. The slightly tongue-in-cheek motto was: "If you can't come to the lab, the lab will come to you."

Initially, iLab was developed for microelectronics experiments, but it has now expanded to teaching experiments involving chemical reactors, mechanical structures, heat exchangers, an instrumented flagpole, a shaker table, polymer crystallization, and a photovoltaic weather station. In addition, iLab has rapidly spread to partner institutions around the world: for example, students in Great Britain, Greece, Sweden, Singapore, and Taiwan have accessed iLab. Furthermore, the MIT group makes available *iLab Shared Architecture*, a toolkit of reusable modules and a set of standardized protocols for developing and managing online laboratories.

With the support of the Carnegie Corporation of New York, iLab has expanded to cooperative development with three African universities (Makerere University, in Uganda; the University of Dar es Salaam, in Tanzania; and Obafemi Awolowo University, in Nigeria). Although in its infancy, this concept—of students who are attending a developing university that has very modest resources but who are sitting at a laptop and running expensive experimental equipment at MIT, in industry, or at other universities—is truly exciting and educationally profound. Professor del Alamo and his colleagues are working toward a vision of "Open iLabs" that someday may provide free and open access to online laboratories throughout the world.

Issues

If open-source materials are to reach their full potential for use by scholars, teachers, students, and self-learners, at least four fundamental issues need to be addressed: intellectual property rights, quality control, cost, and bandwidth.

Intellectual property (IP) rights issues are clearly inherent in archiving projects because for the most part, the publishers of books and journals own the copyrights. The resolution of this problem is usually some variant of a time delay, such as offering open access to a book after the copyright has expired or open access to a journal issue after some fixed number of years has elapsed since publication. In the case of open courseware projects, nettlesome third-party IP issues arise when a professor uses a graph or certain types of excerpts from books or journal articles. Crediting a figure or excerpt from a publisher's product would seem (to me) to be great free advertising; after all, companies pay huge amounts of money for a glimpse of their product to appear in a movie or television program. Some publishers agree, but many do not. In any event, carefully screening materials for IP is a time-consuming and expensive aspect of open courseware projects. Of course, some faculty may also be reluctant to have their teaching materials freely available online, because they plan to use the materials as the basis for a textbook or other commercial dissemination. It was extremely satisfying for me to observe that this was a very minor issue when the MIT faculty undertook to establish MIT OCW.

Quality control—that is, certification of the accuracy and appropriateness of scholarly and teaching materials placed on the Web—is a fundamental issue. The Web is a Wild West of information that has little or no vetting or peer review. The imprimatur and standards of leading colleges and universities, professional organizations, and scholarly oversight groups therefore are of great value when they establish open publication and archiving initiatives.

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The production, maintenance, and distribution of materials on the Web has a very real *cost*. In general, the more sophisticated the materials and distribution, the greater will be the cost. The societal value of freely available materials and indeed the value of sharing materials among institutions are substantial, but there still is a bottom line. I am passionate about keeping MIT OCW available without cost to users, but that has been and is possible only through the generosity of foundations, in the beginning, and of corporate and individual partners and supporters, in the longer run. MIT also has pledged to meet a fraction of the sustaining costs. Most major archives have a business plan in which there are user fees, but strong efforts have been made thus far to keep these as modest as possible and to scale them to the size of the user institution.

Bandwidth is a very serious obstacle to one of the most attractive potentials of the open and nonprofit movements for scholarship and education—namely, their impact in the developing world. Institution building and scholarship in these countries can be given a terrific boost from easy access to these materials. Yet to take the best advantage of the materials, these countries need easy access via broadband. Hopefully, open-access activities will provide further stimulus for governments and non-government organizations (NGOs) to increase the availability and to lower the costs of high-bandwidth connectivity. This is key to bridging the digital divide. In the meantime, MIT OCW has deployed mirror sites on local college and university networks throughout the developing world as a promising alternative. A single mirror site at Makerere University in Uganda generates more traffic than the total traffic from sub-Saharan Africa to the MIT OCW site on the Web. There are currently seventy-six mirror sites of OCW content in countries throughout the developing world.

The ease of use and interactivity of the Internet and the Web make this platform the most attractive option for open courseware and archive access. However, it is not the only way to provide access. The delivery of CDs could work in some instances, although updating, maintenance, and interactivity would be more difficult. The rapidly dropping cost of computer memory could lead to another option. The amount of iPod memory per dollar is approximately doubling each year. In round numbers, a 20-gigabyte device cost $400 in 2004. That cost had dropped to $250 by 2005, when one could purchase 60 gigabytes for $450. Should this continue, $400 might purchase 40 petabytes by 2025.[4] This certainly suggests another mechanism for delivering courseware and archival materials.

Public Diplomacy, Globalization, and the Emerging Meta-University

The promulgation and accessing of high-quality, free or inexpensive educational and scholarly material is a beautiful fit to the Internet and the Web. They are, or can be, empowering and democratizing forces in the world. Furthermore, open materials enable the United States to share a wealth of experience, information, and pedagogy in a manner that is essentially nonprescriptive. Our user surveys indicate that MIT OCW materials are received with considerable appreciation and goodwill around the world.

Of course, U.S. higher education institutions' long history of openness to students, faculty, and scholars from all over the world is an extremely important factor in the excellence of our colleges and universities. For many decades, we have taken this open flow of talented people to and from our campuses for granted. Furthermore, the open flow of scientific, scholarly, and educational materials across national and campus boundaries is indispensable. But this openness has been challenged since 9/11 as the federal government has worked to keep us safe. In my opinion, there were substantial policy and bureaucratic overreactions that led to long delays in issuing visas and to a substantial increase in visa denials. Although much improvement has been made in the processing of student visas, there are still substantial problems with issuing multiple entry visas and with granting visas for short-term visits for purposes such as scholarly meetings and research collaboration.

These matters, together with larger geopolitical considerations, have created a far less favorable opinion of the United States in much of the world today. This was dramatically demonstrated by a poll conducted last year. The Pew Research Center asked 17,000 people from sixteen countries: "Suppose a young person who wanted to leave this country asked you to recommend where to go to lead a good life. What country would you recommend?" In only one of the sixteen countries was the United States the most frequently recommended country.[5]

I cite these matters because as a nation, the United States is in great need of improved public diplomacy—that is, a better demonstration of our fundamental generosity and collaborative spirit to our fellow citizens of the world. For this reason, I am pleased that much of the movement toward openly accessible scholarly and educational materials has been initiated and funded by U.S. institutions. We have launched a movement that is beneficial to humankind—to people all over the globe. Yet it is a movement that is fundamentally nonprescriptive and that enables and encourages development within whatever context scholars, learners, and teachers reside.

Public diplomacy can be a positive force in globalization. Over the next several years, higher education will become increasingly globalized in some way, just as has almost every other dimension of modern activity. But exactly what form this globalization will take is not clear. Scholarship, especially scientific research, has always been an international undertaking, certainly among the highly developed nations. Overall, higher education has been much less so. But some major change is inevitable simply because of changing demographics and increasing wealth, aspirations, and accomplishments in the developing world, especially in Asia and South Asia.

We need only look where the students, especially the science and engineering students, will be. China already awards bachelors degrees to almost four times the number of engineers as does the United States and produces about two-thirds the number of natural scientists. In the last decade, China and India both have doubled the number of three- and four-year engineering degrees they grant annually. The production of PhD's in engineering and natural science in China has also grown very rapidly during the last decade. The United States still dominates in PhD degrees in natural science and engineering, but the numbers of PhD degrees in Germany, China, Japan, South Korea, and the United Kingdom are all increasing steadily.[6] This means that both the numbers of students to be educated and the contributions to research and scholarship will rapidly globalize and presumably improve in quality in many countries. Therefore, U.S. institutions must ponder whether and how they want to contribute differently to education and research on a global scale.

What will the future hold? Will increasing numbers of branch campuses open around the world? Will student-exchange programs and study-abroad programs expand? Will a few higher education institutions dramatically increase the number of students they teach through online learning? Will new forms of global electronic learning and discussion communities be created? I believe that all of these things will occur. But I do not think that any of these modalities will become the prevalent manifestation of globalization. The incredibly large scale of education worldwide, the huge diversity of cultural, political, and economic contexts, and the distribution of public and private financial resources devoted to education are too great.

My view is that in the open-access movement, we are seeing the early emergence of a *meta-university*—a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced. The Internet and the Web will provide the communication infrastructure, and the open-access movement and its derivatives will provide much of the knowledge and information infrastructure. If this view is correct, the meta-university will enable, not replace, residential campuses, especially in wealthier regions. It will bring cost-efficiencies to institutions through the shared development of educational materials. It will be adaptive, not prescriptive. It will serve teachers and learners in both structured and informal contexts. It will speed the propagation of high-quality education and scholarship. It will build bridges across cultures and political boundaries. It will be particularly important to the developing world. The emerging meta-university, built on the power and ubiquity of the Web and launched by the open courseware movement, will give teachers and learners everywhere the ability to access and share teaching materials, scholarly publications, scientific works in progress, teleoperation of experiments, and worldwide collaborations, thereby achieving economic efficiencies and raising the quality of education through a noble and global endeavor. *e*

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Notes

This article is based on my 2005 Clair Maple Memorial Address at the Seminars on Academic Computing, Snowmass, Colorado, August 8, 2005. Among the many people to whom I wish to express gratitude for teaching me and for enabling me to contribute to the open courseware and related movements are my MIT colleagues Hal Abelson, Jesus del Alamo, Vijay Kumar, Steve Lerman, Anne Margulies, Tom Magnanti, Ann Wolpert, Dick Yue, and Bob Brown, who now is president of Boston University. I also want to thank and acknowledge Dan Atkins at the University of Michigan and NSF; Bill Bowen and Ira Fuchs at the Mellon Foundation; Kevin Guthrie, president of Ithaka; Paul Brest and Mike Smith at the Hewlett Foundation; and David Wiley at Utah State University.

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