Institute-wide Task Force on the Future of MIT Education

Final Report

July 28, 2014

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INTRODUCTION

On November 21, 2013, the Institute-wide Task Force on the Future of MIT Education released its preliminary report. Building on MIT's rich history of educational innovation, the preliminary report explored a breadth of possibilities to consider in reimagining the Institute's future. Now in this final report, the Task Force offers a series of recommendations for how MIT can continue to transform education for future generations of learners.

Higher education is at an inflection point. The public conversation about escalating higher-education costs and their impact on access for students from all socioeconomic levels is ever present. At the same time, there is a great hunger for education and there is a great demand for online learning worldwide. The Institute's role in education no longer stops at the borders of our campus, but extends to a global community of learners. MIT is in a unique position to contribute to this dialogue in a meaningful way. The Institute has historic opportunities to reach more people, to infuse the magic of MIT into online and blended learning[1] environments, to reshape residential MIT education leveraging the opportunities of the digital education revolution, and to impact lives and society in ways not previously thought possible.

As with the preliminary report, this final report reflects the collaborative efforts of faculty, students, and staff who brought their experiences and knowledge to bear on this work. With the continued guidance of Corporation and alumni advisory groups and input from the broader MIT community through extensive surveys and discussions, this report also reflects MIT's continued dedication to reinventing MIT education together as a community.

MIT has a long history of pedagogical boldness balanced with deep introspection. The Institute's very existence is based on a grand and daring experiment in teaching. It is a hands-on, science-based, problem-focused engineering education that continues to define MIT's educational model to this day. Founding President William Barton Rogers' espousal of experimental and experiential learning in 1861 contrasted sharply with the tried and true method of rote memorization that had come to define a scientific education by the mid-19th century. This new brand of learning added context and utility to engineering learning. It also made the MIT model the global standard. This early experiential learning reflected the emerging constructivist theory of Jean Piaget, which argues that the interaction between experiences and ideas helps learners create their own knowledge. Renowned MIT professor Seymour Papert built on this theory to define constructionism, which expresses that people learn most effectively when building things and sharing them in communities. Regardless of the label, MIT's commitment to hands-on learning is still evident today. In weighing the importance of MIT values and principles, faculty responding to a survey ranked hands-on experience second only to a commitment to excellence, and students ranked it as the most important (Appendix 3).

MIT's first comprehensive assessment of the state of education at the Institute was a multi-year effort that culminated with the publication of the 1949 report of the Committee on Educational Survey (the "Lewis Commission").[2] As noted in the report's introduction, "the committee was

[1] Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path or pace. "Blended Learning," *Wikipedia*, last modified July 21, 2014, http://en.wikipedia.org/wiki/Blended_learning.

[2] http://libraries.mit.edu/archives/mithistory/pdf/lewis.pdf

instructed to reexamine the principles of education that had served as a guide to academic policy at MIT for almost ninety years, and to determine whether they are applicable to the conditions of a new era emerging from social upheaval and the disasters of war." In setting forth a series of principles and values that have guided MIT in the years since the report's publication, its authors assert, "We believe that the Institute should boldly undertake new experiments in education and new explorations into the unknown."

The authors described a dilemma that continues to face MIT and that remains as relevant today as it was in 1949. The report asks: "Why, then, was there felt a need of critical appraisal at a time when the Institute was conspicuously healthy and vigorous?" The answer in 1949 was no different than it is in 2014: To remain on the cutting edge of research and education, and to maintain its position as one of the world's premier research institutions, MIT must continually evaluate its strengths and weaknesses with regard to the shifting global, technological, economic, and political landscape.

Almost 50 years later, MIT's 15th president, Charles M. Vest, appointed the Presidential Task Force on Student Life and Learning to undertake a review of the Institute's educational mission and its implementation.[3] At that time, in 1996, MIT reached another crossroads and faced a shifting landscape at the dawn of the information revolution. In its 1998 report, the Task Force made a number of recommendations that have helped to shape the General Institute Requirements (GIRs), advising, the first-year experience, teaching, and undergraduate research over the 16 years since the report's release.

Then, in 2003, President Vest established a Presidential Task Force on the Undergraduate Educational Commons to undertake a fundamental, comprehensive review of the common educational undergraduate experience.[4] The Task Force evaluated MIT's role in the face of fundamental changes in science and technology, as well as in MIT's interactions with the world and the shifting demographics of the MIT undergraduate student body. The report, published in 2006, offered recommendations to strengthen the GIRs, identified opportunities for increased international exposure for students, and urged the expansion of MIT's capacity for educational excellence through greater attention to diversity efforts, the improvement of classroom spaces, and improved instruction.

The Institute-wide Task Force on the Future of MIT Education builds on the important work of these previous efforts and it continues MIT's history of critically analyzing its educational model.

The collective effort of the past year has been significant; however, it represents only the beginning of our collaborations. Tremendous opportunities lie before us, but much remains to be done.

The 16 recommendations presented in this report lay the groundwork for MIT to build on the momentum of the Task Force, to refine and realize the vision for the future of education at MIT, and to respond to the aspirations of the world for lifelong learning. They represent exhilarating opportunities to promote educational connections across the Institute, transform pedagogy

[3] http://web.mit.edu/committees/sll/tf.html

[4] http://web.mit.edu/committees/edcommons/documents/tf_full_report.pdf

through bold but thoughtful experimentation, extend MIT's impact to the world, broaden access to high-quality education, and improve affordability for future generations of learners.

In order to achieve the Task Force's vision, MIT will need to be receptive to new opportunities and approaches. The Institute will need to seriously re-examine the GIRs in the context of online and blended learning models. It will need to acknowledge the demand for increased flexibility in the curriculum and in the time it takes to complete a degree (time to degree). Additionally, MIT will need to extend the pedagogical innovation in residential education to a global audience so that the Institute can reach more people, harness the knowledge of a global community of learners who possess different perspectives, and leverage this expertise in pursuing some of the world's most challenging problems. MIT will need to pursue new sources of revenue so that it can continue to invest in its world-class teaching and research infrastructure, and remain competitive in recruiting top talent. The Institute must also remove barriers to access and improve the affordability of an MIT education.

LAYING A FOUNDATION FOR THE FUTURE

There is a tension between a desire to preserve many of the qualities that define an MIT education and a push to make grand, sweeping changes to MIT's very core. The Task Force recognizes this tension and envisions a future that includes a wide array of options where traditional plans may be offered alongside new paths, and where online tools enable modular and flexible learning opportunities that enrich the overall MIT educational experience. The magic of an MIT education is found in the serendipitous interactions of talented individuals, brought together as a meritocracy, with a sense of community and innovative spirit. By reaching new audiences and sharing the "magic of MIT," we can strengthen the residential learning experience while maintaining the attributes, values, and principles that are the hallmarks of an MIT education.

More and more, technology is allowing us to customize our environments, our schedules, and our engagement. Parts of MIT are seeing a growing demand for more flexible degrees. Flexibility brings to our students options—options to reduce or extend their time to degree, options to spend a year off-campus to undertake research or get relevant professional experience in the middle of their studies, options to engage more deeply in teaching and other service opportunities, and options to take classes online over the summer and streamline their programs. The challenge is to use our principles and values to guide us in establishing specific educational outcomes and the qualitative MIT culture to which we aspire.

The world has changed dramatically in the past decades. In order to keep pace with the rate and scope of change in the educational sector and with the demand for access to quality education around the world, we need to create an ecosystem for ongoing research, learning, and innovation about the future of education. Evolving MIT education in a rapidly changing world is both a paramount responsibility and a formidable task. The Institute has been presented with exciting possibilities, but it will require an unwavering commitment to continuing our work if we hope to achieve our vision for the future of MIT education.

To this end, the Task Force makes a number of recommendations:

Recommendation 1: *The Task Force recommends that MIT establish an Initiative for Educational Innovation to build on the momentum of the Task Force, enable bold experimentation, and realize the future the Task Force has imagined for education on campus and beyond.*

The questions posed by the Task Force and the recommendations offered in the following pages have potentially far-reaching consequences. We need to create an ecosystem that promotes educational connections across the Institute and provides an educational innovation hub, or a "sandbox," for conducting the experiments envisioned by the Task Force. We also need to thoughtfully assess the experiments we conduct and take great care in stewarding the campus for future generations of learners.

As a hub for learning research at MIT, it is envisioned that the initiative will have significant faculty involvement and be appropriately funded to enable its work. It will be an opportunity to promote conversations across the Institute—not just about curriculum, technology, and policy, but more generally about *teaching*. It will also be responsible for developing and managing academic programs in education involving both traditional and online methodologies. These programs might include an undergraduate minor in education, a graduate teaching minor, and new undergraduate and graduate teaching opportunities. In addition, it is envisioned that the initiative will play an important role in advocacy with an opportunity to impact national policy. In order to succeed, the initiative must be well integrated with the MIT governance structure and have strong connections with the Committee on the Undergraduate Program (CUP), the Committee on Graduate Programs (CGP), and the Committee on Curricula (CoC), the Office of the Dean for Undergraduate Education (DUE), and the Office of the Dean for Graduate Education (ODGE).

Under the auspices of the initiative and in concert with the existing faculty governance process, MIT will be enabled to engage in bold experiments in the MIT undergraduate and graduate programs, including experiments in existing GIR subjects. The Institute will be able to experiment with offering summer classes for credit with a focus on blended and online pedagogies and with building the capacity needed to extend online offerings and modular approaches.

TRANSFORMING PEDAGOGY

The Task Force makes the following five recommendations to transform pedagogy at MIT.

Recommendation 2: *The Task Force recommends that the new Initiative for Educational Innovation engage in bold experiments to catalyze ongoing research, learning, and innovation about the future of MIT residential education.*

One major role of the new Initiative for Educational Innovation is to engage in bold experiments in MIT educational programs. The Task Force sees a number of opportunities to advance experiments in both undergraduate and graduate education. The following three opportunities are highlighted as specific recommendations to be conducted under the auspices of the initiative and in concert with the existing faculty governance process:

a. **Engage in bold experiments in the MIT undergraduate program**. To enable the future of MIT education, we must engage in bold experiments that will help us learn about both the positive and negative aspects of pedagogical and curricular innovations. This is critical to ensuring MIT's leadership position at a time of disruptive change. It is also a way to experiment with approaches that may both enhance students' learning and render an MIT education more affordable. These experiments must be constructed in an informed way, conducted in concert with the existing faculty governance structure, and coupled with careful assessment components, thus enabling us to reinforce lessons learned and to effect sustained improvement.

   The Task Force recommends that these experiments include, but not be limited to, the following elements:

   - Infusing greater flexibility into the core undergraduate curriculum, including the GIRs;
   - Expanding the use of diverse pedagogies such as project-based and blended learning models;
   - Introducing modularity into the curriculum and understanding the effectiveness of doing so; and
   - Studying new approaches to the assessment of students.

   Proposed experiments go well beyond the use of online technologies in residential and global education, and may include collaborations with other institutions with which MIT has close ties. For example, MIT's unique educational relationship with the Singapore University of Technology and Design provides a potential opportunity for collaborative innovation and experimentation beyond the boundaries of the MIT campus.

   The Task Force makes the specific observation that in the past decades, the world has changed considerably, and these changes have outpaced changes in the MIT GIRs. For example, computational thinking has become central to many fields, the ability to analyze and visualize data has become indispensable, and entirely new methods of fabrication at a variety of scales have emerged, creating a demand for new knowledge and skills.

   In this changed world we must ask:

   - Are the GIRs adequately preparing undergraduates to face the world?
   - Are the GIRs serving our educational needs now and into the future?
   - Can we find ways to maintain the advantages of MIT's common core while increasing flexibility, especially in the face of the growing interdisciplinary nature of MIT majors?
   - Does modularity combined with blended learning models offer a solution that can balance this tension?

   The Task Force is neither suggesting specific classes for inclusion in the GIRs, nor proposing an entirely redesigned set of GIRs, but it is strongly advocating that the faculty engage in bold experiments and seriously re-examine the GIRs, particularly in the context of the new opportunities offered by online and blended learning models. Having the common GIR core is part of the magic of MIT, and retaining a common core is critical, but the Task Force recommends experimentation to help reconsider the mix of the common core requirements. Controlled experimentation can inform a discussion about change and help the Institute move forward in a constructive way. The recommended educational innovation infrastructure, working in collaboration with CUP and CoC, can enable experiments that go beyond the constraints of the current GIRs, and that inform answers to the questions posed above.

b. **Offer summer classes for credit**. The summer provides opportunities for experimentation with pedagogies such as intensive face-to-face interactions, blended learning models, modularity, and project-based learning. It is an opportunity to create a culture of peer-based learning in collaboration with faculty and to further promote MIT's culture of tinkering, designing, co-creating, and remixing—all of which may be more difficult to achieve during the academic year. Under the auspices of the educational initiative, MIT can conduct summer experiments that explore, assess, and catalyze new pedagogies.

Both undergraduate and graduate classes can be offered for credit either in blended formats or online during the summer. The ability to take classes during the summer for credit will provide students with schedule flexibility that may enable more of them to spend a semester away from MIT pursuing academic experiences that broaden their educational experiences. The Task Force acknowledges the 2014 Report of the *MITx* Subcommittee of the Faculty Policy Committee, which offers guidance on assigning credit for online classes.[5] To ensure academic integrity, the report recommends that online activity be reflected in the three-category subject designation[6], that a mechanism to test proficiency be in place for awarding transfer credit for edX classes, and that letter grades not be granted until learning platforms become more robust.

The Task Force recognizes that there is a danger that some students may wish to take summer classes as a way to squeeze even more into their time at MIT at the expense of deep learning and with the risk of additional stress. The Task Force cautions against this behavior. It also cautions against creating an environment that makes it more difficult for students to spend time engaging in activities such as internships, Undergraduate Research Opportunities Program (UROP) experiences, and thesis work that contribute in important ways to their professional development.

During the summer 2014 term, MIT is offering a small number of classes for credit on an experimental basis. The summer@ future program was triggered by Task Force discussions. It represents another step in the exploration of opportunities to enhance the residential learning experience with online educational materials and blended learning models. There was an exceptional response to the program, with 129 students (113 undergraduates and 16 graduate students) participating (Appendix 4).

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[5] http://web.mit.edu/faculty/reports/pdf/MITx2014.pdf

[6] The three categories of time distribution of a subject that, when totaled, represent the total credit hours awarded for it: (1) recitation and lecture, (2) laboratory, design, or fieldwork, and (3) and preparation.

c. **Create an ecosystem that promotes educational connections across the Institute**.
The educational initiative will serve to create an ecosystem that promotes educational connections, and that builds a culture of inter-School synergy. Doing so will help provide contextualization to students, and preserve the value of different perspectives while reinforcing connections and relevance. The Task Force hypothesizes that better connections will help improve learning. For example, strengthened connections between the School of Humanities, Arts and Social Sciences (SHASS) and the Schools of Engineering (SOE) and Science (SOS) could be explored as a mechanism to improve communication skills for MIT engineering and science majors. Likewise, better connections between the Department of Mathematics and SOE could be explored to improve the technical depth of learning in some engineering subjects.

In order to create an environment for faculty "connectors," the initiative should incentivize faculty to collaborate in education across departments with the provision of teaching resources. It should support projects and experiments that map connections in topics and outcomes across the curriculum, that employ online resources to facilitate connections, and that exploit opportunities to use modular approaches to increase flexibility. These types of experiments will enable the study of the benefits of connecting content in new ways.

Recommendation 3: *The Task Force recommends that MIT build on the success of freshman learning communities and consider future expansions of the cohort-based freshman learning community model.*

MIT has a successful history of conducting experiments in freshman learning communities. Online and blended learning models offer new opportunities to further these experiments and offer the possibility to radically transform the undergraduate experience. One of the risks of the online learning model is isolation. Experimenting with these pedagogies within the context of a cohesive learning community is one way to mitigate this risk. Advising, mentoring, and student-faculty interaction continue to be of critical importance to learning and to future success, and must be emphasized in the face of increased online learning components in our MIT residential education.[7]

The Institute can build on the successes of existing MIT freshman learning communities, while learning more about the elements of those successes and their attributes, both favorable and unfavorable, and drawing lessons from the various ways in which students learn. The Task Force recommends the expansion of existing learning communities, or the introduction of new learning communities to explore new opportunities.

For example, one possibility is a freshman cohort where students take some of their GIRs in a blended format with a flipped classroom using the edX/*MITx* platform. This might be combined with a more modular curricular structure and with intensive faculty advising and mentoring. Another possibility is a freshman learning community that places emphasis on hands-on experiential learning and maker skills, tailored to reinforce the freshman GIRs and the connections among them.

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[7] "Great Jobs, Great Lives," The 2014 Gallup-Purdue Index Report, Page 10.

The Task Force notes that the four existing freshman learning communities—the Experimental Study Group (ESG), Concourse, Media Arts and Sciences, and Terrascope—currently have to comply with the GIRs. ESG began in 1969 as a more personalized approach to teaching, and set a precedent in providing a level of flexibility for both subject matter content and pace of completion. As future experiments in freshman learning are envisioned, additional flexibility might include the possibility of new or different GIR cores as described in recommendation 2a. All experiments must include a significant assessment component to ensure that appropriate lessons are drawn from these experiences.

Recommendation 4: *The Task Force recommends that the Institute use online and blended learning to strengthen the teaching of communications.*

The ability to communicate effectively is a critical transferrable skill, and student surveys show that MIT trails our peer institutions in students' self-reported gains in communication skills during college.[8] Given the science, technology, engineering, and mathematics (STEM) focus of most MIT students, this is a difficult issue. Implementation of the communication-intensive (CI) component of the communication requirement (CR) around 2001, which requires undergraduates to take at least one CI class per year, has begun to make a difference. Comparing the 2002 and 2014 Senior Survey results, the number of students reporting that their ability to write effectively had not improved during college decreased from 48% to 12%. Similarly, those reporting no improvement in their oral communication skills decreased from 39% to 6%. While this is a positive trend, online technologies may provide opportunities for further improvement.

MIT should develop materials that describe best practices for teaching effective communication skills, as well as online modules on written and oral communication for use in communication-intensive subjects within the major department (CI-M). The Institute should implement mechanisms to support faculty time for cross-departmental faculty engagement and continuing education on communication skills. Blended learning models for CI subjects in the humanities (CI-H) and CI-M that incorporate smaller student-faculty ratios in face-to-face settings should be explored.

Recommendation 5: *The Task Force recommends that MIT create an Undergraduate Service Opportunities Program (USOP).*

Engaging MIT students in the world provides valuable contextualization for their residential learning experience by allowing them the opportunity to work on serious issues that challenge society, yet to do so in a guided way with an intellectual component. Many MIT students already engage in service activities, but often these engagements are disconnected from the rest of their educational experience. There are already excellent service-related programs on campus, such as D-Lab, that can serve as a starting point from which to build. Additionally, the Public Service Center, which provides excellent guidance, should be better resourced.

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8 "2011 MIT Enrolled Student Survey," Office of the Provost, Institutional Research.

In the same way that UROP has become (and should continue to be) an enormously valuable part of MIT's undergraduate program, the introduction of a formal, Undergraduate Service Opportunities Program (USOP) can help students make service a meaningful part of their educational program and give them the opportunity to work closely with a faculty mentor. The Task Force recommends that the USOP experience not be required of all students, but that it could be taken for credit. USOP experiences could be combined with global teaching opportunities, such as providing local mentorship for globally offered *MITx* classes. The program could also include a social entrepreneurship aspect.

There may also be ways to involve graduate students in USOP or in a corresponding Graduate Service Opportunities Program (GSOP). Encouraging graduate students to engage in the world more broadly through service could be combined with online learning opportunities described in recommendation 6.

Recommendation 6: *The Task Force recommends that the Institute explore online and blended learning models to improve graduate curriculum accessibility.*

As noted above, the Task Force sees a number of opportunities to advance experiments in graduate education. Graduate students need improved access to advanced graduate classes to enable their research. Improved access relates to timeliness: Students need to be able to learn subject matter on demand when needed to support their research progress. Improved access relates to course packaging: In many cases, a full 12-unit graduate class may be accessible only to a small number of students, while smaller modules of material may be relevant and useful for a larger audience.

By offering online on-demand modules, departments may be able to exploit efficiencies and better manage faculty teaching loads. This may also provide an opportunity for graduate students and postdoctoral researchers to participate in the co-creation and testing of these digital learning modules, which is an experience of potential value for those pursuing academic careers. These on-demand modules may target upper-level graduate material that might otherwise be taught infrequently. There may also be opportunities to collaborate with peer institutions to target graduate material not offered at MIT, and both asynchronous and synchronous learning environments could be offered online.

EXTENDING MIT'S EDUCATIONAL IMPACT

The Task Force makes the following five recommendations to extend MIT's educational impact to the world.

Recommendation 7: *The Task Force recommends that this commitment to pedagogical innovation for the residential campus be extended to the world to set the tone for a new generation of learners, teachers, and institutions.*

MITx and edX have created an unprecedented opportunity for MIT to reach a global audience. However, this opportunity comes with a responsibility: if MIT is reconsidering the way in which it addresses residential learning, it is important that it also convey these ideas, rather than old ideas, to learners and educators around the world.

As described previously, practical application has been central to the MIT way of learning. Research continues to reaffirm the invaluable roles of both active learning and hands-on learning in assimilating, contextualizing, and reinforcing the key learning objectives of a learning module. For example, recent studies have shown that active learning has a significant impact on learning outcomes, and that traditional lectures need to be re-examined for their lack of effectiveness.[9]

As MIT improves its methods for educating its students, it is incumbent upon the Institute to convey these ideas and results to the world. OpenCourseWare Educator, which is already a successful venue for disseminating MIT's pedagogical approaches, could become a powerful channel for sharing latest results as MIT embarks on its journey towards a future model of learning. In this context, the following opportunities have been identified by the Task Force.

a. **Exploration of modularity based on learning objectives and measurable outcomes.** In January 2014 Harvard and MIT released a report summarizing an analysis of the data collected during the first year of open online classes.[10] Modularity refers to breaking a subject into learning units or modules, which can be studied in sequence or separately. The finding that drew the most attention is the low rate at which students who enroll in an *MITx* or HarvardX class complete it. The first 17 HarvardX and *MITx* classes recorded 841,687 registrations, of which only 43,196 (5.1%) earned a certificate of completion.

   While the completion rate is low, other data from the report suggests that students are focused more on learning certain elements of a class and less on completing what has traditionally been considered a module or unit of learning. For instance, in addition to those who completed a course through *MITx* or HarvardX, 35,937 registrants explored half or more of the units in a course, and 469,702 viewed some but less than half of the units of a course.

   The way in which students are accessing material points to the need for the modularization of online classes whenever possible. The very notion of a "class" may be outdated. This in many ways mirrors the preferences of students on campus. The unbundling of classes also reflects a larger trend in society—a number of other media offerings have become available in modules, whether it is a song from an album, an article in a newspaper, or a chapter from a textbook. Modularity also enables "just-in-time" delivery of instruction, further enabling project-based learning on campus and for students worldwide.

   The fall 2013 survey of faculty and instructors found that while faculty report that they seldom convert their classes into smaller units (less than 10% to date), they feel that many of their classes (25%) could benefit from a more modular approach.[11] Similarly, in a survey

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[9] http://www.pnas.org/content/early/2014/05/08/1319030111.full.pdf+html

[10] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2381263.

[11] http://web.mit.edu/ir/surveys/pdf/FutureEduFaculty-Overall.pdf

of students, approximately 40% of respondents report that they have taken MIT classes that they feel would benefit from modularization (Appendix 3).[12]

Aside from the likelihood of reduced attrition, modularity has the added benefit of allowing instructors to develop online material in a more incremental manner. Whereas it can take months to produce a full *MITx* class, a module could be created in a matter of weeks and could be used as a foundation for a variety of disciplines. The Institute also has a significant opportunity to reuse modules across courses.

Not only could modules be reused across departments and Schools, but also across institutions. As edX continues to add institutions from around the world, new opportunities for synergies are emerging. Much like a playlist on iTunes, a student could pick and choose the elements of a calculus or a biology course offered across the edX platform to meet his or her needs, but for most effective learning, modular units must be integrated into the whole. Thus, while the effort to study and complete a module may be more accessible, the effort to integrate the information into a complete class remains significant but may be facilitated by incremental learning.

To achieve this kind of fluidity and malleability in learning, the Task Force recommends exploring options for establishing a module repository. To support student selection of modules, there must be some mechanism for storing and curating the content. Whether through tags or filters, a simple but effective repository would allow students and educators to identify and utilize the modules that best meet their needs. *MITx* and OCW must work together to frame and enable such a vision.

b. **Further exploration of the role of game-based learning**. The impact of gaming in engaging students is only beginning to be understood. As gaming continues to permeate popular culture, so too does an increased acceptance of game-based learning. Through the Scheller Teacher Education Program, MIT is testing new methods to support instruction through gaming. Through further exploration, MIT can modernize its tools for a new generation of learners.

    In the short term, the Task Force recommends studying how game-based learning can be applied to existing classes as a case study and even to develop *MITx* courses focused on game-based learning content. In the long-term, the Task Force recommends incorporating game-based techniques into some residential MIT classes.

c. **Partnering with other colleges and universities to encourage blended learning using *MITx* content.** EdX has enjoyed great success in its collaborations with colleges and universities around the country. In fall 2012, a lecturer at San Jose State University used the 6.002x materials on the edX platform to teach Introduction to Circuit Analysis. The class viewed *MITx* video lectures and completed *MITx* problem sets. The lecturer spent a short time in class facilitating questions and answers, and then devoted the remainder of the class to peer and team instruction and problem-solving. Pass rates increased from 55%

[12] http://web.mit.edu/ir/surveys/pdf/FutureEduStudent-Overall.pdf

of students in conventional classes to 91% of students in the blended class.[13] Similar to the "Intel Inside" campaign of the 1990s, in which Intel provided the processors for consumer computers, "*MITx* inside" might serve as the foundation for classes being taught in a blended fashion at colleges and universities around the world. In this model, MIT would provide *MITx* content to colleges or universities; those colleges or universities would then use *MITx* as a basis for the tailored educational experience that they develop to meet their students' needs.

In the short-term, the Task Force recommends the following:

- Seek partner universities that can license *MITx* modules;
- Develop new models of blended learning and activities to combine with digital learning;
- Seek blended learning opportunities at other universities where *MITx* material could be used to "flip" the classroom locally. Collaborate with universities to share results and set up mutually beneficial experiments;
- Offer pedagogical advice to participating schools; and
- Consider needs-based pricing or a fund to provide access to *MITx* materials to a wide range of partners across the world.

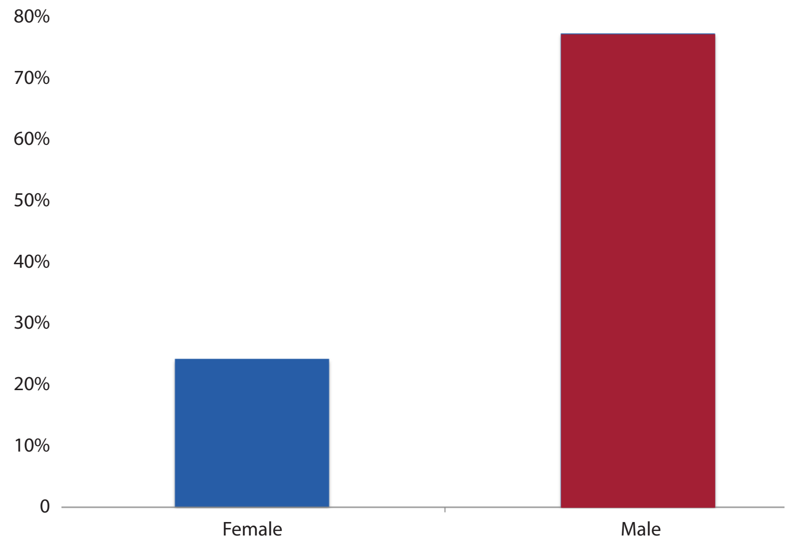
The unbundling enabled by *MITx* and edX also creates the possibility of smaller institutions. Consider a town with an industry in metallurgy. Online content, combined with blended learning, could enable small, specialized colleges in that town that focus on metallurgy. The Task Force recommends exploring "micro-institutions" of this nature in the future.

d. **Using open problems to seed global discussions**. Problem-based learning is at the heart of an MIT education. While understanding the foundation and principles of a particular discipline is essential, the Task Force feels that the investment of students in learning is most successful when they apply their learning to real-world problems. Many such problems do not have clearly defined solutions and they enable a continuing conversation that also often spans departmental silos. The Task Force recommends encouraging departments to develop classes or series defined by the challenges they seek to address. For instance, one might imagine an *MITx* series on air pollution. Within that series, a student would find a number of classes—including air purification, urban planning, politics, and poverty—that are intended to aid the understanding and examination of air pollution from a variety of perspectives. This might require a student to work on projects with students from different corners of the world who may already be addressing the nuances of air pollution in their individual communities. This connection will help create a global community of thought and practice around global challenges, and a cadre of sophisticated problem solvers.

13 https://www.edx.org/blog/san-jose-state-university-edx-expand#.U6hq3hYgF8Y.

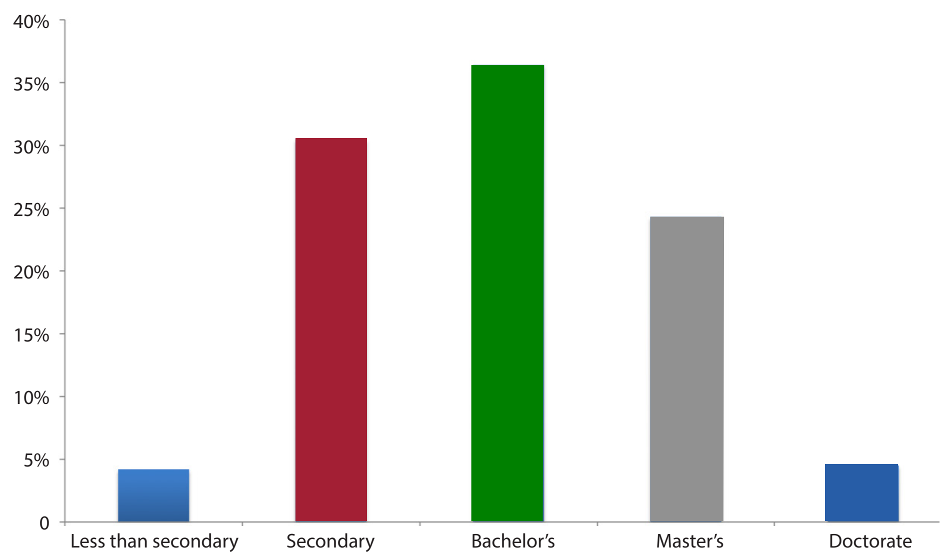
e. **Developing a strategy for increasing the diversity of *MITx* learners**. While *MITx* has successfully reached a new audience of learners, the audience is primarily male and educated (Figures 1 and 2).

Figure 1. Gender of *MITx* participants through June 13, 2014



Source: MIT Office of Institutional Research

Figure 2. Educational level of *MITx* participants through June 13, 2014



Source: MIT Office of Institutional Research

The Task Force recommends defining a strategy to reach more women and students of all nationalities, racial and ethnic groups, and socioeconomic circumstances. The Task Force recommends further analysis and consideration of the issues that might serve as obstacles to reaching a more diverse audience. Clearly, there are political, technological, and financial barriers throughout the world that will make it difficult for *MITx* to reach certain audiences, but what steps might MIT take to more effectively reach those who might hunger for an education but not have access to one?

In the short term, the Task Force recommends ensuring that *MITx* classes represent the great diversity of MIT faculty and student interests and backgrounds. In the long term, MIT should design a system of accountability to ensure that its outreach strategy is continuously practiced and revised. For *MITx* to have the impact that MIT imagines, barriers to access must be further evaluated and addressed.

Recommendation 8: *The Task Force recommends supporting efforts to create a lasting community and knowledge base for* MITx *learners.*

There are currently over 1,000 local edX communities listed on the social networking site meetup.com.[14] While that community has developed organically, it represents a significant opportunity to leverage broad interest and engagement to crowd-source solutions to problems via a kind of innovation network. By supporting a lasting community of students who become experts on a particular topic, new opportunities for meaningful peer-to-peer instruction will also emerge.

In the long term, MIT might look to develop a "Wikipedia-like" knowledge base that gathers the best community resources to share ideas and best practices. Also, MIT might consider international competitions and other recognitions to engage the world community. From the $100K Entrepreneurship Competition to the Clean Energy Prize, MIT has successfully developed a robust infrastructure of problem-based competitions that generate world-altering ideas and products. Imagine if those competitions were expanded to include *MITx* learners all over the world. There is great potential to engage students who possess different expertise and different perspectives in pursuing answers to some of the world's most challenging problems.

Recommendation 9: *The Task Force recommends that MIT define a K-12 strategy through a special interest group under the auspices of the Initiative for Educational Innovation.*

From the Edgerton Center to the Scheller Teacher Education Program to the Lemelson-MIT Program's InvenTeams initiative, MIT offers over 80 K-12 educational programs. However, in true MIT fashion, the programs have developed in a grassroots fashion over time, and have sought and received little coordination. There is also widespread interest within MIT from students, faculty, and staff, and from MIT alumni, to engage with K-12 students. With such broad K-12 programming, and a high demand for an MIT-style education, the Task Force recommends defining a K-12 strategy through a special-interest group.

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[14] http://www.meetup.com/edX-Communities/

Approaching K-12 outreach in a more strategic way has a number of benefits. In addition to providing new opportunities to experience MIT educational programming, MIT would be better positioned to improve the diversity of its applicant pool and to reach students who might otherwise disengage from learning. MIT has a long history of successfully partnering with high schools to reach students as they begin to think about applying for college. By defining a strategy to reach younger students, the Task Force believes that the benefits for both the students and for MIT are potentially significant. Along these lines, the Task Force recommends conducting pilots and experiments. It also recommends considering strategies and initiatives for teacher education.

In the long term, and depending on the outcome of the K-12 experiments, the Task Force recommends developing a framework for engaging the K-12 community in the United States and around the world.

Recommendation 10: *The Task Force recommends that the Institute create new opportunities for engagement between the MIT community and the world.*

As noted previously, there are over 1,000 local edX communities around the world. While the formation of these communities provides great value to the groups of learners, in-person exposure to MIT faculty, students, and alumni could prove mutually beneficial.

Part of the great appeal of *MITx* is its potential to create new opportunities for global interaction for MIT students. MIT enjoys a number of successful programs that connect its students with research and innovation around the world. For instance, the MIT International Science and Technology Initiatives (MISTI) program matches hundreds of MIT students annually with global internships and research opportunities. In the summer of 2013, 10 MIT students who received MISTI training visited four countries and acted as *MITx* ambassadors during their MISTI internships. They met with *MITx* learners in their host countries to provide tutoring and a visible connection to MIT.

The Task Force recommends building on the success of this experiment by formalizing a MISTIx program in which engagement with the *MITx* community becomes an important part of a student's MISTI experience.

The Task Force encourages student engagement in *MITx* course authorship and tutorship. MIT has long enjoyed a successful Undergraduate Research Opportunities Program that places undergraduate students in labs and centers to gain first-hand and meaningful experience working with faculty members on their research. There is similar potential for students to gain valuable teaching experience by partnering with a faculty member in designing *MITx* content.

The Task Force also recommends encouraging faculty to participate in global education through open problems, crowd-sourced content and local *MITx* gatherings. While the Task Force recognizes the value to MIT students in spending time with global *MITx* communities while traveling abroad, there is similar potential for faculty to engage with global communities. By engaging directly with *MITx* students around the world, faculty would be able to develop new avenues for understanding the world's challenges and identifying talent for meaningful collaboration. Likewise, *MITx* learners would benefit from the opportunity to work directly with MIT faculty, in essence bringing MIT to them.

MIT alumni can also play an important role as coaches and mentors. In an experiment with the city of Chicago, called ChicagoX, MIT alumni acted as mentors to students in Chicago who took a computer science course offered by *MITx*. Positioning alumni to provide in-person guidance to *MITx* learners not only enhances the online learning experience, but also creates a tangible connection to MIT for students who might someday apply to MIT.

Recommendation 11: *The Task Force recommends that MIT move forward to consider the types of certifications that can be supported through* MITx *and edX, and develop pricing methodologies and revenue-sharing arrangements for agreed-upon certifications.*

Increasingly, employers are focusing on certifying an employee's or potential employee's competencies rather than relying on his or her formal degree. Badging is another new trend in certification—a badge is essentially recognition for a smaller module of learning. These new ways of thinking about certification tie in with the opportunities created by *MITx*. While learning for personal improvement is valuable, there is untapped potential to explore new opportunities to certify that learning. This might take several forms, three of which the Task Force believes are ready for immediate attention and expansion.

First, *MITx* has developed the concept of XSeries, in which a student earns a certificate for passing a series of courses in a specific subject. This new model allows departments to better understand and meet student needs and to reimagine the structure of a course and its place in a larger context of a discipline.

MITx has announced three XSeries certificates, one each in Aerodynamics, Foundations of Computer Science, and Supply Chain Management. The XSeries is comprised of a set number of courses designed to help students to understand and apply new concepts. In Foundations of Computer Science, for instance, students enroll in seven modules (each roughly half of a regular MIT course) that introduce key concepts of computer science and computational thinking. From programming to Java to digital circuits, the XSeries provides a solid basis for understanding computer science. The first XSeries certificates were awarded in July 2014.

The Task Force urges each MIT department to think in terms of XSeries instead of individual courses when developing content for edX. This should be combined with thinking about modules instead of whole courses for reasons discussed earlier.

In the long term, the Task Force envisions opportunities for XSeries to develop into something akin to an *MITx* minor, major, or even an *MITx* or edX degree in recognition of more comprehensive learning.

Second, the Task Force recommends pursuing the development of new professional and executive education courses. In March 2014, MIT Professional Education offered MIT's first online professional course. The course, Tackling the Challenges of Big Data, aimed at technical professionals and executives, was the first of a line of professional programs delivered via edX.[15] The course served as a training opportunity for working professionals and represents MIT's initial foray into online professional education.

Third, the Task Force recommends experimenting with merging education options for MIT and *MITx* courses. Through programs like MISTI, there are new opportunities for MIT students to leave campus and gain real-world experience by interacting with *MITx* learners in their local communities. The reverse could be true for *MITx* learners. Imagine a student in Brazil who has gained an understanding of quantum physics through *MITx* but who otherwise has had no MIT connection. After reaching a certain point in her online studies, perhaps that student could be invited to MIT to participate in on-campus interactive learning opportunities with other *MITx* students from around the world. In fact, such a program is being piloted as a follow up to 15.391x in the summer of 2014.

While improved opportunities for learning drive each of these recommendations, certification represents an important opportunity for revenue generation. This revenue can be used to subsidize MIT's investment in online education.

ENABLING THE FUTURE OF MIT EDUCATION

MIT faculty, researchers, and graduates contribute to the world in extraordinary ways, and an MIT residential education remains highly sought after despite perceived barriers of cost. MIT is able to admit only a fraction of the exceptional students who wish to come to campus. Undergraduate applications have tripled since the early 1990s to approximately 19,000, while admissions have been relatively flat at about 1,550. Undergraduate selectivity has also increased dramatically over the past 20 years among the top higher education institutions.

The Institute is committed to making a rich educational experience affordable and to providing those who are admitted with the aid needed to complete their MIT degrees. In order to fulfill this commitment, the Institute must pursue opportunities to bolster the current financial model and strengthen MIT's ability to support future generations of students. In working to enhance the sustainability of the MIT financial model, it is important to understand the drivers of cost.

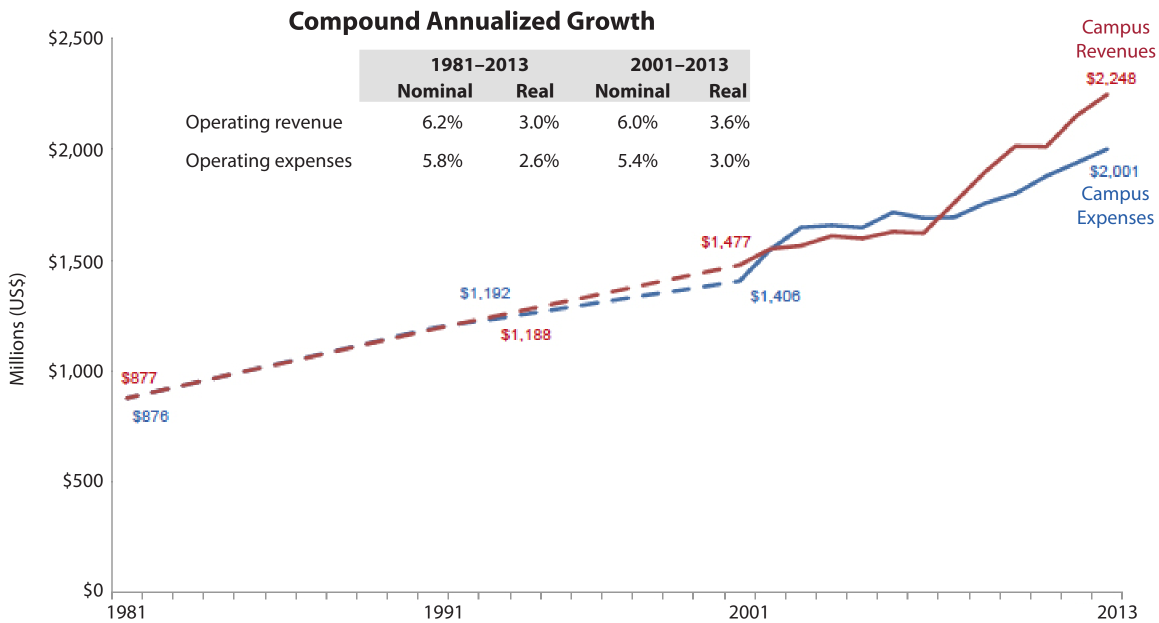
The Drivers of Cost of an MIT Residential Education

In a market that focuses on excellence, MIT incurs high costs. These costs result from the Institute's need to attract and retain the best faculty and the brightest students, to provide premier research and educational facilities, and to perform the unparalleled research that is integral to the research university model. Providing the facilities required for our exceptional faculty, students, and researchers to advance research discovery and innovation is inherently expensive (Figure 3). Nevertheless, we will need to continue to invest in our world-class teaching and research infrastructure and remain competitive in recruiting top talent if we are to maintain our preeminence.

[15] http://web.mit.edu/professional/onlinex-programs/courses/tackling_the_challenges_of_big_data.html

This investment pays off in terms of educational outcomes. The MIT model produces outstanding students and advances knowledge in remarkable ways. MIT contributes significantly to educating some of the brightest engineers, scientists, and businesspeople of our time. Moreover, graduates from MIT perform exceedingly well in their life pursuits. These outcomes not only influence the formation of companies, job creation, patents, and inventions, but also advance the boundaries of science and engineering.

Figure 3. Campus operating revenues and expenses, FY1981–FY2013



Note: Excludes Lincoln Laboratory, Singapore-MIT Alliance for Research and Technology, and the Broad Institute.
Real revenue and expenses are adjusted based on CPI-U.

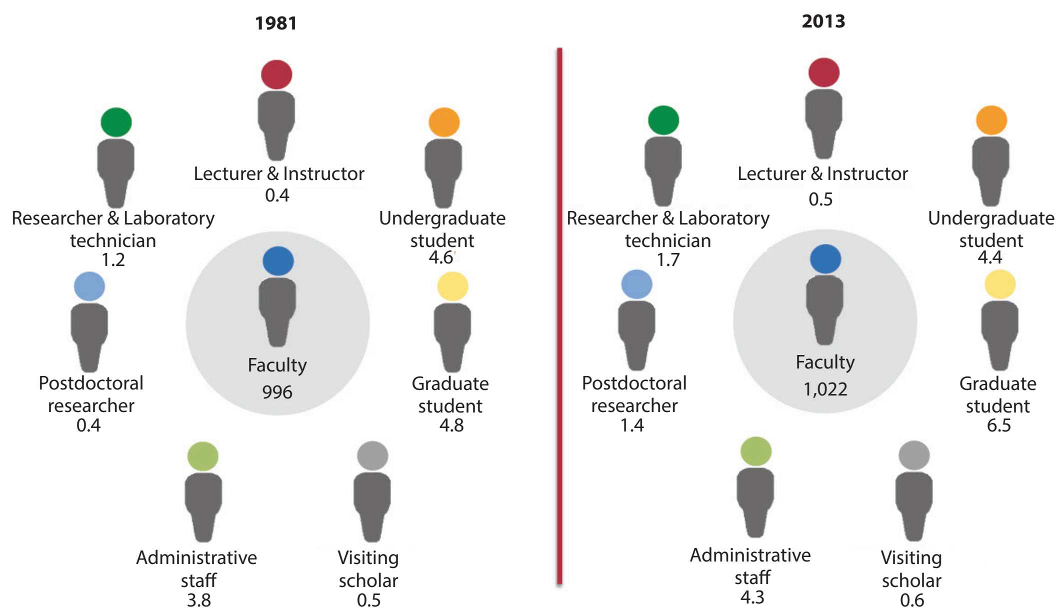
Source: Report of the Treasurer 1981, 1991, 2001–2013

In 1981, campus revenues and expenses, measured in 2013 dollars, were about $877 million and $876 million respectively. Looking at the time frame since 2001, after adjusting for inflation, campus expenses including research grew at a real rate of 3% compounded annually. Over the same period, revenue growth, especially from investments and fundraising, enabled the Institute to support these costs. During the period of 1981 through 2013, the mix of expenses has remained relatively constant, with the percentage of expenses associated with compensating people approximately half of total expenses. MIT's expanding research program has enabled dramatic growth in the number of graduate students and postdoctoral trainees engaged on campus.

The Evolving Campus Population

The number of MIT faculty has remained relatively constant over the past 30 years, with 996 faculty members in 1981 and 1,022 in 2013 (Figure 4). The ratio of undergraduate students to faculty was 4.6 to 1 in 1981 and only slightly lower at 4.4 to 1 in 2013. However, the numbers of graduate students, research staff, and postdoctoral trainees at MIT have all grown significantly as a result of the substantial growth in research funding over this same time period. The numbers of faculty and undergraduates have been centrally controlled, while the numbers of graduate students admitted and research staff and postdoctoral trainees hired have been determined at the departmental level. These changes in population on campus have evolved based on individual unit decisions with little opportunity for strategic integration.

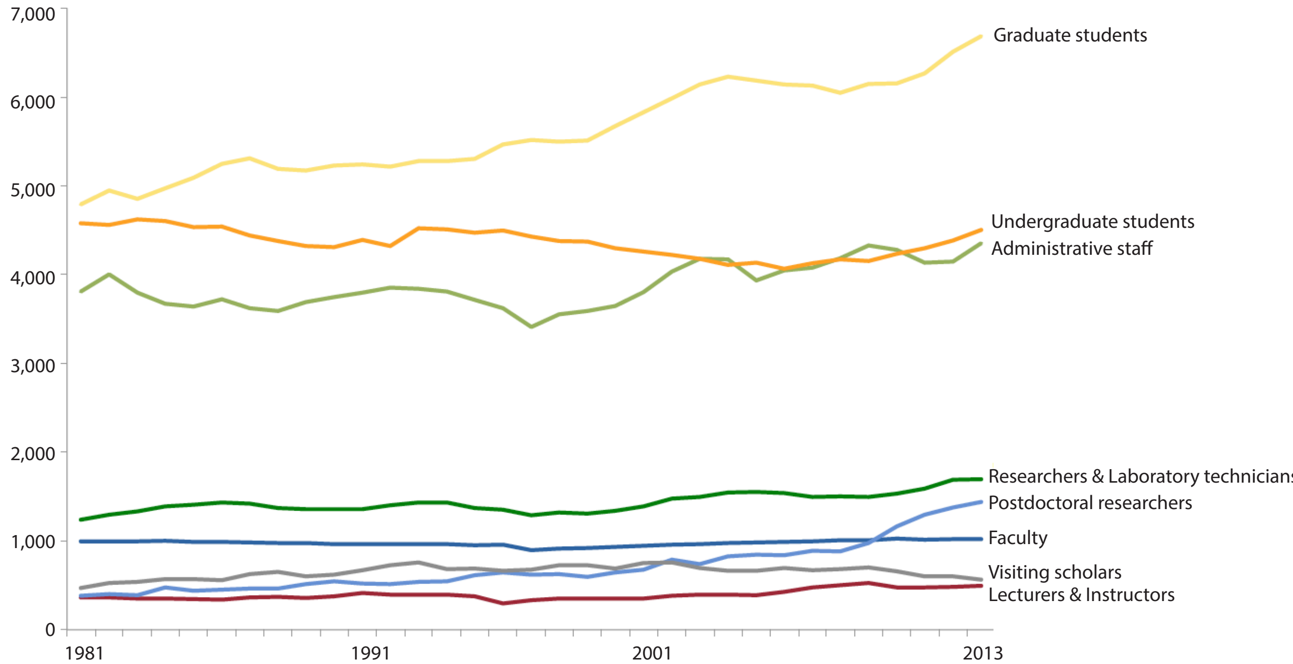
Figure 4. How we have evolved: Headcount 1981 vs. 2013, students and staff per faculty member



Note: Excludes the Broad Institute, MIT Federal Credit Union staff, retired faculty, affiliates, and visiting students. In FY2013, there were 752 visiting students, 1,025 affiliates, and 239 retired faculty on campus. Figures for FY1981 are unavailable.

As described above, we are unable to meet the demand for high-quality residential education due to the high cost of the residential experience. Through online and blended learning environments, MIT can reach more learners, but it must address concerns about the impact on faculty teaching loads, and experiment with possibilities to leverage faculty time. Online experiences present new opportunities for envisioning educational roles for the future. For example, the roles of *MITx* instructor and *MITx* student may exist in 2020. As the Institute continues its work to reinvent MIT education, this model can be used to project how potential experiments might impact the campus population (Figure 5).

Figure 5. The campus populations, 1981–2013



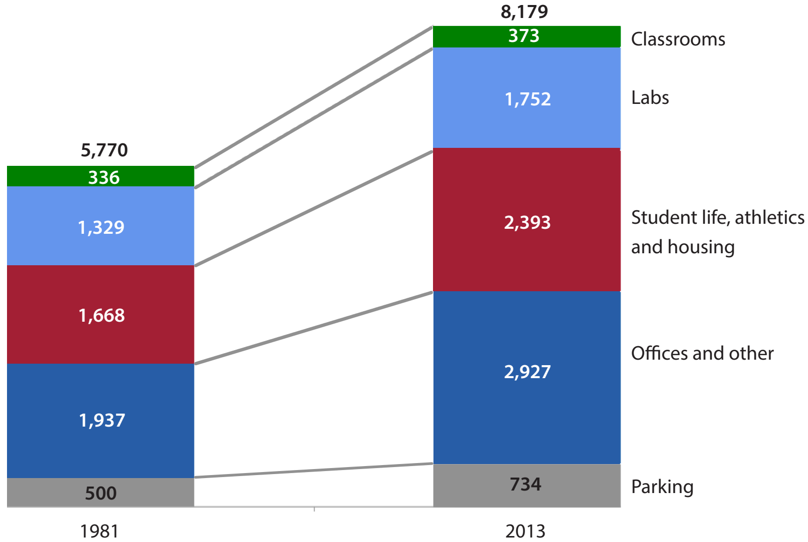
Note: Excludes the Broad Institute, MIT Federal Credit Union staff, retired faculty, visiting students, and affiliates.

MIT's expanding research program has enabled dramatic growth in the number of graduate students and postdoctoral trainees engaged on campus. Between 1981 and 2013, the number of graduate students grew from 4,780 to 6,643, yet the number of undergraduates remains similar in 2013 to its earlier 1981 level of about 4,500 students. The number of postdoctoral researchers more than tripled during this same time period from 398 in 1981 to 1,430 in 2013. Approximately half of the growth in research and laboratory technical staff has been within the life science areas.

Growth in administrative staff in recent years can be attributed to increases in the following areas: local administration to support research activities; staff to support the growth in educational programs and expanded international reach of the Sloan School of Management and the Office of Digital Learning *MITx* online learning activities; staffing for Resource Development as MIT prepares for its fundraising campaign; and facilities staff to maintain the expanding MIT campus required to support the growing campus population.

Since 1981, the net assignable square feet (NASF) of space on campus has grown by 42% to 8,179,000 NASF (Figure 6). This expansion has been necessary to enable the Institute's growing research enterprise, which is so integral to graduate education in science and engineering. Research expenditures on campus more than tripled from $184 million in 1981 to $662 million in fiscal 2013. This growth in research funding enabled the expansion of graduate education and significant growth in the number of graduate students and postdoctoral trainees on campus. In order to accommodate the growing campus population, laboratory space grew by almost 32%, space for student life and housing by close to 43%, and office space—much of which is used for conducting and supporting research—by about 51%.

Figure 6. The growth of campus infrastructure, net assignable square feet of space, 1981–2013



Source: Space Accounting System. 2013 Net assignable square feet.

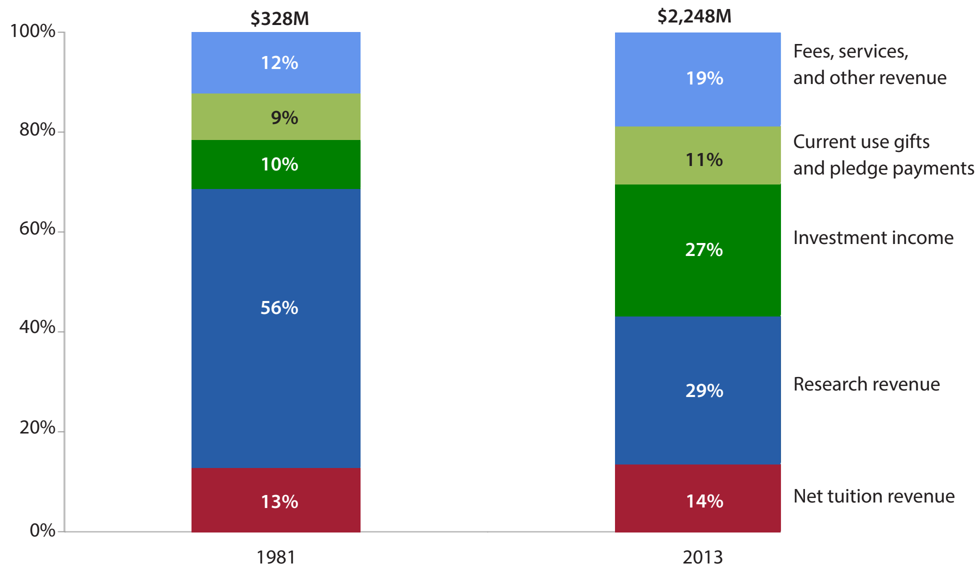
MIT's average operating cost per NASF (based on actual expenses) has been below market rate. This is largely due to the age of the campus and the associated deferred maintenance. MIT is now engaged in a program of capital renewal to bring older structures to a higher standard, as well as an enhanced maintenance program to help the newest and newly renovated facilities retain their capacity to further MIT's mission. While this will increase the average operating cost per square foot, primarily due to depreciation resulting from the renewal program, this will result in more efficient buildings due to the benefits of modern and sustainable construction techniques. In addition, the increased complexity of the facilities required to support MIT's advanced research enterprise continues to impact the cost of constructing new buildings.

Based on our residential education model, costs will continue to rise, but the way MIT prices education may change, and the mix of revenue sources to support education will continue to evolve.

The Evolving Campus Revenue Mix

The campus revenue mix has evolved over many decades as the Institute has adapted to external influences. In 1981, research funding comprised 56% of revenue. Today, while research expenditures have grown significantly, their percentage of campus revenue has dropped to 29%. Declining federal funding for research and diminishing family resources to support the cost of education have been balanced with increased revenues from investments and donations, with investment income growing from 10% of the total in 1981 to 27% today.

Figure 7. Evolution of campus revenue mix, FY1981–FY2013



Note: Excludes Lincoln Laboratory, the Broad Institute, and Singapore-MIT Alliance for Research and Technology.

Source: Report of the Treasurer

The generosity of MIT alumni and the many friends of the Institute enables affordability for today's students. We are largely dependent on an inter-generational transfer of wealth to guarantee the experience of residential education for both today's students and future generations. While the model of supporting today's students with alumni gifts is not threatened over the near term, we may be unable to sustain the same rate of growth in the future as we have in the past. For this reason, it would be prudent to actively explore opportunities to capture new revenue streams to complement the current model.

Preserving and enhancing MIT's exceptional research and educational environment will require both a strengthening of existing income sources and consideration of new revenue opportunities. Two current sources of Institutional support—government research funding and tuition—are under pressure. There is a growing interest among policy makers and the public in slowing the growth of gross tuition prices and in raising financial aid. It may be possible to increase the revenues generated from other existing sources of funds by both raising the level of development activity to support increases in charitable gifts and expanding the scope of institutional and corporate partnerships.

Opportunities to expand professional and executive education offerings and to extend online classes and materials present new and exciting possibilities to reach more learners with a very high quality education at lower cost. MIT's ability to capture these opportunities depends greatly on finding ways to provide the faculty with the time needed to devote to these pursuits.

The Task Force makes the following five recommendations to enable the future of MIT education.

Recommendation 12: *The Task Force recommends that MIT strengthen its commitment to access and affordability.*

Concerns about the rising cost of higher education and the impact on access for students from all socioeconomic levels are valid. While it is true that higher education is expensive, MIT remains committed to need-blind admissions for undergraduates and to providing those who are admitted with the aid needed to complete their MIT degrees. In fall 2013, while MIT's tuition rate with fees was $43,498, the average net tuition paid by undergraduates was half that amount, or $22,208, because of MIT's need-based undergraduate scholarship program. This demonstrates MIT's commitment to making an MIT education as affordable as possible for students from all socioeconomic backgrounds. However, MIT needs to do even more. The Institute must continue to improve affordability.

But improving affordability alone will not solve the issue of access. In addition to making residential education more affordable, we have to reach more students. In 2013, MIT received over 43,000 total student applications for undergraduate and graduate school combined, and only 10% gained admission to their program of choice. Undergraduate applications topped 19,000, and only 8.2% were admitted. For the upcoming 2015 academic year only 7.9% of applicants were admitted. Clearly, there is a vast unmet need for access to high-quality education.

The Task Force encourages MIT to evaluate possibilities to achieve increases in undergraduate class size so that more students can experience the rich magic of an MIT residential education. Over time, it is possible that experiments with flexibility in time to degree might present opportunities to relieve housing pressures, which is one of the primary barriers to increasing class size. The Task Force recognizes that some faculty growth may be required to accommodate the needs of a growing student body; however, new types of supporting roles might also help to leverage faculty time.

Recommendation 13: *The Task Force recommends that the Institute expand fundraising activities to embrace a broader MIT community.*

The MIT model is sustainable because of the tremendous impact MIT has on its students, and the commitment of our alumni to supporting future generations of learners. We cannot assume that this culture of philanthropy and willingness to give back will continue to grow at the same rate seen in previous generations. The Institute needs to appropriately recognize and more deeply engage different sectors of a broader MIT community and beyond if we are to further improve affordability for students of all socioeconomic levels and ensure access for a greater number of students.

In addition to the Institute's undergraduate and graduate student bodies, there is a growing community of postdoctoral researchers—1,459 last fall. Some spend as many as five years on campus and continue on to extremely successful careers. With *MITx*, we are creating a new form of affiliation, one that may even have a residential component. With expanding professional and executive education programs, we have a growing number of accomplished professionals affiliated with the Institute. MIT's Alumni Association should explore how to best recognize and engage those who complete certificates and online programs, and those who participate in professional and executive education programs. The Institute should strongly embrace its community of postdoctoral researchers and executive education students, and steward these communities for lifelong value and learning and for the benefit of MIT.

Recommendation 14: *The Task Force recommends that MIT charge an ad hoc working group to further evaluate revenue opportunities surrounding technology licensing and venture funding.*

The group would analyze entrepreneurial finance initiatives currently underway at MIT, practices at other universities, and gaps in capital markets for MIT-related start-up businesses. The recommendations of this working group can provide a starting point for further enhancement of the innovation ecosystem at MIT.

a. **Technology licensing**. MIT's Technology Licensing Office (TLO) is often cited as a leader among peer institutions. However, the TLO's current mission does not include generating revenue for the Institute. It may be possible to increase the TLO's financial contribution to MIT without sacrificing the extent to which it supports commercial investment in the development of inventions and discoveries flowing from research at MIT.

The Task Force considered opportunities to build infrastructure that would support inventors as they seek to translate their fundamental discoveries into production-ready products. This would involve complementing MIT's current research strength with an additional development component. Creating such infrastructure might lead to greater revenues from commercialization, but it could also involve tilting the direction of faculty and student research activity in ways that would be inconsistent with other parts of MIT's mission. Given the current portfolio of technologies that have been, and are being, developed at MIT, there do not seem to be substantial opportunities for further revenue generation from technology licensing without significant changes to the culture, practice, and direction of faculty and student research. However, if the target is modest rather than significant revenue generation, there are a number of strategies that MIT could pursue to enhance the revenue stream from technology licensing.

This is an opportune time to consider these opportunities as MIT seeks to enhance its ability to innovate through the recent launch of the MIT Innovation Initiative.

b. **Venture capital**. There have been suggestions that MIT create a venture fund to invest in the development of promising new technologies invented by students and faculty, and there are various proposals to expand MIT-based venture funding in some way. Proponents view these proposals as a natural way for MIT to capture some of the returns associated with its innovative faculty and students and as a potential way to fill in gaps in the venture funding space by enhancing funding access for MIT affiliates. Opponents are concerned about the inherent conflict of interest in MIT's funding its own faculty and students. They worry that this activity would distract from MIT's main focus and conflict with its central mission of education and research.

> The working group should study the range of structures that could be used to support the entrepreneurial ventures of both faculty and students, and investigate the potential financial, cultural, educational, and philanthropic impact of these different structures. The group should solicit views of relevant MIT stakeholders and make a recommendation to the Academic Council regarding the possible establishment of an MIT venture fund for supporting student and faculty start-up companies.

Recommendation 15: *The Task Force recommends that the Institute establish a working group on spaces for future student life and learning to bring together stakeholders from around campus to envision, plan, and create spaces for the future of MIT education.*

The newly formed working group would build on the work of the Working Group on the Future of Campus Teaching and Learning Spaces chaired by Professor John Brisson in 2011–2012. The charge to that group conveyed that "…MIT has a historic opportunity to take bold steps in redefining its physical infrastructure for teaching and learning consistent with its mission, strategic goals, values and culture." This historic opportunity is further strengthened today by the momentous rise of digital learning, on campus and beyond, enabling learning anywhere at any time, combining online activities with in-person interactions and hands-on experiences, and inspiring the Institute to imagine what MIT's facilities for the future could be.

The Task Force can envision academic villages that provide environments for enhanced interactions to occur both inside and outside of the classroom and laboratory settings. The Task Force can also imagine a system of maker spaces strategically located around campus, further enhancing the experiential learning so integral to an MIT education. These maker spaces would complement the state-of-the-art maker space facility now being planned to support innovation and entrepreneurship activities.

The community-wide working group would bring together key individuals from the chancellor's areas, the Schools, Libraries, Campus Planning, Information Systems and Technology, and MIT's academic computing environment Athena. This working group would further study these concepts and additional opportunities to open up grand spaces on campus that would accommodate new methods of teaching and learning. The group would work within the framework of the Institute's capital planning governance structure under the auspices of the Building Committee.

Charge to the Working Group on Spaces for Future Student Life and Learning:

- Holistically assess campus needs for teaching and learning spaces including classrooms, library, performing arts, and "sandbox" spaces;
- Examine campus needs for common spaces, including informal gathering spaces, meeting and conference spaces;
- Agree on a vision for teaching, learning, and common spaces that are well integrated with the campus;
- Recommend a prioritized plan for creating these spaces and making the vision for spaces for future student life and learning a reality; and

- In this way ensure that our campus of the future is comprised of the spaces needed to enable the next generation of student life and learning.

Recommendation 16: *The Task Force recommends that MIT bolster infrastructure for Executive and Professional Education to reduce barriers to offering programs and engage more faculty to broaden program delivery.*

MIT offers education programs aimed at satisfying targeted needs of professionals and companies. The Sloan School of Management Executive Education Program and the School of Engineering Professional Education Program each target different audiences. The Sloan program is geared toward senior leadership and executives, and Professional Education is tailored for technical managers and professionals. While MIT's existing programs are clearly successful, they are limited by several factors: the number of participating faculty, Institute supplemental compensation regulations, restricted classroom and hotel facilities, and reputational considerations. The Executive Education and Professional Education Programs generally operate independently of each other, with some duplication and overlap and some confusion for potential enrollees.

There are a number of opportunities to coordinate existing programs on campus and to systematize pricing, as well as to enhance infrastructure support, encourage faculty involvement, and link these initiatives with the edX platform. This could potentially involve the creation of an organization to coordinate marketing, infrastructure, resources, and activities for program delivery. Such a structure might reduce overlaps and confusion for prospective enrollees. The new organization could also interface with global corporations that would benefit from MIT coursework for their educational and training needs. There are also a number of opportunities to extend MIT's offerings in the area of executive education, and edX has begun to explore offering such programs through the Office of Digital Learning.

To move toward a specific recommendation in this field, MIT should support and expand conversations to agree to a standard methodology for compensating planners, developers, instructors, hosting departments, and the Institute for offerings that are delivered by the existing programs. This would provide a framework for new programs to be offered by other units at the Institute. There are multiple markets for such content, including MIT alumni, corporations that might customize content for their employees, and broad professional communities interested in fields where MIT has particular expertise.

The business models of edX and *MITx* already intersect with these initiatives. Online professional and executive education will require a substantial investment of both time and resources to create content, and clear guidelines are needed about how any revenue will be divided. Developing a firm foundation for pricing and certification in the executive education and professional education markets will be invaluable as edX and related online activities expand.

IMAGINING THE FUTURE OF MIT EDUCATION

In preparing this report, the Task Force has focused on action. What goals might we imagine for the Institute and what concrete steps might we recommend to achieve these goals? But what will an MIT education of the future look like if we are successful in reaching our aspirations of transforming pedagogy, extending MIT's educational impact to the world, and lowering barriers to access?

The Task Force envisions a future in which MIT's impact is even greater than it is today. It is a future in which the magic of MIT not only extends beyond the boundaries of our campus, but also creates opportunities to harness the knowledge of a global community to address the world's great challenges. It is a future in which enhanced programs in service and teaching empower MIT students to make meaningful and lasting contributions to the world.

We imagine a future that extends MIT's capacity to reach a global audience of learners—more undergraduate students in our residential program, more professionals through expanded offerings in our executive and professional education programs, and more learners worldwide taking online classes through *MITx* and edX.

We see a future in which the MIT residential education model is not threatened, but rather strengthened, as the Institute is guided by our core values and principles. We see a future in which new online educational tools enrich the interactions between faculty and students by maximizing time for hands-on learning, making the role of instructor more important than ever.

By pursuing the Task Force's recommendations—by creating the spaces that will enable the next generation of student life and learning, supporting the faculty with new instructional roles, introducing flexibility to the curriculum and in time to degree, modularizing course content, and embracing a broader MIT community—the magic of MIT will shine even more brightly.

We may not be able to achieve all of these aspirations over the short term, or even over the longer term, but by taking the next steps outlined in this report, the Institute will be able to build on the momentum of the Task Force and continue to lay the groundwork for the future.

APPENDICES

Appendix 1. Presidential Charge to the Institute-wide Task Force on the Future of MIT Education

In a letter to the MIT Community on February 6, 2013, President Rafael Reif described the formation of an Institute-wide Task Force.

To the members of the MIT community:

With great optimism and excitement, I write to share the news that I am creating an Institute-Wide Task Force on the Future of MIT Education.

Reinventing what we do and how we do it

At my inauguration, I made the case that, thanks to the pressures of cost and the potential of new online teaching technologies, higher education is at a crossroads. As a result, we have a truly historic opportunity to better serve society by reinventing what we do and how we do it. I proposed that MIT should continue to use *MITx* and edX to create the best online education possible, in ways affordable and accessible for students far beyond our campus. And I challenged us all, in the great MIT spirit of learning by doing, to use our own campus community to invent the residential research university of the future.

Listening to our community and the wider world

Since then, in my listening tour across MIT, people have told me over and over how glad they are that MIT is helping to lead this educational revolution—and how important it is that we "get it right." Conversations with leaders in Washington and at the World Economic Forum have confirmed my view that we are rapidly reaching an inflection point in the history of higher education and that the outcome will be critically important for MIT, for colleges and universities in general, and for generations of students around the world.

Leadership of the Task Force

To help MIT assess and rise to the demands of this complex challenge, I am following a path many MIT presidents have followed successfully before me: I am creating an institute-wide task force that will draw on and focus this community's legendary capacity for rigorous analysis, technical know-how, creative problem-solving and thinking big.

To lead this effort, I have chosen two co-chairs: Professor Sanjay Sarma, who already serves as our Director of Digital Learning, and Executive Vice President and Treasurer Israel Ruiz SM '01.[1] A member of the edX board, Israel also brings to the task a deep understanding of MIT's physical and financial resources and previous experience in leading such a complex "volunteer" effort, since he co-chaired the 2009–2011 Institute-Wide Planning Task Force that helped MIT find a creative path forward during the global financial downturn.

[1] Professor Karen Willcox was later added as a third co-chair.

I am asking Sanjay and Israel to assemble the remaining members of the Task Force, including faculty, students, alumni and staff who can represent the broad interests of the MIT community. I expect that they will announce the list of members within a few weeks.

* * *

I encourage everyone to read my official charge to the Task Force, which describes its scope and purpose. We face big questions, with big consequences. To arrive at the best solutions, we will need to draw on the collective experience and wisdom of individuals and groups from across the MIT community. If we share our best thinking, informed by our highest aspirations for MIT, I have no doubt that we will come to answers that will serve our community and advance the larger conversation.

Sincerely,

L. Rafael Reif

Charge to the Institute-wide Task Force on the Future of MIT Education

Higher education is striving to respond to the forces of disruptive change. While many US students struggle to cover the cost of higher education, colleges and universities are straining to cover the cost of providing that education. Yet at the same moment, advances in online teaching technologies are opening up extraordinary new possibilities, suddenly making it possible to offer highly effective but comparatively low-cost advanced instruction to students on campus and to millions of learners around the world.

The positive implications for society are immense and impossible to fully foresee. And I am convinced that these forces offer us the historic opportunity to reinvent the residential campus model and perhaps redefine education altogether. Our society can only benefit if we improve what the residential research university does better than any other institution: Incubate brilliant young talent, and create the new knowledge and innovation that enrich our society and drive economic growth.

For MIT—an institution passionately committed to the kind of hands-on, team-focused, apprenticeship education that depends on community and human contact—the challenge and the opportunity are particularly urgent and direct. In short, to stay true to our educational values, we must seize the opportunity to reimagine what we do and how we do it. I raised this challenge at my inauguration. In the four months since, the stunning pace of change has proved that we are in the midst of an educational revolution.

MIT has already chosen to help lead one aspect of this revolution through edX and *MITx*, our ongoing experiments in online learning. But I believe we can and should take the lead in helping to invent the future of education more broadly—both on our campus and beyond. Defining this path and leading us toward a financially sustainable solution will be the charge of this Task Force.

Building on a legacy of educational innovation

MIT has helped lead the world to new educational frontiers before. In its very founding, with its bold insistence on learning by doing, MIT helped invent the educational model that turned the United States into an industrial success. In the 1950s, MIT rebuilt its engineering curriculum on a foundation of basic science. In the 1970s, MIT dared to make frontline research a routine part of the undergraduate learning experience through its now widely copied Undergraduate Research Opportunities Program (UROP). In the 1980s, with Project Athena MIT created a crucial prototype of the connected campus. In 2002, MIT launched the unprecedented experiment in free online sharing known as MIT OpenCourseWare. And in late 2011, we took the next step in online learning with the creation of *MITx*, followed shortly by edX, a partnership with Harvard University to launch a non-profit learning platform open to students and institutions around the world.

Today, I ask that this Task Force be bold—just as bold—in experimenting with ideas that would both enhance the education of our own students on our own campus and that would allow us to offer some version of our educational experience to learners around the world. Your explorations may lead you to answers that will have implications and applications far beyond MIT, and I encourage you to capture and consider those ideas as well.

This challenge is non-trivial, but you will be able to draw on a growing resource never available before: the rapidly evolving research on learning science, including the remarkable flow of data emerging from our own online learning efforts. Use this information to inspire your thinking. The future of education may include many possible models and scenarios. Experiments will be necessary, and as we learn more along this journey, we will need flexible thinking, reliable feedback and an "ecosystem" that helps us adapt. Help us imagine how to make that ecosystem work.

Leadership

Sanjay Sarma, Professor of Mechanical Engineering and Director of Digital Learning, and Israel Ruiz, EVP and Treasurer, will lead the Task Force as Co-Chairs.

Leveraging the wisdom of our community

In the best tradition of MIT, it is vital that we use this Task Force to expand discussion of these complex, critical issues to include all members of our community. I therefore ask that the Task Force move immediately to create a mechanism, such as an Idea Bank, that will allow people throughout the MIT community to contribute their experiences and recommendations. And although I propose below some preliminary questions to focus your discussions, I encourage you to solicit ideas and concerns from the MIT community, leverage existing research on education and identify additional areas of importance.

A commitment to transparency and communication

Because the Task Force will consider topics that go to the marrow of MIT, we owe the community a commitment to transparency and to regular communications about the progress of its work. I encourage you to suggest the most effective tools and approaches we can use to meet these commitments.

The Charge

So that you may advise me and MIT's administration, I charge the Task Force to:

- Propose an "ecosystem" for ongoing research, learning and innovation about the future of education.
- Recommend a range of possible experiments and pilot projects that will allow us to explore the future of MIT education:
  - *On our own campus*, in ways that incorporate online learning tools to the fullest extent while maximizing the value of face-to-face learning for both faculty and students.
  - *Beyond our campus*, through which learners around the world could benefit from important aspects of MIT's educational content, vision and values
- Evaluate the future strength and sustainability of MIT's current financial model in this evolving context and propose alternative or complementary approaches.
- Develop a roadmap that will describe the work streams and the phases of work necessary to enable this ecosystem and implement these experiments.

Proposed questions to be addressed:

1. What can we learn from the many examples of "blended models" of education, which seek to magnify the effectiveness of online instructional tools with in-person teaching?
2. MIT has traditionally used a four-year, two-semester system. More modular models are also being tested. What other approaches could emerge by 2020?
3. Online technologies have already proven very effective at *instruction*—the conveying of content. But as our graduates can attest, an MIT *education* clearly includes many learning experiences that can only occur in person. Today, the MIT learning experience involves several modes of interaction: lectures, recitations, labs, projects, internships, study groups, individual study and so on. It also features signature educational approaches such as UROP and MISTI (MIT International Science and Technology Internship program), and intensive project-based hands-on learning in many fields. What learning experiences will constitute an MIT education in 2020? Which elements would be enhanced by online technologies, and which truly demand interaction in person? What new experiences could courses incorporate?
4. How can MIT improve accessibility and affordability?
5. What are the implications for MIT's financial model and pricing structures?
6. What are the implications for MIT's physical spaces, including classrooms, research laboratories, residential spaces and common spaces?
7. What are the pathways and barriers, advantages and disadvantages, to extending important aspects of the MIT educational experience to vastly more learners than we could ever bring to our campus?

Working Groups

- Working Group on MIT Education and Facilities for the Future
- Working Group on the Future Global Implications of edX and the Opportunities It Creates
- Working Group on a New Financial Model for Education

Timeline and Results

I ask that you complete a preliminary report in approximately six months, for the start of the 2013–14 academic year. This initial report should include your initial findings on all the elements of the charge. I expect that your final report could be complete a year from now.

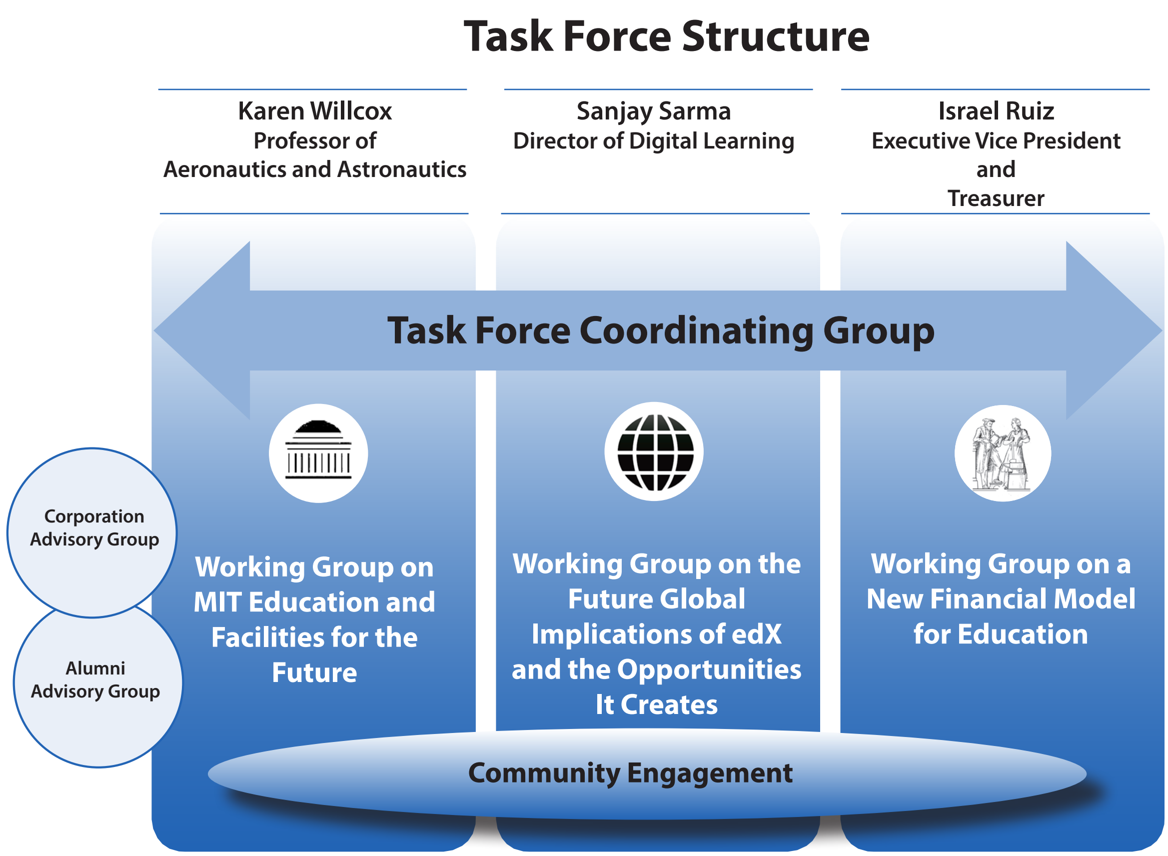
The task before you is serious and pressing. I hope it will also be fascinating, and I urge you to bring to it all of your creativity and your highest aspirations for MIT. MIT has long stood for openness, accessibility and educational innovation, and through your efforts, we can lead the way to a new realization of these ideals.

I am deeply grateful for your willingness to serve the Institute through this Task Force, and I believe your work will also serve the world.

Sincerely,

L. Rafael Reif

Appendix 2. Task Force Structure and Membership



Three Working Groups of Faculty, Students, and Staff

Working Group Membership includes faculty representing all five schools, staff and both undergraduate and graduate students, with approximately 50 individuals participating as members. The Task Force Coordinating Group is comprised of faculty, students, and staff representing the three working groups, and is designed to provide connectivity across the groups. Corporation and Alumni Task Force Advisory Groups were formed to provide insights and recommendations as the Task Force performs its work.

Task Force Membership

Task Force Co-Chairs

Israel Ruiz, Executive Vice President and Treasurer
Sanjay Sarma, Director of Digital Learning
Karen Willcox, Department of Aeronautics and Astronautics[2]

Working Group on MIT Education and Facilities for the Future

Chair

Karen Willcox, Department of Aeronautics and Astronautics

Faculty

Samuel Allen, Department of Materials Science and Engineering
Deepto Chakrabarty, Department of Physics
Isaac Chuang, Department of Electrical Engineering and Computer Science
Catherine Drennan, Department of Chemistry
Dennis Freeman, Dean for Undergraduate Education
Daniel Hastings, Engineering Systems Division and Aeronautics and Astronautics
Daniel Jackson, Department of Electrical Engineering and Computer Science
SP Kothari, Sloan School of Management
Anne McCants, Department of History
Augustín Rayo, Department of Linguistics and Philosophy
Mitchel Resnick, Program in Media Arts and Sciences
Laura Schulz, Department of Brain and Cognitive Sciences
Nader Tehrani, Department of Architecture
Karen Willcox, Department of Aeronautics and Astronautics

Staff

Peter Bedrosian, Registrar's Office
Lori Breslow, Office of the Dean of Undergraduate Education

Students

Devin Cornish, Undergraduate, Department of Mechanical Engineering
Kuang Xu, Graduate, Department of Electrical Engineering and Computer Science

Working Group on the Future Global Implications of edX and the Opportunities It Creates

Chair

Sanjay Sarma, Director of Digital Learning

[2] Professor Willcox stepped down as associate department head effective December 31, 2013.

Faculty

Martin Culpepper, Department of Mechanical Engineering
Michael Cusumano, Sloan School of Management
Rick Danheiser, Department of Chemistry
Steven Eppinger, Sloan School of Management
Eugene Fitzgerald, Department of Materials Science and Engineering
Steven Hall, Chair of the Faculty
Sep Kamvar, Program in Media Arts and Sciences
Philip Khoury, Associate Provost
Eric Klopfer, Department of Urban Studies and Planning
Thomas Malone, Sloan School of Management
Christine Ortiz, Dean of Graduate Education
Sanjay Sarma, Director of Digital Learning
Hanna Rose Shell, Program in Science, Technology and Society
Hazel Sive, Department of Biology
Jacob White, Department of Electrical Engineering and Computer Science

Staff

Vijay Kumar, Office of Digital Learning, Office of Educational Innovation and Technology
Bhaskar Pant, MIT Professional Education

Students

Anubhav Sinha, Undergraduate, Department of Electrical Engineering and Computer Science
Ellan Spero, Graduate, Program in Science, Technology and Society

Working Group on a New Financial Model for Education

Chair

Israel Ruiz, Executive Vice President and Treasurer

Faculty

John Belcher, Department of Physics
Claude Canizares, Vice President
Andrew Lo, Sloan School of Management
James Poterba, Department of Economics
Craig Wilder, Department of History

Staff

Elizabeth Hicks, Office of Student Financial Services
Michael Howard, Vice President for Finance
Karl Koster, Corporate Relations
Israel Ruiz, Executive Vice President and Treasurer
Anthony Sharon, Office of the Executive Vice President and Treasurer

Rochelle Weichman, Sloan School of Management
Heather Williams, School of Science
David Woodruff, Office of the Vice President of Resource Development

Students

Patrick Hulin, Undergraduate, Department of Mathematics
George Chen, Graduate, Department of Electrical Engineering and Computer Science

Task Force Coordinating Group

Co-Chairs

Israel Ruiz, Executive Vice President and Treasurer
Sanjay Sarma, Director of Digital Learning
Karen Willcox, Department of Aeronautics and Astronautics

Faculty

Claude Canizares, Vice President
Michael Cusumano, Sloan School of Management
Daniel Jackson, Department of Electrical Engineering and Computer Science
Eric Klopfer, Department of Urban Studies and Planning
SP Kothari, Sloan School of Management
Anne McCants, Department of History
Hazel Sive, Department of Biology
Jacob White, Department of Electrical Engineering and Computer Science

Staff

Anthony Sharon, Office of the Executive Vice President and Treasurer
Heather Williams, School of Science

Students

Patrick Hulin, Undergraduate, Department of Mathematics
Ellan Spero, Graduate, Program in Science, Technology and Society

Task Force Corporation Advisory Group

Chair

Diana C. Walsh, President Emerita, Wellesley College

Members

Raja H.R. Bobbili, Student, JD/MBA Program, Harvard University
Vanu Bose, CEO, Vanu, Inc.
R. Erich Cauffield, New Orleans Federal Lead for White House Strong Cities, Strong Communities (SC2) Initiative
Diane B. Greene, Member, Board of Directors, Google Inc., Intuit and MIT
Brian G. R. Hughes, Chairman and Product Engineer, HBN Shoe, LLC

Robert B. Millard, Managing Partner, Realm Partners, LLC
Megan J. Smith, Vice President, Google X, Google, Inc.
Kenneth Wang, President, US Summit Company

Task Force Alumni Advisory Group

Chair

John W. Jarve ’78, President of the Association of Alumni and Alumnae of MIT, 2013–14

Members

Katy Brown ’93, SM ’96
Dan W. Butin ’90, Founding Dean of the School of Education at Merrimack College
John Gavenonis ’98, Global Technology Manager, Renewable/Sustainable Materials, E. I. Du Pont de Nemours, DuPont Performance Polymers
Bhavya Lal ’89, SM ’90, SM ’92, Core Staff Member at the Science and Technology Policy Institute
Thomas H. Massie ’93, SM ’96, U.S. Representative from Kentucky
Andrew N. Sutherland, Founder, Quizlet
Priyamvada Natarajan ’90, ’91, SM ’11 Professor of Astronomy and Physics, Yale University

Financial Data and Analysis Team

Liaison from Task Force Working Groups to Data Team

Michael Howard, Vice President for Finance

Staff

Christine Albertelli, Office of the Vice President for Finance
Deborah Leitch, Office of the Vice President for Finance
Allen Marcum, Office of the Vice President for Finance
Lydia Snover, Office of the Provost
Basil Stewart, Office of the Vice President for Finance

Staff Support

Robin Elices, Office of the Executive Vice President and Treasurer
Aaron Weinberger, Office of the President

Appendix 3A. Fall 2013 Survey of MIT Faculty and Instructors

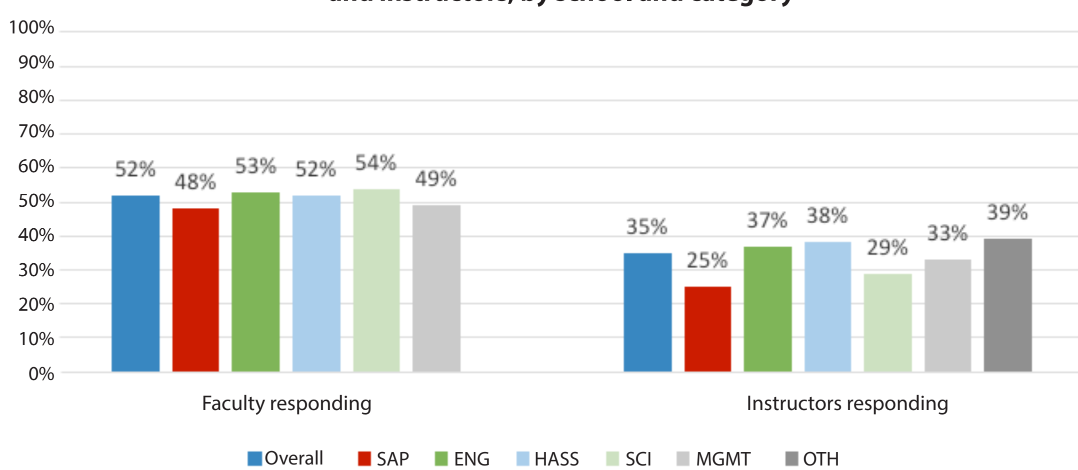
Preliminary Survey Summary, June 2014
MIT Institutional Research, Office of the Provost

Overview

In August 2013, the Institute-wide Task Force on the Future of MIT Education invited all faculty and instructors to participate in a survey designed to understand educational resource needs, both current and anticipated, and to gain a firmer grasp on how our instructors' interactions with students are changing. The survey was open until October 1, 2013, with invitations and reminders from the Task Force co-chairs, Chancellor Eric Grimson, and Director of Institutional Research Lydia Snover.

The survey closed with 52% of faculty and 35% of other instructors participating, with similar response rates throughout the survey across schools. A higher percentage of tenured faculty continued the survey through to the end over other categories of respondents.

Figure 3A.1. Participation in fall 2013 survey of MIT faculty and instructors, by school and category



GLOSSARY OF TERMS

ENG: School of Engineering

FAC: Faculty

HASS/SHASS: School of Humanities, Arts and Social Sciences

INS: Instructors

MGMT: Sloan School of Management

OTH: Other (includes faculty and instructors with apppointments in areas for the Dean for Undergraduate Education, Dean for Student Life, Vice President for Research, Office of the Provost, MIT Libraries, MIT Press, and Tech Review

SAP: School of Architecture and Planning

SCI: School of Science

Question: Were you previously aware of the Institute-wide Task Force on the Future of MIT Education?

Awareness of the Task Force varied slightly by school, with faculty reporting greater awareness than instructors.

Table 3A.1. Awareness of Institute-wide Task Force on the Future of MIT Education, by employee type and school

	Employee type				School							
	FAC	INS	Total		SAP	ENG	HASS	SCI	MGMT	OTH	Total	
	%	%	%	#	%	%	%	%	%	%	%	#
Yes	73%	64%	70%	654	71%	71%	65%	74%	71%	70%	70%	654
No	27%	36%	30%	287	29%	29%	35%	26%	39%	30%	30%	287
Total	**100%**	**100%**	**100%**	**941**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**941**

MIT Values and Principles

The MIT Community has shared a number of values and principles of an MIT education with the Task Force, with themes including:

- Commitment to excellence
- Commitment to technical depth
- Constant and widespread faculty-student interaction
- Learning by doing: hands-on experience

- Extensive curricular offerings
- Leadership training, fostering teamwork, and developing communication skills
- Respect for truth above all other authority
- Education in the service of pushing the boundaries of knowledge

Question: Recognizing this list is not exhaustive, from your perspective, which values and principles of an MIT education do you feel are most important to maintain or develop? Please list up to three.

The most commonly mentioned values to maintain or develop (mentioned 10 or more times) included the following:

1. *Commitment to excellence*—Comments on general excellence, excellence in research and teaching, depth of understanding, and high academic standards.
2. *Commitment to hands-on experience*—Comments on learning by doing, project-based learning, the broad hands-on experience, apprenticeships and internships, and laboratory work.
3. *Education in the service of pushing the boundaries of knowledge*—Comments on broad expansion of knowledge, as well as the advising and mentoring that enables students to pursue their own expansion of knowledge.
4. *Constant and widespread faculty/student interaction*—Comments on both the quality and quantity of faculty-student interaction, face-to-face conversations, and mentoring.
5. *Commitment to technical depth*—Comments on knowledge of fundamentals, basic principles, depth of knowledge, and technical focus.
6. *Respect for truth above all other authority*—Comments on a general respect for truth, as well as truth both within the scientific enterprise and outside it.
7. *Leadership training, fostering teamwork, and developing communication skills*—Comments on leadership in science, technology, and society; teamwork; collaboration at all levels; and communication.
8. *Scholarship that will best serve the nation and the world*—Variety of comments on MIT's responsibility to serve the community, both locally and globally.
9. *Extensive curricular offerings*—Comments mention MIT's extensive curricular offerings across science and technology.
10. *Critical perspective*—Comments discuss MIT's ability to train critical thinkers and insightful minds.
11. *Interdisciplinary and collaborative teaching*—Comments mention MIT's interdisciplinary approaches to teaching, and collaboration between areas.
12. *Learning to learn*—Comments on how students learn to become effective lifelong learners, developing a toolkit for future exploration that includes research methodologies.
13. *Integration of research with education*—Comments discuss how MIT combines innovative research with education, allowing students access to faculty at the top of their fields.

14. *Creativity*—Comments mention the student creativity, unique culture, and innovative spirit that thrives at MIT.
15. *Honesty and integrity*—Comments on broad honesty and integrity, both academically and otherwise.
16. *Problem-solving skills*—Comments reference a variety of skills and approaches for problem-solving, both individually and in a group.
17. *Knowledge of the fundamentals*—Comments that discuss MIT's focus on knowledge of the fundamentals and core concepts.

Question: If you could change up to three things about the way MIT educates its students, what would you change? Please list up to three.

The most commonly mentioned things to change (mentioned 20 or more times) included the following:

1. Better integrate more hands-on experience

   "More learning by doing, with increasing uncertainty in nature of solution as student emerges towards graduation"

   "More emphasis on learning by doing (hands reinforcing mind)"

2. Broadly increase avenues for faculty-student interaction

   "Given edX, we need to increase the personal contact with faculty, grad students, as well as on-campus student learning groups so that attending MIT as opposed to MITx *has clear, significant benefits"*

   "Even more faculty/student interaction within the classroom and lab"

3. Balance/reconsider academic workload to reduce student stress

   "Build, rather than degrade, self-esteem of each student"

   "Reduce the pressure. Do more with less. We are teaching them how to cut corners, and not how to shine. They simply are not able to do their best because they do not have enough time."

4. Make degree programs more flexible

   "Provide greater flexibility as to course requirements and humanity requirements. Let the student define more of his/her path through MIT with self-imposed rigor rather than rigid requirements."

   "Less reliance on pre-programmed sets of requirements"

5. Increase focus on communication skills

   "I wish we taught our students how to write with greater coherence and clarity, and to express themselves with more impact (in both written and oral communications)."

6. De-emphasize large lectures

   "Fewer large lectures, far more active learning classrooms"

   "Move from lecture-style to more discussion-oriented teaching"

7. Promote more interdisciplinary connections between subjects/ideas/concepts

"Focus on connections among ideas/concepts as currently presented in separate disciplines"

"Provide students with a sense of how traditional disciplines are deeply interconnected in the modern landscape of science and engineering."

8. Promote greater awareness of global and social context

"Better situate technical study in cultural, social, and historical understanding"

"Better global citizens- more awareness around social and economic issues"

9. Grow HASS program, give it more resources, or give it more respect

"Make the humanities and social sciences integral to what an MIT [education] is about"

"To be a great leader, my guess is that people need a great liberal arts/humanities education. Most STEM [science/technology/engineering/mathematics] faculty don't value humanities."

10. Adjust balance of problem sets (p-sets) versus projects

"Emphasize 'problem-solving' or 'project-based' learning"

"Reassess the amount of 'busy work', i.e., p-sets, and how these assignments contribute to the overall learning experience"

11. Adjust the valuation/emphasis on teaching versus research [mostly increase emphasis on teaching]

"Greater involvement of all faculty in the department's teaching programs, courses, time spent with undergrads."

"Make teaching an important part of faculty role as leading researchers are often excellent teachers"

12. Emphasize student independence

"Clearly define our role as educators and not as caretakers for students away from home"

"I think the students should be given greater freedom to explore and pursue their own interests in a relatively unstructured environment."

"Perhaps more ways to encourage students to think independently"

13. Firehose culture needs to be reconsidered

"Lower the intensity just a little: currently it seems too pressurised [sic], which, arguably, actually impedes effective learning"

"Reduce the cultural forces promoting overwork and busyness to such an extreme that it degrades mental health"

14. Improve quality of advising/mentoring

"More active mentoring of individual undergraduates, in order to make sure that each individual achieves the best experience they can have at MIT."

"The advising is often weak in general, especially in the first year (though usually thesis and UROP [Undergraduate Research Opportunities Program] advising is quite good)"

"Undergraduate and graduate advising is sorely lacking at present. Many students slip through the cracks."

15. Improve quality of teaching/innovate new methods

"Constant evaluation of how courses are taught with emphasis on better and creative teaching"

"More use of innovative teaching approaches, including interdisciplinary, technological, and pedagogical ideas"

"The Institute should advocate that faculty incorporate research findings from education research: active learning, concept questions, peer discussion, etc."

16. Reduce class size in some or all courses

"Smaller classes for more personalized education, unique from massive online courses"

17. Help students learn to take care of themselves better

"Encourage them not to overload on courses (quality, not quantity)"

"Emphasize more the importance of time management and sleep"

Top responses by School indicate a great deal of overlap, with a call for more integration of hands-on experience and increasing focus on communication skills as a top item for four of the five schools. While "broadly increase avenues for faculty-student interaction" was second on the list overall, it is the top concern for faculty and instructors in the Schools of Science and of Engineering. Items that tied as a top response are included; responses common to each school are shaded with the same color.

Table 3A.2. Faculty and instructors' top things to change about the way MIT educates students, by school

School of Architecture and Planning
1. Better integrate more hands-on experience
2. Promote more interdisciplinary connections between subjects/ideas/concepts
2. Grow HASS program, give it more resources, or give it more respect
3. Firehose culture needs to be reconsidered
3. Promote greater awareness of global and social context
3. Modernize/expand classroom and laboratory facilities
School of Engineering
1. Broadly increase avenues for faculty-student interaction
2. Better integrate more hands-on experience
3. Balance/reconsider academic workload to reduce student stress
4. Increase focus on communication skills
4. Promote more interdisciplinary connections between subjects/ideas/concepts
4. De-emphasize large lectures

Table 3A.2. Continued

School of Humanities, Arts, and Social Sciences
1. Increase focus on communication skills
2. Balance/reconsider academic workload to reduce student stress
3. Grow HASS program, give it more resources, or give it more respect
4. Firehose culture needs to be reconsidered
4. Reduce requirements/allow for more flexibility
4. Promote greater awareness of global and social context
4. Broaden the MIT experience
School of Science
1. Broadly increase avenues for faculty-student interaction
2. Better integrate more hands-on experience
3. De-emphasize large lectures
4. Increase focus on communication skills
5. Reduce class size in some or all courses
Sloan School of Management
1. Better integrate more hands-on experience
2. Balance/reconsider academic workload to reduce student stress
3. Adjust the valuation/emphasis on teaching vs research
4. Increase focus on communication skills
4. Promote greater awareness of global and social context

What You've Taught

As the Task Force considers new models of delivering education, we need to understand our current teaching practices.

MIT departments may use Who's Teaching What (WTW), available at web.mit.edu/wtw to track teaching data, which feeds into the system for online subject evaluations. Faculty and instructors reviewed their individual teaching history from the last two academic years and were asked to confirm the list and offer any modifications.

Question: According to MIT records, these are subjects you have taught recently (academic years 2011–2012 and 2012–2013). Please confirm that you taught these subjects and add any we may have missed. Is this list correct?

The coverage of teaching data in WTW varies by school more than employee type. For example, more than 40% of Management faculty and instructors indicated that the list was not correct (Table 3A.3). Looking at academic departments with more than 10 faculty or instructors responding, the top departments indicating the list was not correct included Sloan School of Management, Chemical Engineering and Earth, Atmospheric and Planetary Sciences. More than 95% of the faculty and instructors in six departments (Literature Section, Brain and Cognitive Sciences, Mathematics, Physics, Biological Engineering, and Political Science) said their lists were correct.

Table 3A.3. Faculty and instructor responses to request to confirm accuracy of Who's Teaching What list of subjects taught during academic years 2011–2012 and 2012–2013

	Employee type				School							
	FAC	INS	Total		SAP	ENG	HASS	SCI	MGMT	OTH	Total	
	%	%	%	#	%	%	%	%	%	%	%	#
Yes, list is correct	85%	81%	84%	608	82%	83%	90%	92%	57%	72%	84%	608
No, list is not correct	15%	19%	16%	118	18%	17%	10%	8%	43%	28%	16%	118
Total	100%	100%	100%	726	100%	100%	100%	100%	100%	100%	100%	726

Modularity

The Task Force has explored the possibility of offering educational content in smaller modules or discrete segments, often referred to as competency-based learning. Faculty and instructors were asked if any of their classes had already been converted into smaller-unit offerings, and if they had taught classes that could benefit from this method. Less than 10% indicated they have taught classes that have been converted, but 25% indicated their classes could benefit from this approach.

Question: Have you taught classes that have been converted into smaller units, e.g. 12-unit subjects that have been converted into units of six or fewer? Have you taught classes that could benefit from being offered in smaller, more discrete segments or modules?

Figure 3A.2. Faculty and instructors who responded that they have taught classes that have been converted into smaller units, or have taught classes that could benefit from being offered in smaller segments or modules

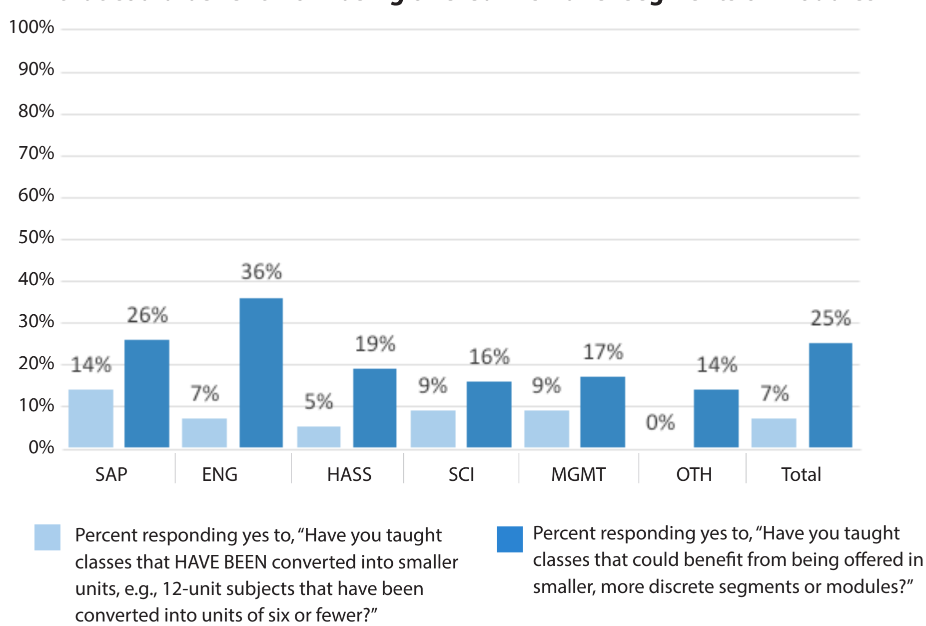


Table 3A.4. Classes (subjects) that have been converted to smaller units, or 'modularized', as reported by faculty and instructor survey respondents

Subject number	Subject title
1.107	Environmental Chemistry and Biology Laboratory
2.003	Dynamics and Control I
2.005	Thermal-Fluids Engineering I
2.01	Elements of Structures
2.02A	Engineering Materials: Properties and Applications
2.02B	Mechanics of Structures
2.031	Dynamics II
2.081J/16.230J	Plates and Shells: Static and Dynamic Analysis
2.087	Engineering Mathematics: Linear Algebra and ODEs
2.674	Micro/Nano Engineering Laboratory
5.062	Principles of Bioinorganic Chemistry
5.311	Introductory Chemical Experimentation
5.32	Intermediate Chemical Experimentation
5.33	Advanced Chemical Experimentation and Instrumentation Laboratory
5.512	Synthetic Organic Chemistry II
5.72	Statistical Mechanics
8.13	Experimental Physics I
11.202	Planning Economics
11.203	Microeconomics
11.521	Spatial Database Management and Advancement Geographic Information Systems
11.523	Fundamentals of Spatial Database Management
11.524	Advanced Geographic Information System Project
15.356	Product and Service Development in the Internet Age
15.369	Corporate Entrepreneurship: Strategies for Technology-Based New Business Development
15.904	Advanced Strategic Management
15.915	Laboratory for Sustainable Business
15.912	Strategic Management of Innovation and Entrepreneurship
15.913	Strategies for Sustainable Business
15.915	Laboratory for Sustainable Business
17.541	Japanese Politics and Society
20.213	DNA Damage and Genomic Instability
21M.051	Fundamentals of Music
ESD.101	Concepts and Research in Technology and Policy
ESD.260	Logistics Systems

Note: Information regarding the academic year in which the subjects were offered was not collected, and the table does not include 11 special studies and special seminar subjects in Courses 11, 15, ESD, MAS whose titles may change on a yearly basis.

More than 170 subjects were suggested as possibly benefitting from modularity, with the greatest number suggested in Electrical Engineering and Computer Science (Course 6), Mechanical Engineering (Course 2), various Humanities fields (Course 21), Aeronautics and Astronautics (Course 16), and Management (Course 15).

Table 3A.5. Number of subjects identified through survey, by department, that may benefit from modularity

Department	Course	Subjects
Electrical Engineering and Computer Science	Course 6	27
Mechanical Engineering	Course 2	20
Aeronautics and Astronautics	Course 16	14
Humanities	Course 21*	14
Management	Course 15	13
Civil and Environmental Engineering	Course 1	9
Physics	Course 8	8
Chemical Engineering	Course 10	8
Architecture	Course 4	7
Earth, Atmospheric and Planetary Sciences	Course 12	7
Materials Science and Engineering	Course 3	6
Urban Studies and Planning	Course 11	6
Biological Engineering	Course 20	6
Engineering Systems Division	ESD	6
Linguistics and Philosophy	Course 24	5
Chemistry	Course 5	4
Mathematics	Course 18	4
Biology	Course 7	3
Nuclear Science and Engineering	Course 22	3
Brain and Cognitive Sciences	Course 9	2
Political Science	Course 17	2
Total		**174**

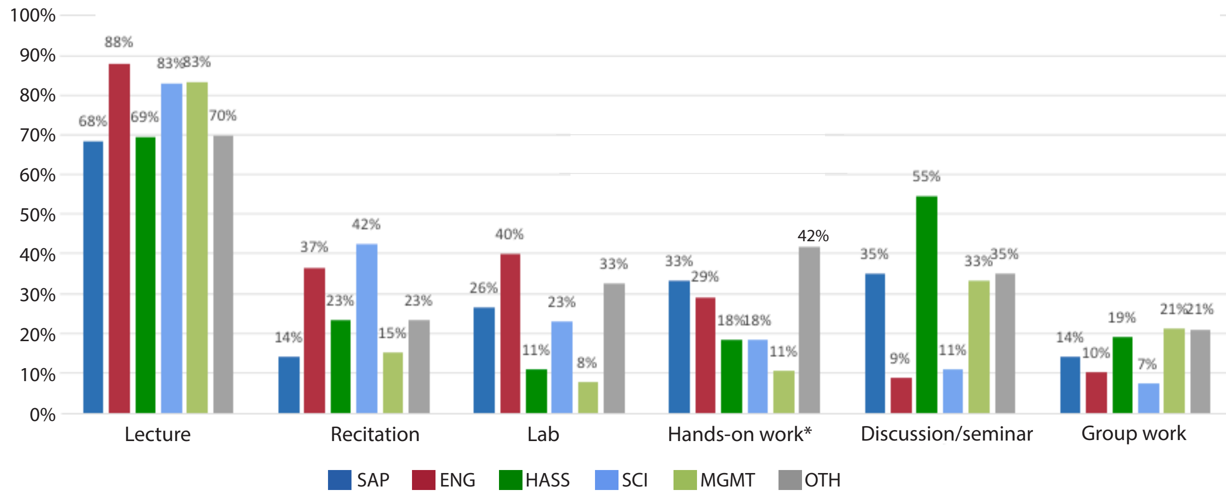
*Course 21 includes Course 21A (Anthropology), 21F (Foreign Languages and Literatures), 21H (History), 21L (Literature), and 21M (Music).

Tell Us About a Specific Subject

Faculty and instructors were asked to describe in detail one of their subjects from WTW, with the option to select a different one if they preferred. More than 100 faculty and instructors chose to describe an extra subject, resulting in detail on more than 700 subjects taught in the last two years.

Question: How is this subject taught to students, e.g., primarily lectures, lectures plus recitations, hands-on lab work? Please describe:

Figure 3A.6. Teaching methods used in more than 700 subjects taught over academic years 2011–2012 and 2012–2013, as described by faculty and instructors, by school.



* Hands-on work includes work performed in D-Lab, Experimental Study Group, Edgerton Center, and Terrascope subjects.

Question: Have you taught this subject more than once or do you plan to teach it again in academic year 2013–2014?

MIT faculty and instructors generally teach a subject more than once.

Table 3A.6. Faculty and instructors who reported having taught a subject more than once, or who plan to teach it again in academic year 2013–2014

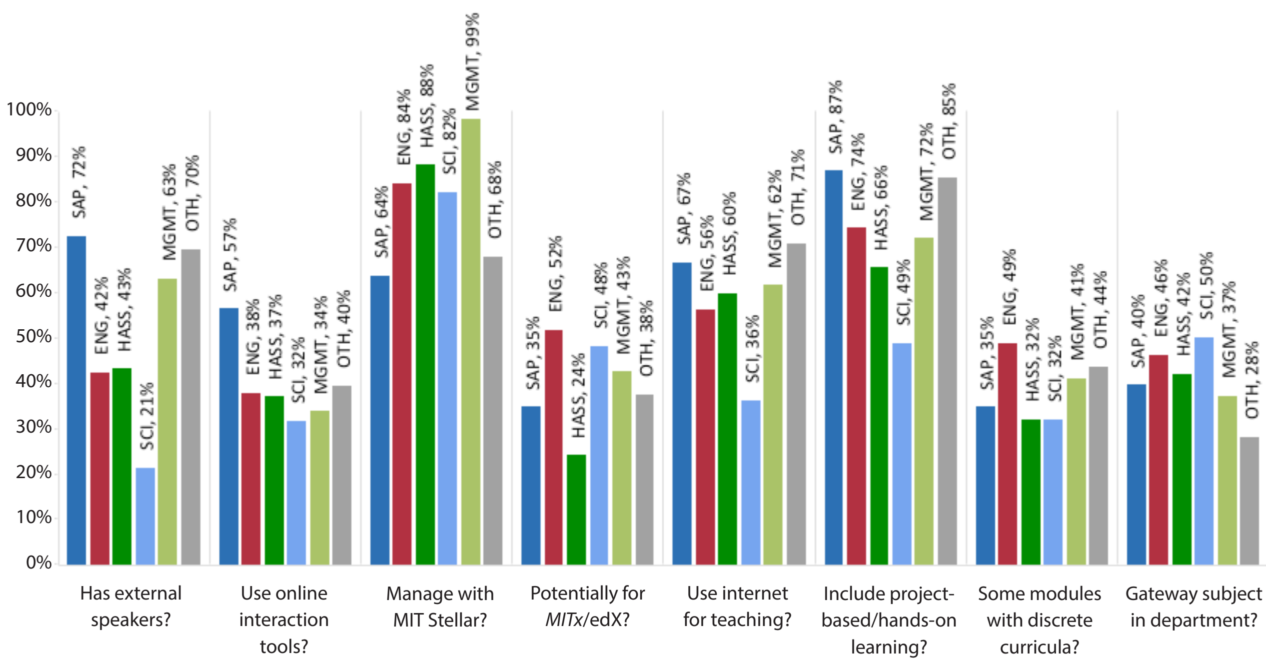
	Employee Type				School							
	Fac	Ins	Total		SAP	ENG	HASS	SCI	MGMT	OTH	Total	
	%	%	%	#	%	%	%	%	%	%	%	#
Yes	94%	88%	92%	759	90%	93%	93%	90%	99%	88%	92%	759
No	6%	12%	8%	66	10%	7%	7%	10%	1%	13%	8%	66
Total	**100%**	**100%**	**100%**	**825**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**825**

Subject Features

Question: Tell us about the features of this subject.

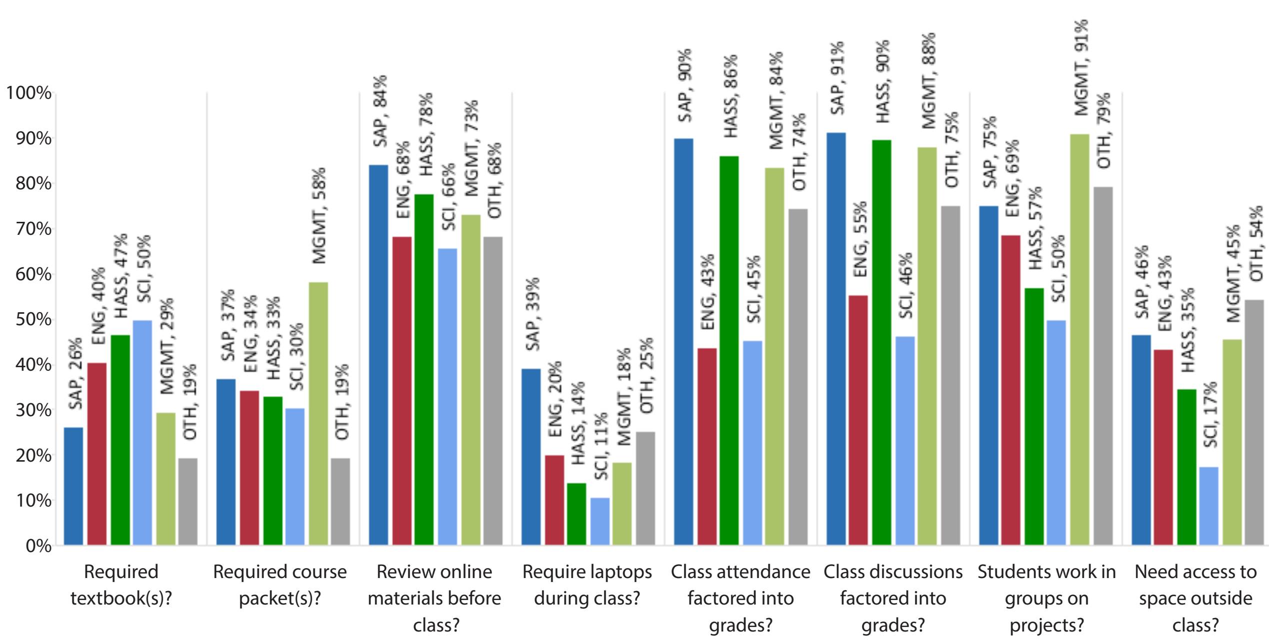
We see a wide variety of feature adoption by school.

Figure 3A.4. Features of subjects of more than 700 subjects taught over academic years 2011–2012 and 2012–2013, as described by faculty and instructors, by school.



Question: Tell us about student preparation and participation.

Figure 3A.5. Types of student preparation and participation required in more than 700 subjects taught over academic years 2011–2012 and 2012–2013, as described by faculty and instructors, by school.



Subject Space Needed

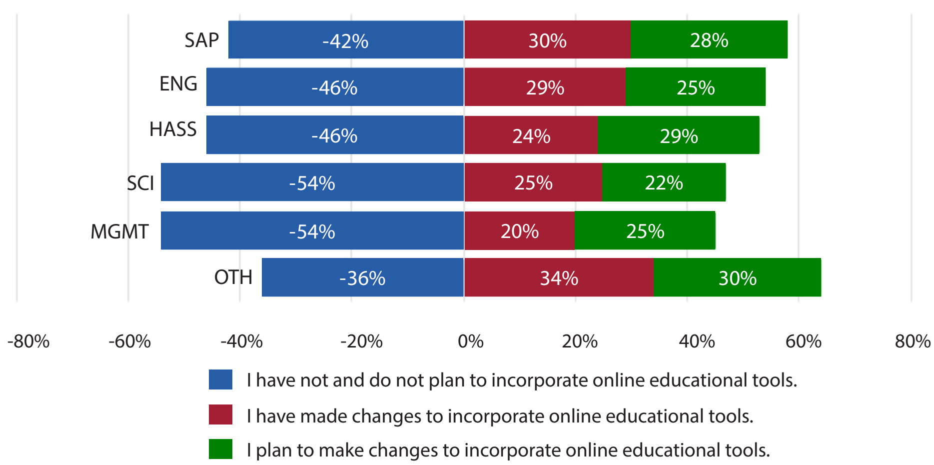
Question: Please describe the space(s) and the open hours for accessing the space. If there is a web page describing the space, please enter the URL.

Spaces mentioned the most include labs or similar spaces (34%), small group workspaces (17%), library (12%), computer clusters or computer access (9%), a specific room (4%), other or multiple spaces (24%).

Additional Online Education Tools

Question: In addition to any online tools you may have said were features of this subject, have you made other changes to incorporate online educational tools? Do you plan to incorporate any online educational tools in the future?

Figure 3A.7. Faculty and instructors planning to change or incorporate online educational tools (in additional to those already reported) to more than 700 subjects taught over academic years 2011–2012 and 2012–2013, by school.



Question: Please describe which online educational tools you have incorporated or plan to incorporate into this subject and how you use them.

Top 10 most common responses:

1. Lectures or course content—This includes all course content including handouts, lecture notes, presentation slides, readings, links to resources, and recorded lectures.
2. Specific online resources—This includes resources specific to a single class, e.g., virtual labs, music composition software, links to articles in the media.
3. Modules online—This includes small segments of the class material available in modular online format as well as online tutorials that may have been created by other faculty or industry.

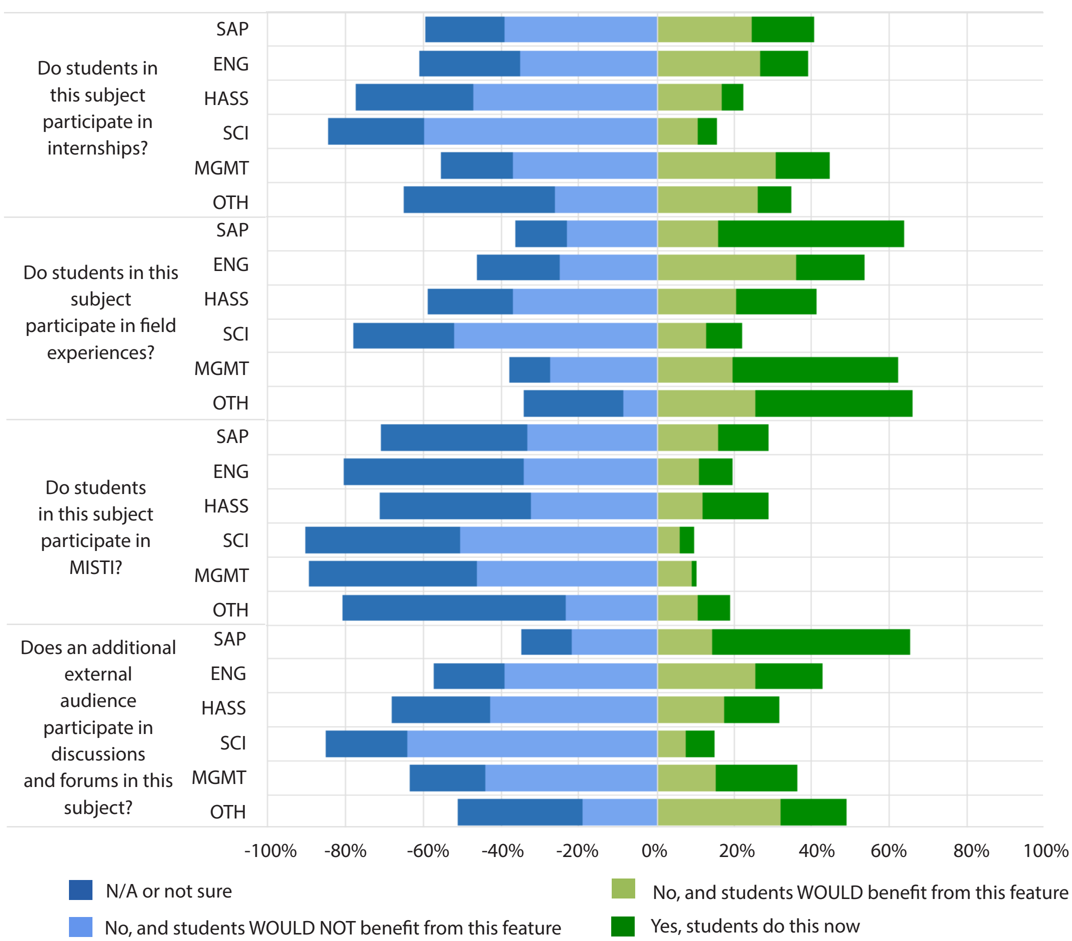
4. Simulations—This includes any sort of simulation in which students could participate, whether it be stock trading, explorations of physical principles, or flight simulators.
5. None/nothing yet.
6. I'm not sure, I don't know how, help me?
7. Discussion forum—This includes a variety of different platforms with the common theme of students and possibly instructors/faculty interacting and discussing subject material online.
8. Stellar.
9. Pre-class assignment.
10. *MITx* platform—This includes all responses that said specifically that they integrate content from the *MITx* platform into their curriculum.

Student Benefits

Question: Potential student benefits.

The Task Force wanted to gauge the appetite for internships, global experiences, and external audience participation in MIT subjects.

Figure 3A.8. Perceived student interest in and benefit from external experiences and/or viewpoints, as reported by faculty and instructors, by school.*

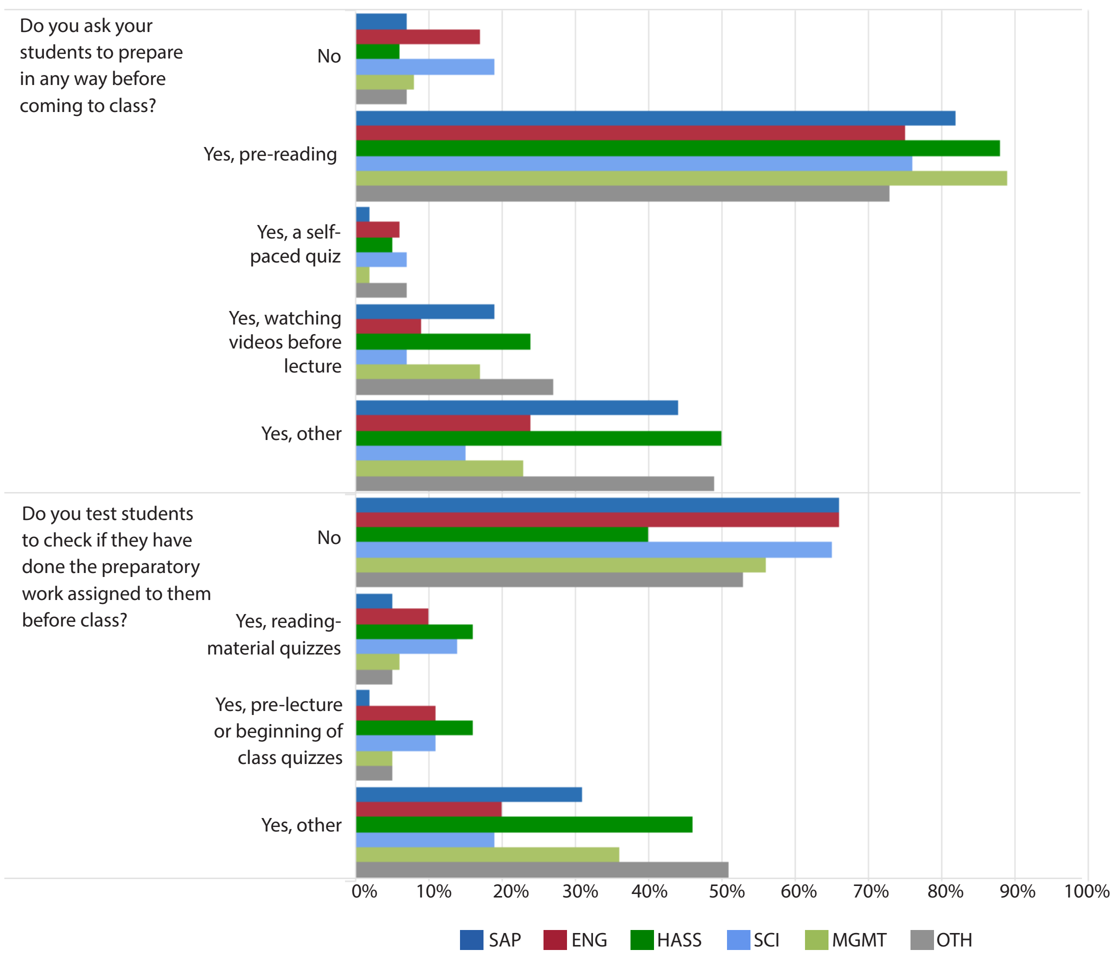


* Faculty and instructors respondents reported on the students in the more than 700 subjects they reported teaching during academic years 2011–2012 and 2012–2013.

Student Class Preparation

Question: Part 1—In general, do you ask your students to prepare in any way before coming to class? Part 2—In general, do you test students to check if they have done the preparatory work assigned to them before class (e.g., questions about assigned readings or videos)?

Figure 3A.9. Faculty and instructors who reported asking students to prepare prior to class, and who check if preparatory work has been done, by school.



"Other" ways students are asked to prepare before coming to class include working on problem sets; writing or other exercises before class; and preparing or making progress on projects, presentations, or performances.

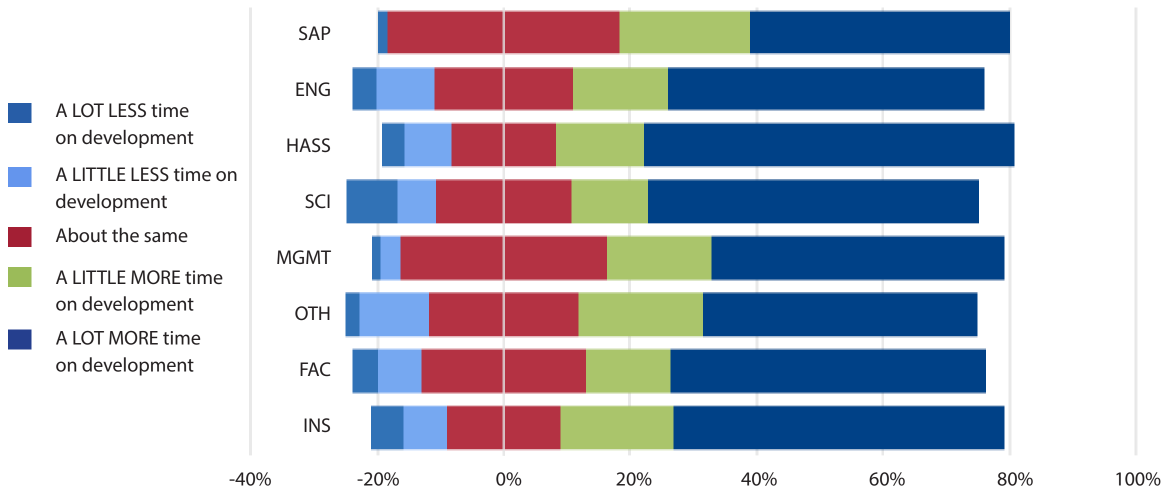
"Other" means of determining if students have done the assigned preparatory work before class include cold-calling in class and class discussion or activities. In the Schools of Engineering and of Science, checking student submission of work was chosen most often as the top means of checking students' preparation.

Subject Development versus Delivery

Question: Thinking about this subject, generally, how much time do you spend on subject development as distinct from subject delivery?

Faculty and instructors in all schools generally reported spending a lot more time on subject development than subject delivery.

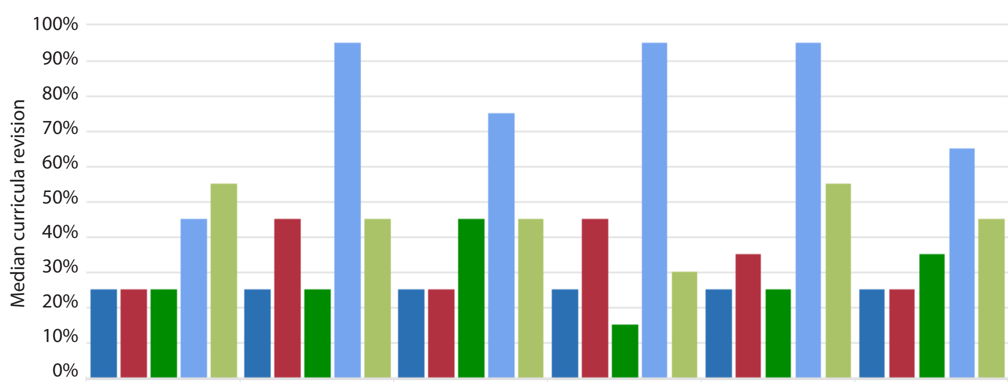
Figure 3A.10. Time spent on subject development versus delivery, as reported by faculty and instructors, by school.



Subject Revision

Question: What percent of the curricula and materials do you revise each time you teach this subject? Please make your best estimate.

Figure 3A.11. Percentage of curricula and materials revised each time subject is taught, by type and school.



	SAP	ENG	HASS	SCI	MGMT	OTH
Lectures	25%	25%	25%	25%	25%	25%
Problem sets	25%	45%	25%	45%	35%	25%
Lab assignments	25%	25%	45%	15%	25%	35%
Exams	45%	95%	75%	95%	95%	65%
Other	55%	45%	45%	30%	55%	45%

The other candidates for revision included major essay or research paper topics, and class projects for individuals or groups. Instructors indicated they need to revise class readings and case studies, as well as notes and handouts they might provide. A few need to line up new external speakers and field experiences or internships for each subject.

Pedagogical Innovations

Question: Are there any pedagogical innovations you would institute in this subject (e.g., new content, modularity, pre-class assignments, practical examples, more discussion, project-based learning, blended learning, active learning)?

The 10 most common responses included the following:

1. Active learning—Discussion, dialogue, hands-on work, smaller classes, general active learning
2. I already use some of these innovations.
3. New content—Either yearly revisions to existing content, new ways of presenting existing content, or expansion into a new domain
4. Real-world connections—Practical examples, real-world problems, industry visits, guest speakers, etc.
5. Modularity—Course could benefit from being split up into smaller pieces
6. Project/group work, learning from peers—Teamwork, project-based learning and assessment, learning from peers
7. Blended learning—Moving aspects of the class online, including lectures, lecture notes, quizzes, self-assessments, teaching interfaces, discussion groups, etc.
8. Educational technologies—An additional technology, often specific to a single class, that would help students learn (e.g. clickers, Kinect, flight simulators)
9. Pre-class assignments—Readings, quizzes, or self-assessments for students to do before class
10. Course-specific innovation—A structural or pedagogical change that depends on the type and structure of the course, or its relationship to related courses

Appropriate for *MITx*/edX

Question: You indicated this subject might be appropriate for **MITx*****/edX. Please describe why you think it is a good candidate, and how you envision the subject could be delivered.***

Close to 300 individual subjects were considered suitable for *MITx*/edX, with reasons including:

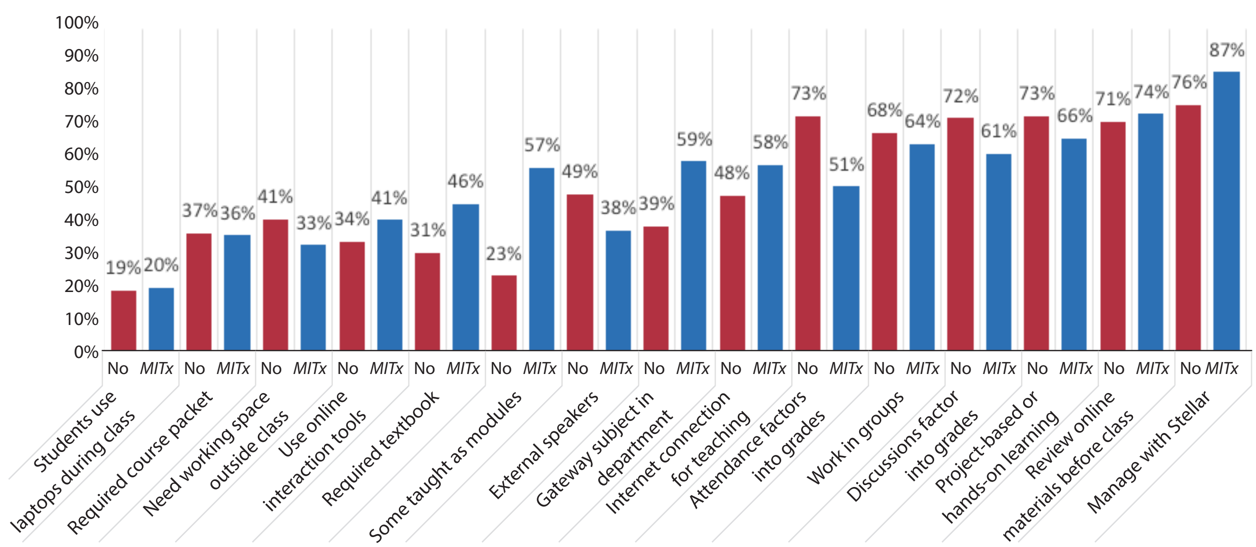
- Popular, foundational, or important subject matter
- Modularity inherent in course structure
- Already exists or is in development
- Curriculum is already in appropriate format

Of the courses suggested, 172 (62%) were undergraduate-level courses and 103 (37%) were graduate-level courses, primarily concentrated in the Schools of Engineering and of Science. Half the courses suggested came from seven departments: Electrical Engineering and Computer Science, Management, Mechanical Engineering, Aeronautics and Astronautics, Physics, Materials Science and Engineering, and Biology.

Table 3A.7. Number of subjects indicated by faculty and instructors as potentially appropriate for *MITx*/edX, by course level and school.

	Undergraduate		Graduate		Both		Total	
School	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Engineering	74	43%	49	48%	1	33%	124	45%
Science	46	27%	15	15%	2	67%	63	23%
Humanities, Arts, and Social Sciences	31	18%	2	2%	0	0%	33	12%
Sloan School of Management	2	1%	20	19%	0	0%	22	8%
Architecture and Planning	8	5%	14	14%	0	0%	22	8%
Other	11	6%	3	3%	0	0%	14	5%
Total	**172**	**100%**	**103**	**100%**	**3**	**100%**	**278**	**100%**

Figure 3A.12. Subect features that may or may not be suitable for *MITx*/edX



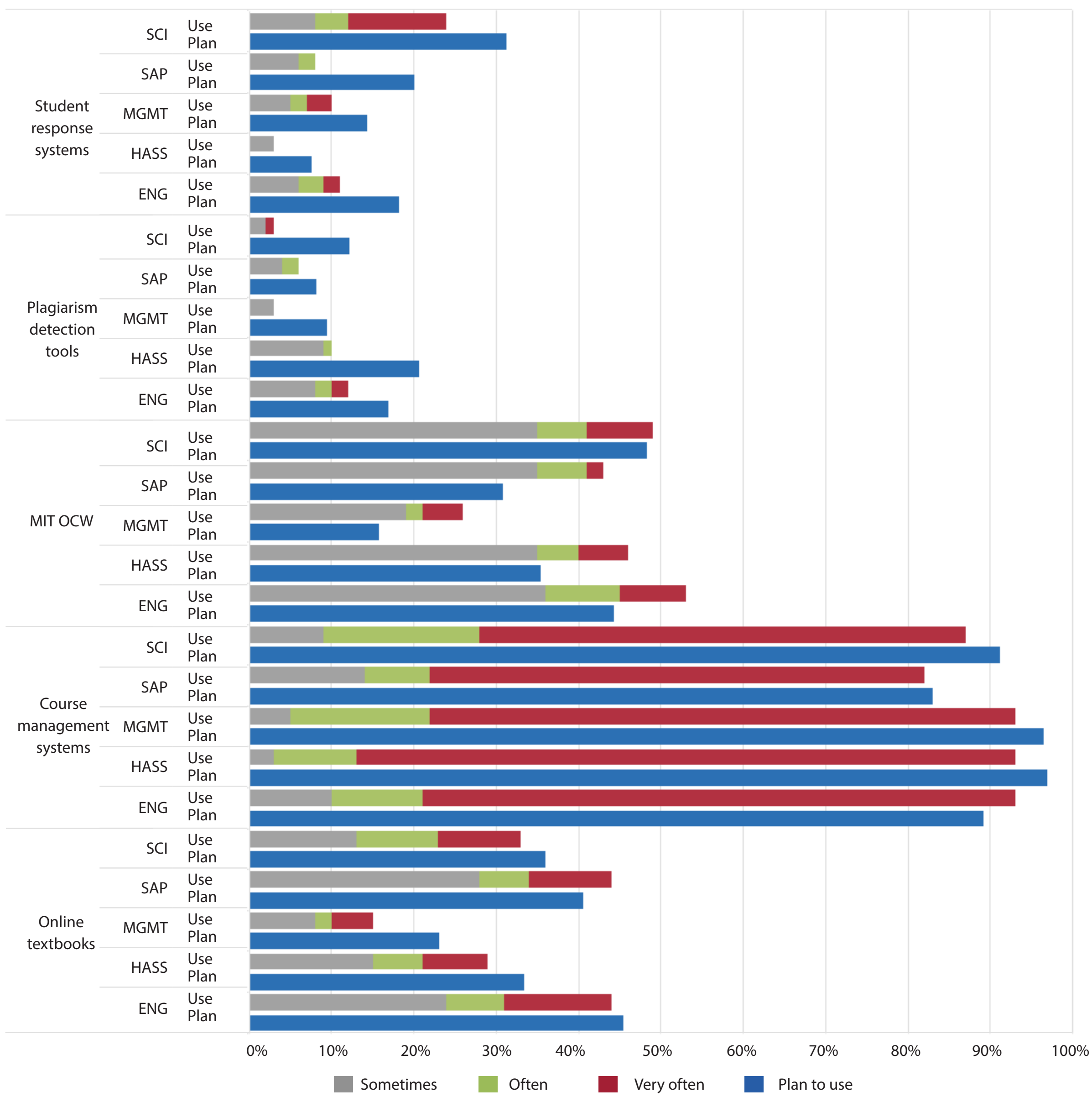
Subjects suggested for *MITx*/edX may have different characteristics than those not suitable for online delivery, with reasons including that they may already be taught with modules, that they are managed via Stellar, or that they have a required textbook.

Your Use of Educational Technology

Question: During the last academic year (2012–2013), about how often did you use the following educational technologies, in any context? Do you plan to use any of this technology in the future? If you are not aware of the listed technology, please select "Not aware of this technology."

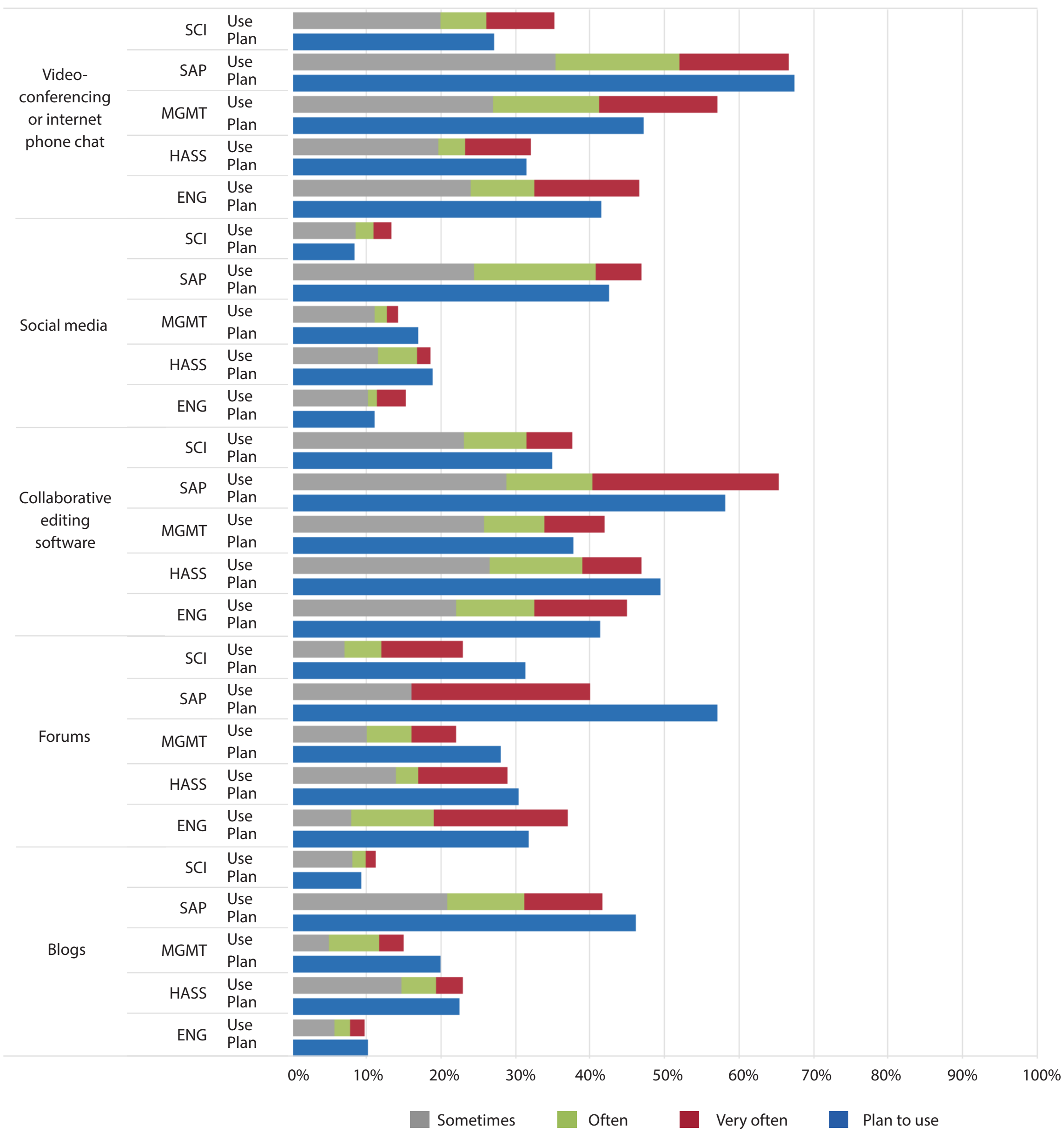
More faculty and instructors indicate that they plan to use student response systems in the future than they do now.

Figure 3A.13. Frequency of use of education technologies during academic year 2012–2013, and planned future use



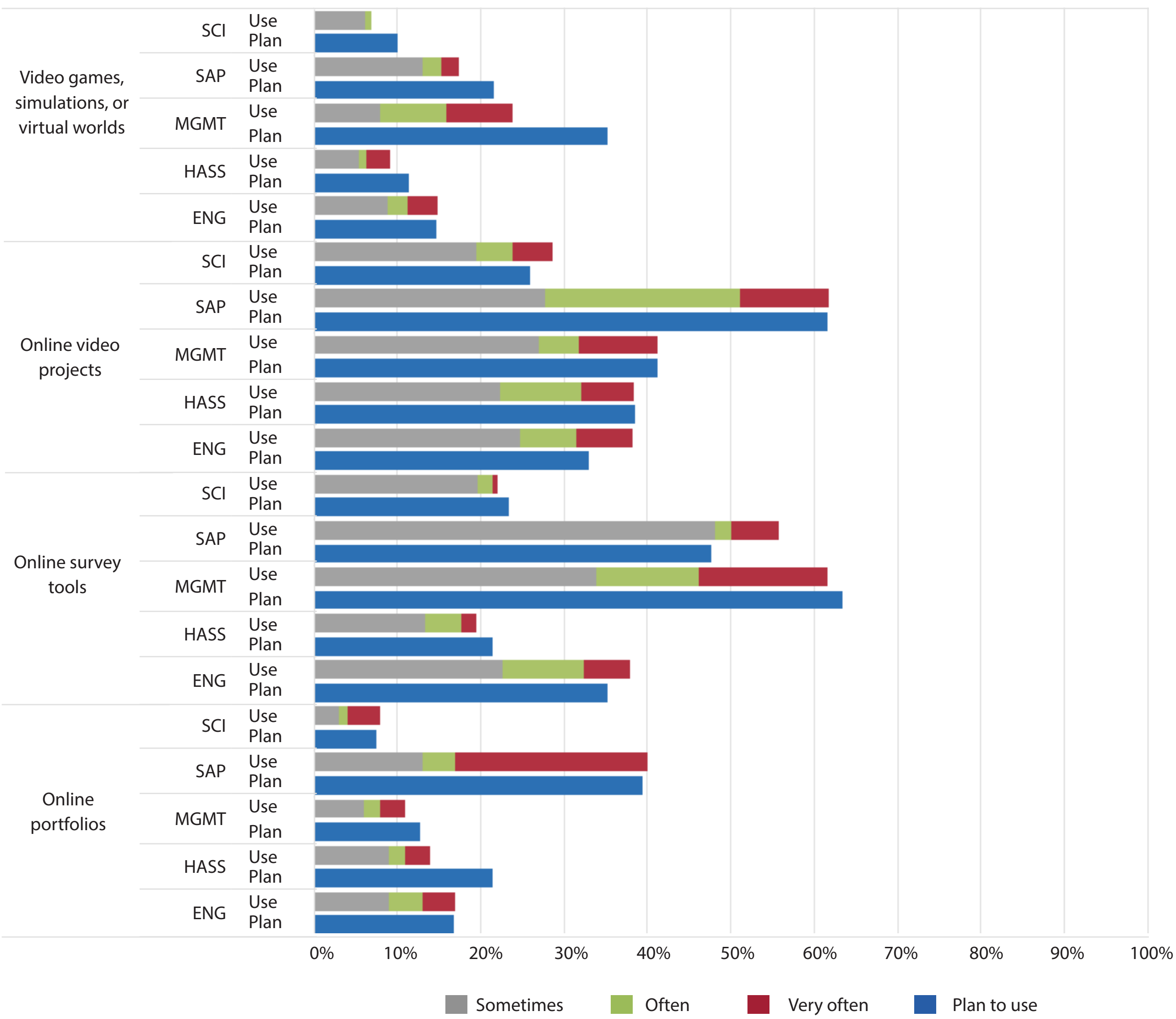
More faculty and instructors indicate that they plan to use forums in the future than they do now. Two forum systems are used most: Piazza and Stellar, with Piazza used more in the Schools of Engineering and of Science. Blogs are used in the Schools of Humanities, Arts, and Social Sciences, Engineering, and Architecture, with the majority using WordPress, followed by Blogger.

Figure 3A.14. Frequency of use of interaction technologies during academic year 2012–2013, and planned future use



The current use and plan to use for these technologies is pretty similar, with the exception of Sloan indicating greater use of simulations and virtual worlds.

Figure 3A.15. Frequency of use of "new media" technologies during academic year 2012–2013, and planned future use



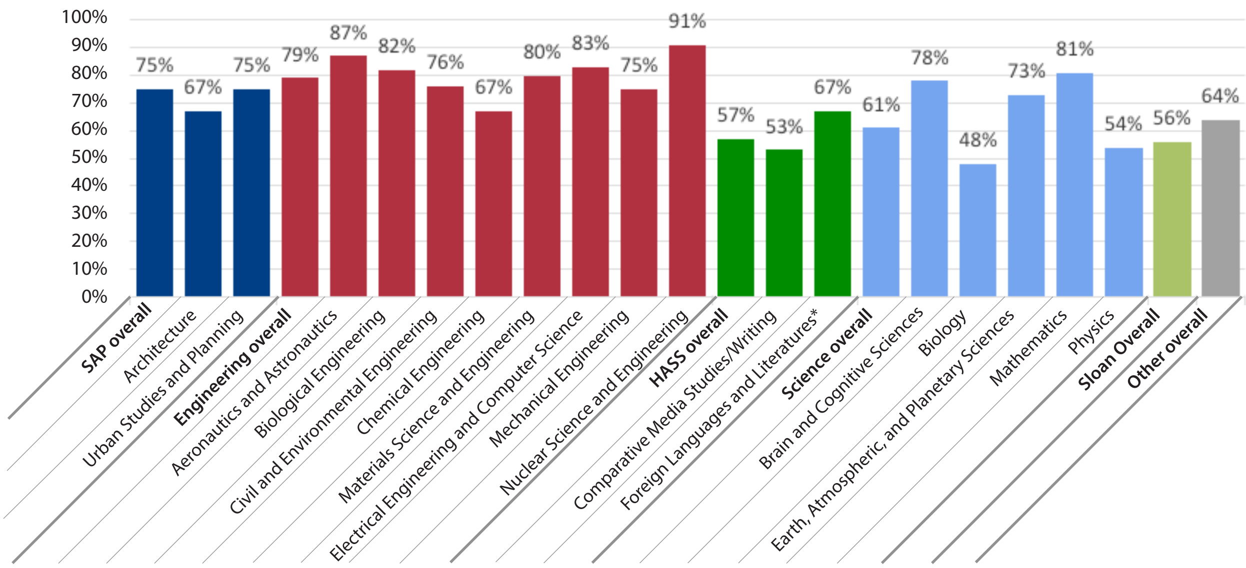
Question: Have you found any of the tools or technologies listed above particularly useful? Please describe.

The top tools listed were: Stellar, collaborative tools (e.g., Google docs for shared group writing and projects), online conferencing tools (e.g., Skype, WebEx), videos (online, for training and for assignments), wikis, video sharing (e.g., YouTube, Vimeo), blogs (e.g., Wordpress), forums (e.g., Piazza), simulation tools, survey software, document sharing and repositories (e.g., Dropbox, Github), OCW, and online textbooks or reference material.

Repositories

Question: For any subjects you have taught, have you stored the subject materials in a repository (online or physical) that could be accessed by other instructors, including current and future lecturers, recitation instructions, and teaching assistants?

Figure 3A.16. Storage of subject materials in physical or virtual repositories, selected departments*



* Effective July 1, 2014, Foreign Languages and Literatures was renamed Global Studies and Languages.

Close to half (44%) of the faculty and instructors indicated they use Stellar as a repository and 20% indicated that they use OCW as a repository for subject materials.

- Stellar, 44% [n=207]
- OCW, 20% [n=95]
- Wiki, website or blog, 13% [n=59]
- Dropbox, 9% [n=40]
- Other repository (e.g., Git, SVN, Mercurial), 7% [n=34]
- My electronic files 5% [n=24]
- Course locker (e.g., Athena), 4% [n=18]
- Department server, 4% [n=17]

Future Technologies

Question: Thinking about how you plan to teach in the future, what 1–2 technologies, tools or methods could MIT provide that you would find most useful?

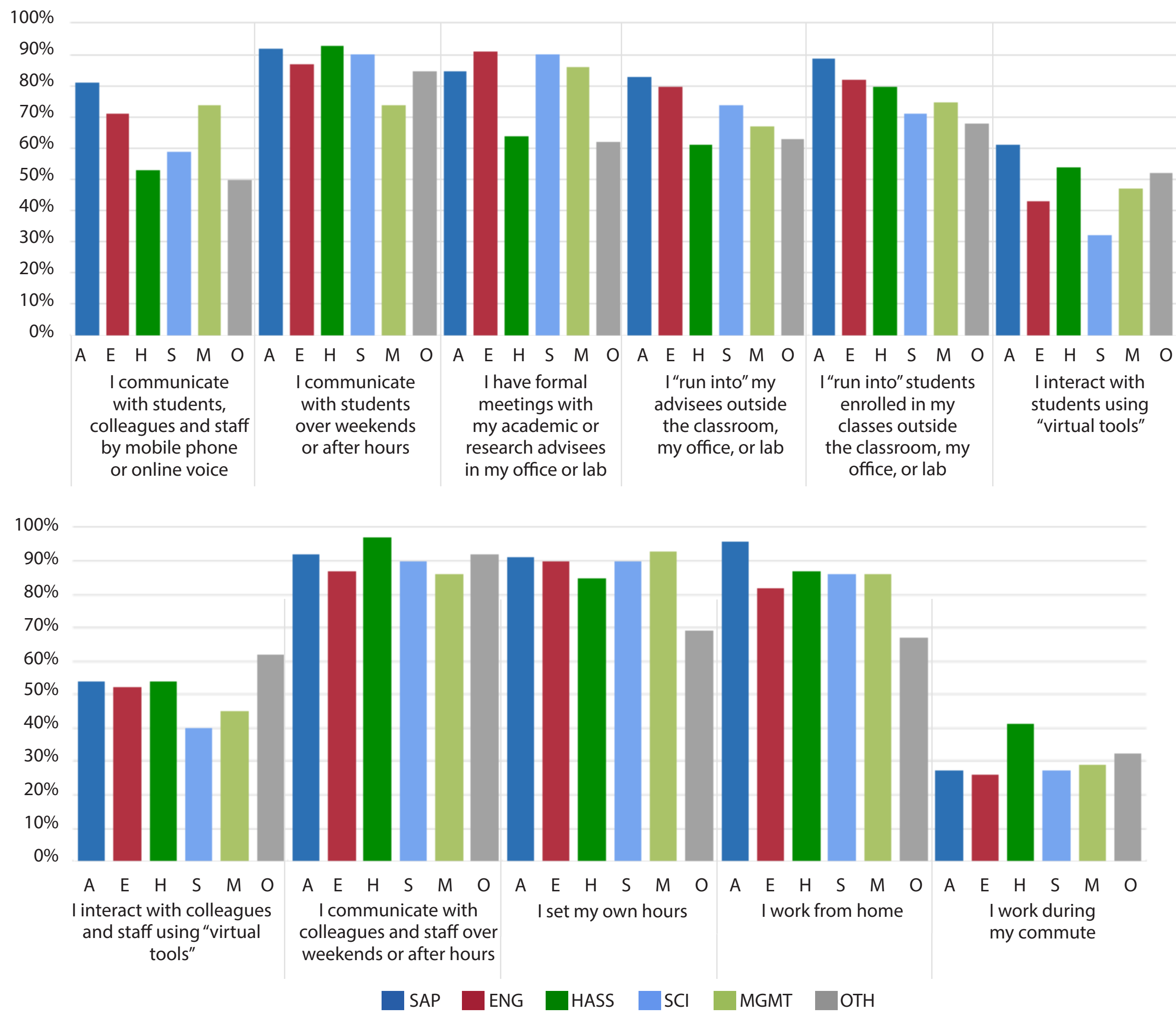
Approximately 400 responses are available for review, with specific experiments suggested. Themes include better "smart" electronic classrooms with smartboards, lecture capture, and student response systems, as well as collaboration tools such as high-quality video and web conferencing, collaborative editing software, and shared repositories.

Where You Work

The MIT learning experience involves several modes of interaction: lectures, recitations, labs, projects, internships, study groups, individual study, and so on. It also features signature educational approaches such as UROP and MISTI (MIT International Science and Technology Internship program), and intensive project-based hands-on learning in many fields.

Question: During a typical work week at MIT, do any of the following apply to how you work?

Figure 3A.17. Modes of interaction and work reported by faculty and instructors during a typical work week at MIT

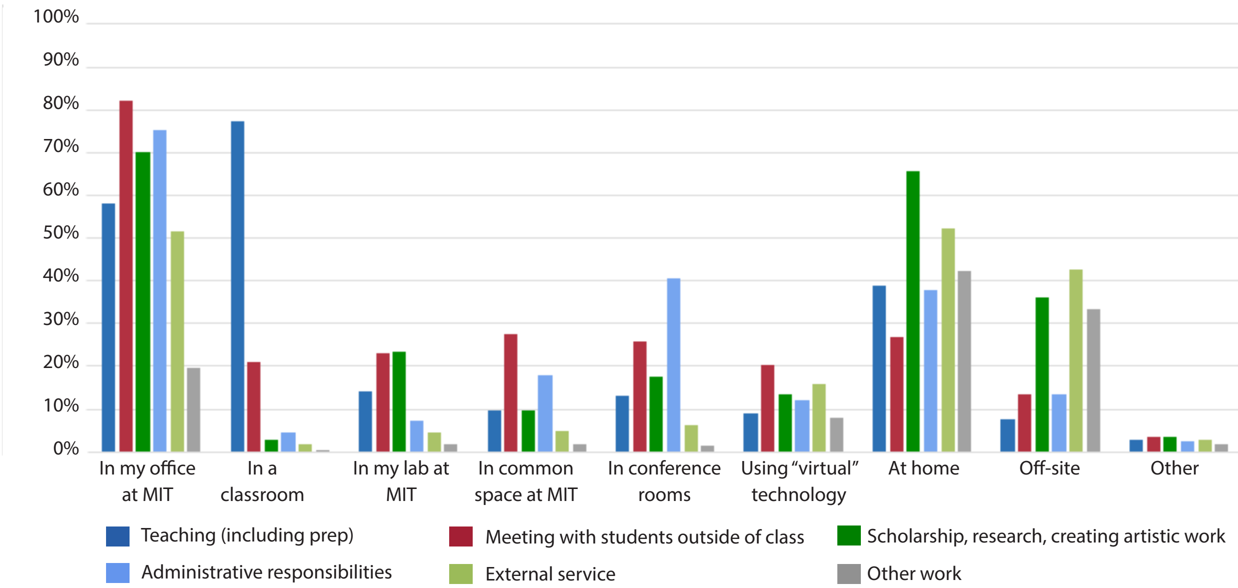


Education Locations

The Task Force recognizes education can occur in a variety of physical settings. We hope to understand how you use space now and how you feel those needs may change as modes of MIT education delivery evolve.

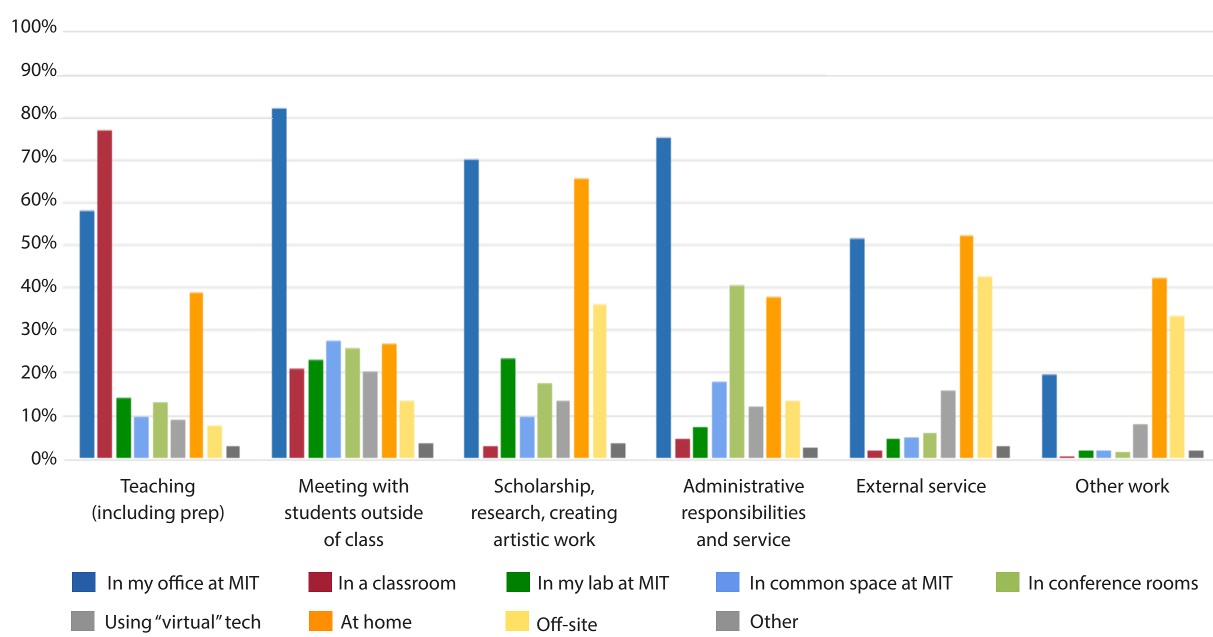
Question: During a typical work week in spring term 2013 (February–June 2013), what were the top 1–3 locations where you conducted the following activities?

Figure 3A.18. Faculty and instructors' work activities, by location



Other spaces mentioned were in other offices or labs (e.g., at Harvard, Massachusetts General Hospital), MIT Libraries, MIT Museum and MIT performance space, area cafés, and while commuting.

Figure 3A.19. Faculty and instructors' work spaces, by activity



Future Classroom Needs

Question: Thinking about how you teach, how are your needs for future classroom and teaching space changing, if at all?

The needs mentioned the most included the following:

- Not changing/no change specified, 35% [n=137]
- Better access to educational technology in classrooms, 27% [n=107]
- Flexible spaces that can convert from lecture to group work to discussion to seminar… , 10% [n=38]
- Smaller classrooms or classrooms designed for discussion are more useful, 8% [n=31]
- Group work spaces/spaces for meeting with students, 7% [n=26]
- Must accommodate larger class sizes, 5% [n=21]
- More/better lab space, 2% [n=6]
- Will be accommodated by *MITx*, 1% [n=2]

Interacting with Students

Question: How many of each of the following types of formal advisees (enrolled in degree programs) do you currently have?

Table 3A.8. Number and type of formal MIT advisees for faculty and instructor survey respondents

	0	1	2	3	4	5	6–7	8–10	11–15	16–20	21–25	>25	#
Freshmen	75%	2%	1%	1%	4%	7%	4%	4%	1%	0%	0%	0%	623
Undergraduate upperclassmen	44%	5%	6%	5%	7%	7%	9%	7%	3%	4%	2%	1%	668
Graduate/ professional students	28%	7%	10%	7%	7%	7%	9%	10%	9%	2%	1%	2%	698

Question: Do you have any suggestions for how MIT can increase opportunities for faculty and student interaction?

This question yielded approximately 300 responses, with common suggestions including the following:

- Fund increased social interactions, generally more meals together
- Create more informal common spaces for faculty and students to interact, across disciplines

- Require, recognize, reward advising or mentoring
- Encourage more Undergraduate Research Opportunities Program (UROP) and research participation, possibly through funding
- Reduce faculty administrative workload (e.g., more teaching assistants, provide grant-writing support)
- Create programs to have more faculty "in-residence" or housed near campus
- Hold smaller classes or seminars to encourage student-faculty interaction
- Encourage extracurricular interaction, e.g., reduce fees for faculty to visit gym or play on department athletic teams

Closing Thoughts

Various other questions were posed to participants, yielding responses too numerous to elaborate upon in this report. There were some 400 responses to the question, "What one thing could MIT reasonably do to better support your teaching?" and participants shared some 300 comments about the the future of education at MIT.

About half of those who completed the survey expressed their willingness to participate in more in-depth discussions.

Appendix 3B. Fall 2013 Survey of MIT Undergraduate and Graduate Students

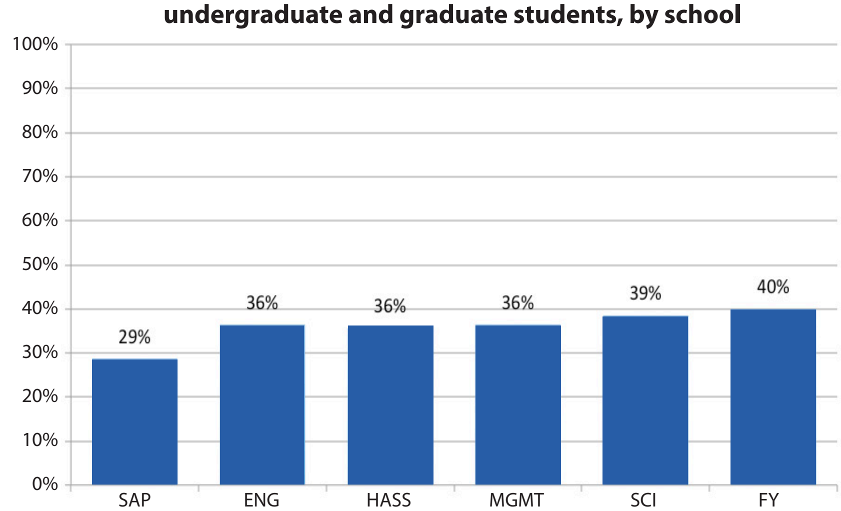
Preliminary Survey Summary, June 2014
MIT Institutional Research, Office of the Provost

Overview

In September 2013, the Institute-wide Task Force on the Future of MIT Education invited all students to participate in a survey designed to better understand how they learn, how they interact with faculty, and what educational technologies they use. The questions on digital learning were written to collect student perspectives about the potential impact on coursework, research, and professional and personal development. The survey was open until October 15, 2013, with invitations and reminders sent to students from Chancellor Eric Grimson, student representatives on the Task Force, and Director of Institutional Research Lydia Snover.

By the close of the survey, 39% of undergraduates and 35% of graduate students had responded.

Figure 3B.1. Response to fall 2013 survey of MIT undergraduate and graduate students, by school



GLOSSARY OF TERMS

ENG: School of Engineering

FY: First-year undergraduate students (freshmen)

G: Graduate students

HASS/SHASS: School of Humanities, Arts and Social Sciences

MGMT: Sloan School of Management

SAP: School of Architecture and Planning

SCI: School of Science

UG: Undergraduate students

Question: Were you previously aware of the Institute-wide Task Force on the Future of MIT Education?

Awareness of the Task Force among the respondents varied slightly by school.

Table 3B.1. Awareness of Institute-wide Task Force on the Future of MIT Education, by level of student and school

	Level		Level						
	UG	**G**	**SAP**	**ENG**	**HASS**	**MGMT**	**SCI**	**FY**	**Total**
Yes	32%	31%	29%	39%	33%	20%	36%	8%	32%
No	68%	69%	71%	61%	67%	80%	64%	92%	68%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

MIT Values and Principles

The MIT Community has shared a number of values and principles of an MIT education with the Task Force, with themes including:

- Commitment to excellence
- Commitment to technical depth
- Constant and widespread faculty-student interaction
- Learning by doing: hands-on experience
- Extensive curricular offerings
- Leadership training, fostering teamwork, and developing communication skills
- Respect for truth above all other authority
- Education in the service of pushing the boundaries of knowledge

Question: Students: Recognizing that this list is not exhaustive, from your perspective, which values and principles of an MIT education do you feel are most important to maintain or develop? Please list up to three.

The most common values to maintain or develop, listed in order of the frequency with which they were mentioned (five times or more), were the following:

1. *Commitment to hands-on experience*—Comments on learning by doing, project-based learning, the broad hands-on experience, apprenticeships and internships, and laboratory work.
2. *Commitment to excellence*—Comments on general excellence, excellence in research and teaching, depth of understanding, and high academic standards.
3. *Education in the service of pushing the boundaries of knowledge*—Comments on broad expansion of knowledge, as well as the advising and mentoring that enables students to pursue their own expansion of knowledge.
4. *Commitment to technical depth*—Comments on knowledge of fundamentals, basic principles, depth of knowledge, and technical focus.
5. *Leadership training, fostering teamwork, and developing communication skills*—Comments on leadership in science, technology, and society; teamwork; collaboration at all levels; and communication.
6. *Constant and widespread faculty-student interaction*—Comments on both the quality and quantity of faculty-student interaction, face-to-face conversations, and mentoring.
7. *Respect for truth above all other authority*—Comments on a general respect for truth as well as truth both within the scientific enterprise and outside it.
8. *Extensive curricular offerings*—Comments mention MIT's extensive curricular offerings across science and technology.
9. *Scholarship that will best serve the nation and the world*—Variety of comments on MIT's responsibility to serve the community, both locally and globally.
10. *Problem-solving skills*—Comments reference a variety of skills and approaches for problem-solving, both individually and in a group.
11. *Promoting diversity in all forms*—Comments that discuss diversity of thought, background, interests, etc.
12. *Interdisciplinary and collaborative teaching*—Comments mention MIT's interdisciplinary approaches to teaching, and collaboration between areas.

Question: If you could change up to three things about the way MIT educates its students, what would you change? Please list up to three.

The most common things to change (mentioned more than 20 times), included the following:

1. Focus the curriculum on applying skills and knowledge, hands-on experience

   "An increased emphasis on practical skills over pure theory."

   "More hands-on classes/opportunities to see real world applications (field trips outside of lecture)."

2. Emphasize faculty-student interaction, improve mentoring

   "Faculty/student interaction- increase for all, and make professors more visible and open to talking."

   "Improve mentoring skills of professors (some are great, some are terrible)."

3. Improve quality of teaching/innovate new methods and class structures

   "Require graduate TAs [teaching assistants] and PROFESSORS to take pedagogy courses."

   "Better training and screening for TA's, some TA's are incomprehensible and some don't care, possibly provide better incentives for TA's in general or for ability."

   "MIT feels like a research institute, not a university. Professors primary focus is not on education (even of their grad students); it is on getting high profile research results."

4. Increase focus on communication/teamwork/leadership skills

   "MIT needs to ensure its grads are good communicators. It hardly matters how good your work is, if you can't communicate it persuasively."

   "Adding more opportunities for leadership, teamwork, and communication development."

5. Make degree programs more flexible

   "Lessen the CI-H [Communication Intensive in the Humanities] requirement, to address quality over quantity."

   "Fewer GIRs [General Institute Requirements] and more opportunities to pursue a major starting freshman year."

   "Encourage self-driven learning more with personal project funding and resources."

6. Use more technology to facilitate learning, use existing technology more effectively

   "Lectures should be entirely online."

   "More on-line content: lectures, books etc."

7. Have more collaborative projects, encourage students to collaborate across disciplines

   "Allow for greater interaction across different hierarchical boundaries. I feel like there is a great disparity between faculty, graduate students, and undergraduate students."

   "More freedom in crossing the (often set by the departments) boundaries between the disciplines. Ability to start in one graduate program and finish in another. Ability to choose the number and extent of the subjects I'm curious about and not the ones dictated by the departments and degree requirements."

   "More space for collaborative work."

8. Balance/reconsider workload to reduce student stress

   "Developing a more healthy environment (aka, reducing stress and pressure)."

   "…it sometimes seems that students are driven past their reasonable limits or have such high expectations that students can't accept that failure happens."

9. De-emphasize large lectures

   "Less large hall lectures…more breakout sessions (particularly for undergrad classes)."

"Huge classes (mostly the GIRs) need more in regards to individual help. Recitations help, but this depends on the quality of the TA, size of recitation, etc."

10. Use technology appropriately and consider the impact

"Don't change for change's sake. Don't believe the digital learning hype and force it on students. I fear that all your talk about this will make you follow it up."

"Less reliance on lecture slides: slower paced lectures without slides, using chalkboards, and focused on student interaction are much more effective. Students can process what is being taught much more easily."

11. Add or increase emphasis on a specific program

"Add a full-fledged statistics department--yeah I know this is perhaps unreasonable to ask for, but I think it would do MIT a lot of good; at the very least, ensuring more students have a solid understanding of basic statistics is immensely helpful and applicable to everyday life."

"Require computer science coding requirement."

12. Emphasize student independence

"Trust the autonomy of students: their own ideas and process to get knowledge."

"MIT needs to think seriously about the 'exploration' vs. 'liability' problem. MIT is very liability-sensitive, to a point where it often prevents students from doing things that would help them learn. Someone needs to think seriously about what the right balance is here."

13. Adjust balance of psets (problem sets), projects, and exams

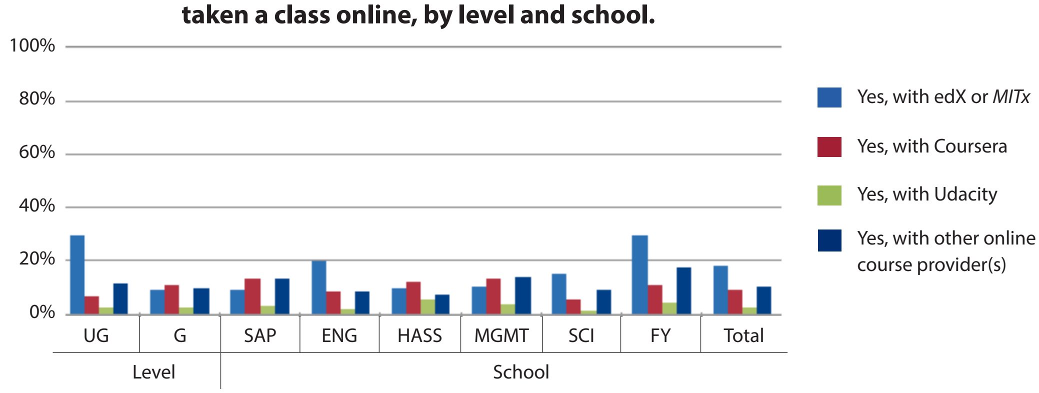
"Stop the "pset based learning". Putting the learning in a pset is not an excuse for poor teaching."

"Decrease the weight placed on exams in favor of psets and other non-time-constrained or collaborative assignments."

Online Classes

Students were asked whether they had taken a class online and, if so, on what platform. Roughly one third of undergraduates had taken a class via edX or *MITx*, while less than 10% of graduate students had used this platform.

Figure 3B.2. Survey respondents who have taken a class online, by level and school.

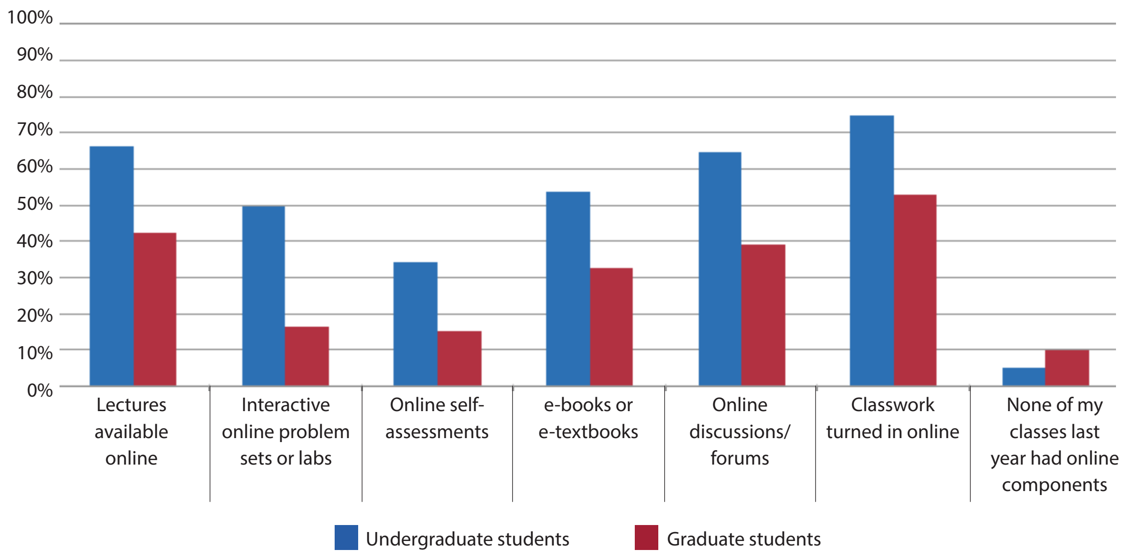


Tell Us about Your Classes

Students were asked about online components in classes they had taken in the past year, whether at MIT or elsewhere. Undergraduate students were much more likely to report that they had taken classes with online components, from classes with lectures available online to classes with online self-assessments to classes with online discussion forums. Overall, 5% of undergraduates and 10% of graduate students reported that none of their classes in the past year had online components.

Question: In the past year, did any of your classes (at MIT or elsewhere) include online components? Please check all of the features your classes included and enter any we missed.

Figure 3B.3. Percentage of students whose 2012–2013 classes included online components

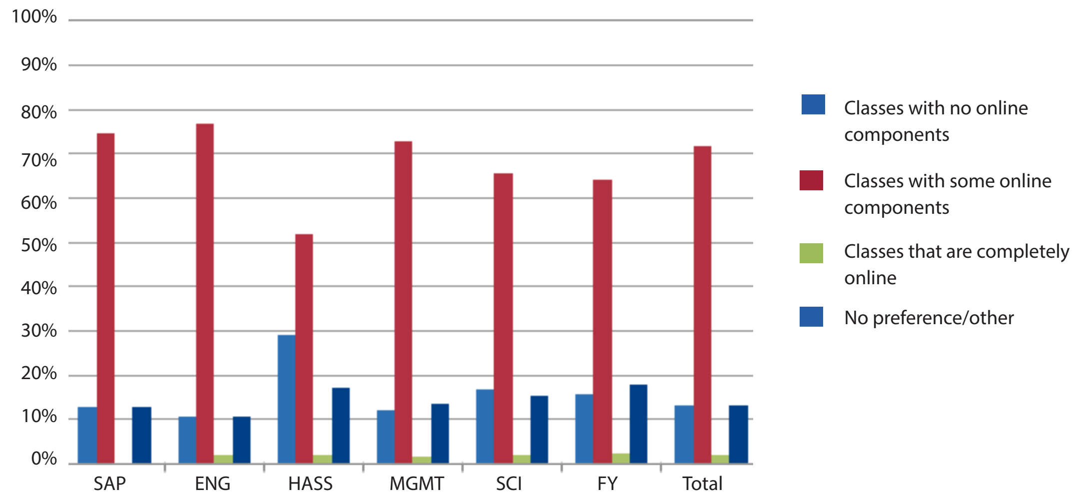


Learning Environments

Students reported that they both preferred—and learned more in—classes with a combination of online and in-person components. While there was little difference between undergraduate and graduate students, preferences varied significantly across schools. More students in the School of Humanities, Arts, and Social Sciences felt that they learned most in classes with no or some online components. Students in the School of Engineering, however, were more comfortable than their peers by a statistically significant margin with classes that were entirely or partially online. No students from the School of Architecture and Planning reported that they learned most from classes conducted completely online, but this difference was not statistically significant; this is likely a result of the small number of responses.

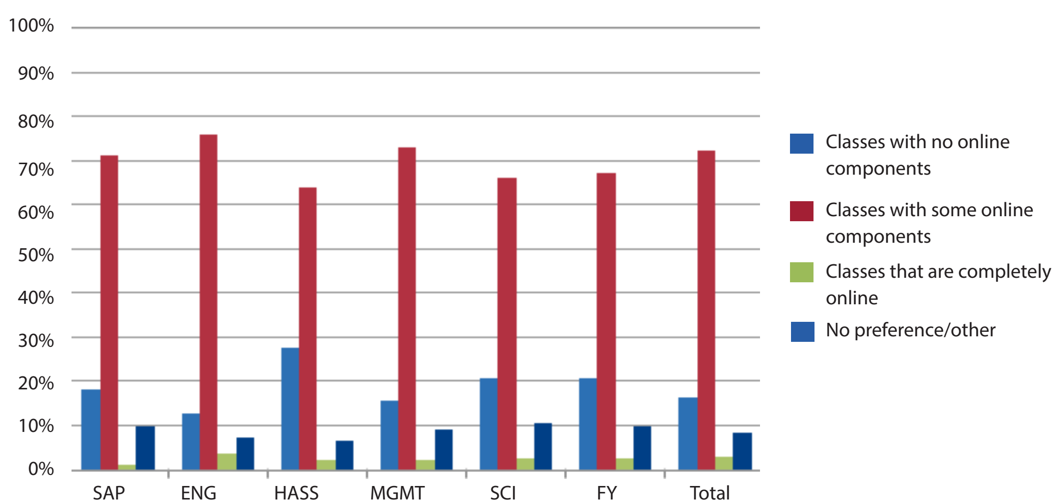
Question: Below are a few ways of describing the ways in which students are taught. In what type of learning environment do you tend to learn the MOST?

Figure 3B.4. Environments in which students report learning the most



Question: In general, what type of learning environment do you PREFER?

Figure 3B.5. Students' preferred learning environments



Question: Do you have suggestions for 1-2 types of space MIT could provide (within reason) to help MIT students learn, communicate, and develop professionally?

A total of 309 comments were collected from students. Comments were assigned to categories by theme, seven of which included 10 or more comments. These are listed below, along with specific suggestions or highlights.

1. Group workspaces (54 comments)

   "More rooms indoors with tables and whiteboards that are clean and nice. More seating areas inside in open spaces where people can work but where people are also allowed to talk (i.e., not a library)."

2. Additional/improved individual study spaces (47 comments)

   "There is nowhere private to go on campus unless you are a professor with your own office. Rooms for private contemplation or quiet study for graduate students would be immeasurably helpful."

   "Allowing access to MIT classrooms (that are not reserved by faculty) after hours is really nice."

3. Pleasant workspaces/lounges (35 comments)

   "Lounges for every major / "hackerspace" with cool technologies like a LeapMotion, KINECT, myo, Oculus rift etc where students from different disciplines can collaborate. Similar to Harvard's i-lab, but more casual than the Martin Trust Center."

4. Meeting spaces (16 comments)

   "More large conference rooms, preferably mostly soundproof, as opposed to those in the 5th floor of the student center."

   "Meeting places near food but with places for computers/plugs/wifi are good for informal meetings."

5. Restaurants/dining spaces (16 comments)

   "The bars could do with some work and proper thought."

   "Can we have a more inviting coffee shop? Some people like very silent workspaces, others need some festivity to the environment."

6. Computing space (15 comments)

   "Make Athena clusters more hospitable and useful collaborative spaces. Their purpose is a little outdated and they need to evolve."

7. Library expansion/improvement (10 comments)

   "Places like libraries where people could go and study with the added bonus of being able to talk there. They could be more like centers of meeting without having to decide on a dorm or coffee shop to meet in."

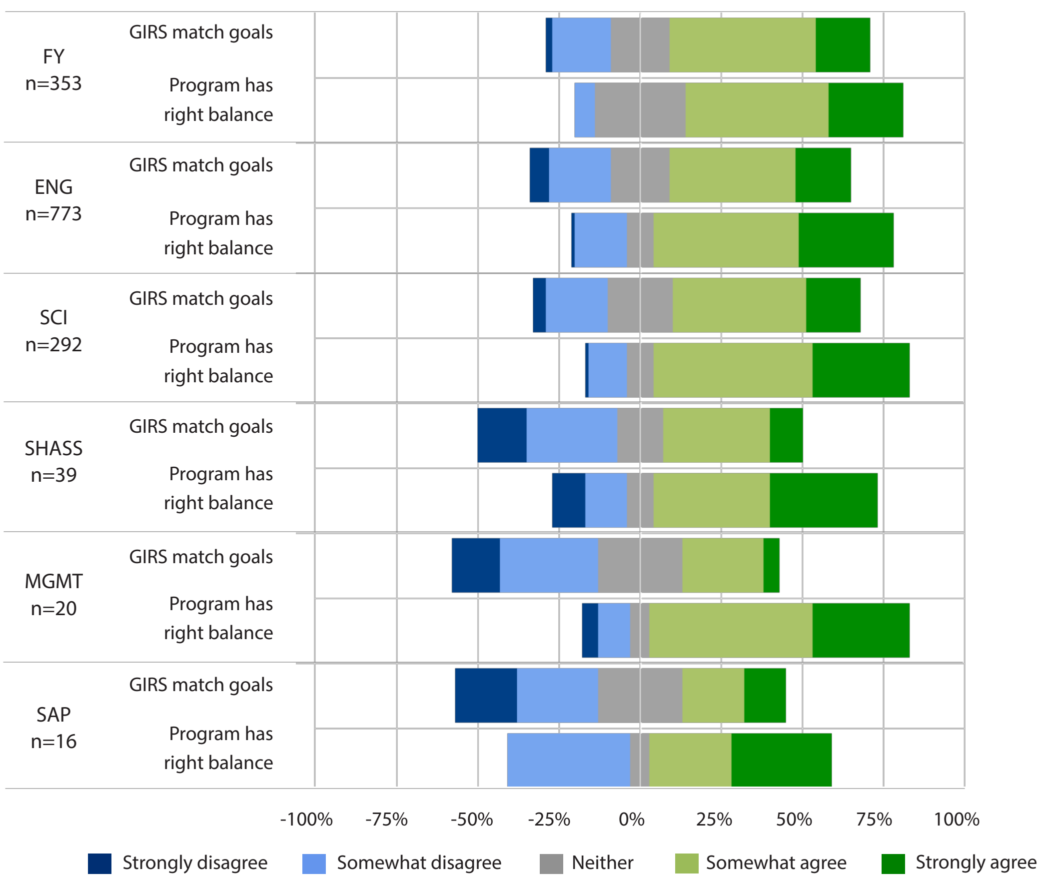
   "Libraries open later."

Requirements and Flexibility

Undergraduate students were asked to indicate their level of agreement with the two statements below. In general, students from three schools (SHASS, Sloan, and SAP) were less likely to agree or strongly agree with the statement that the GIRs matched their educational goals at MIT, though this may have been a function of a relatively small sample size.

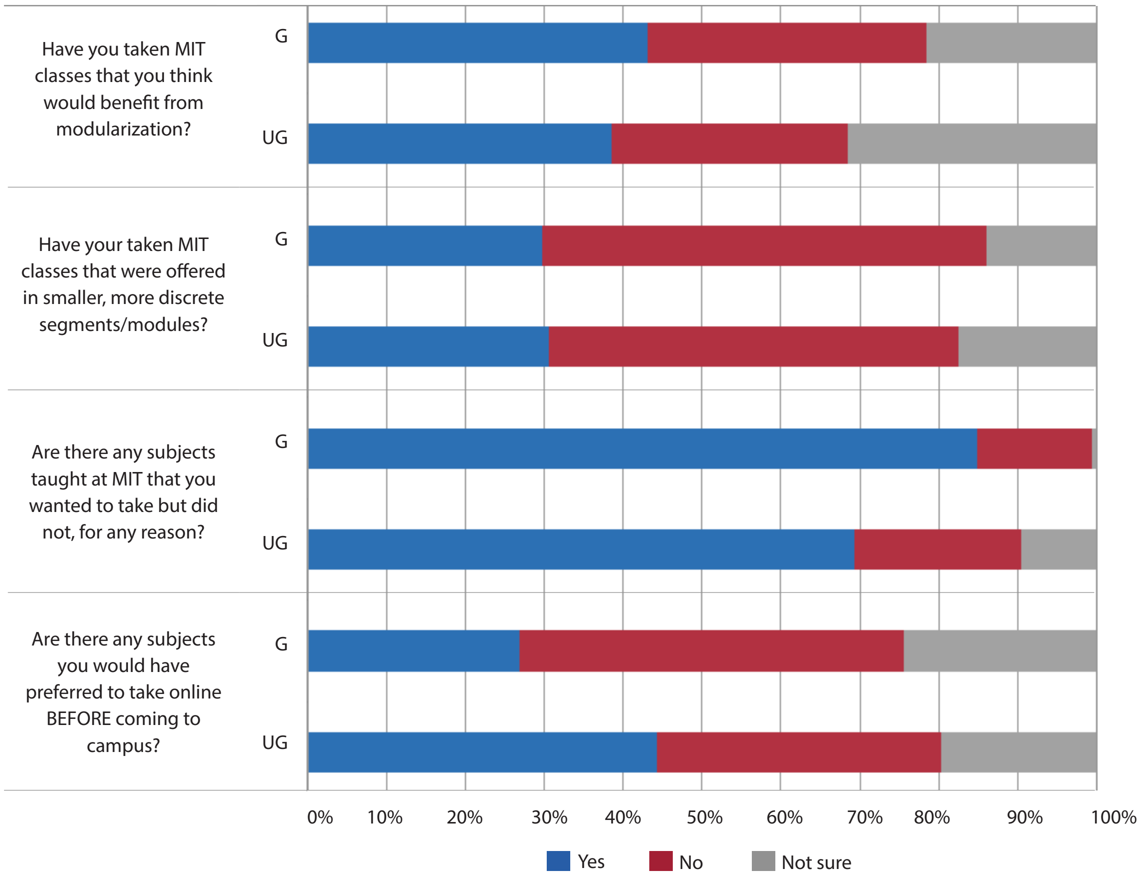
Question: Part 1—The options available to me in the General Institute Requirements match my educational goals at MIT. Part 2—My chosen MIT degree program has the right balance of general institute requirements, departmental requirements, hands-on classes, and elective opportunities.

Figure 3B.6. Student agreement that General Institute Requirements match education goals and that degree program has right balance of requirements and electives



One of the key areas explored by the Task Force is flexibility in the curriculum. More than two thirds of both undergraduate and graduate students responded that there were subjects taught at MIT that they wanted to take but did not. More than 40% of undergraduate students suggested that there were subjects they would have preferred to take online before coming to campus. Students were less certain about modularity: about 30% of both undergraduate and graduate students reported having taken classes offered in modular format. About 40% of students reported having taken classes that could benefit from modularization, but nearly a third of students responded that they were unsure if they had taken any such classes.

Figure 3B.7. Students' experience with and opinions about modular classes

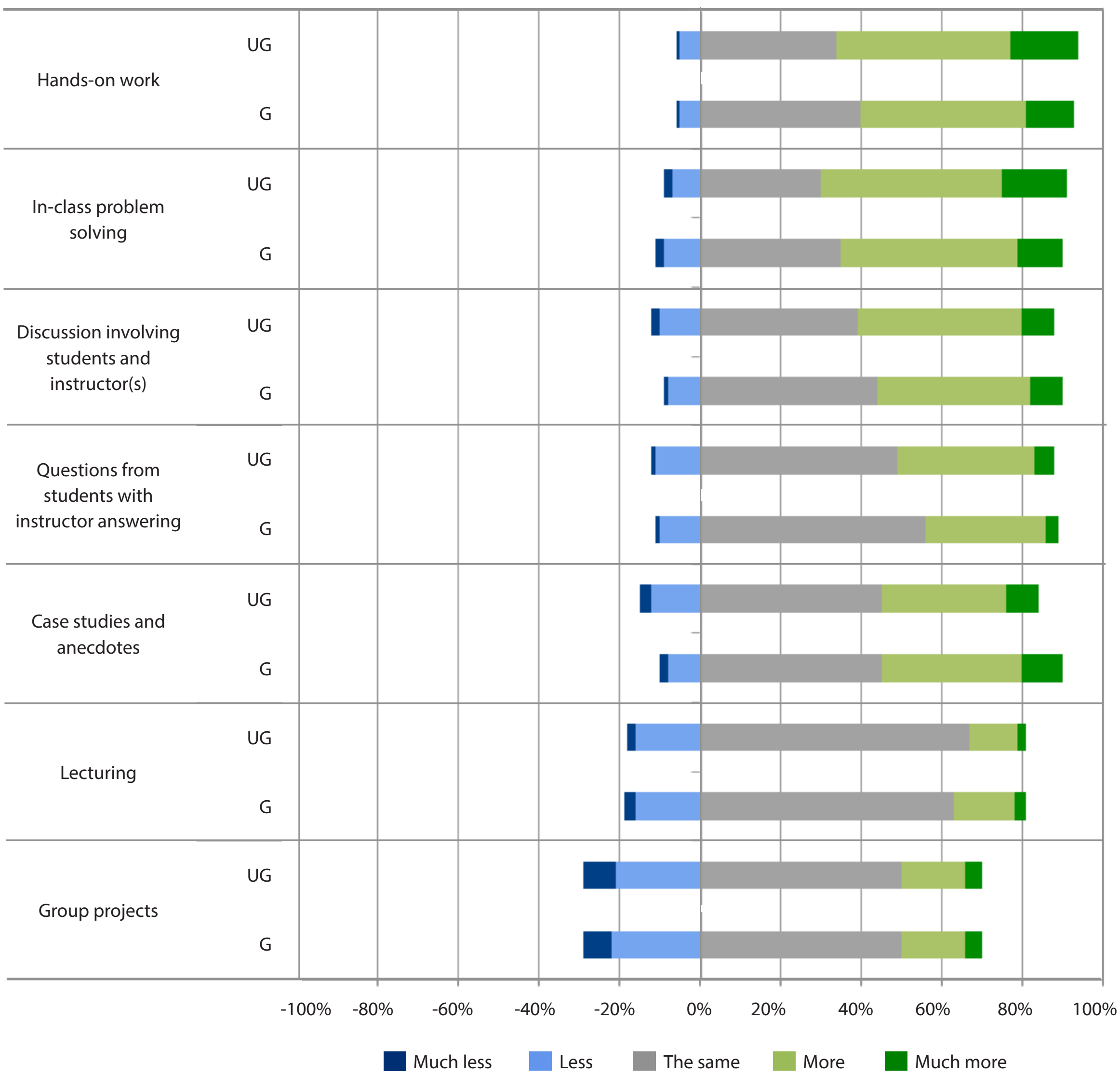


Time in Class

When asked how they would change the way faculty and instructors spent time in class, students were most likely to respond that they would like more time spent on hands-on work, in-class problem solving, and discussion. On average, students were satisfied with the amount of time spent on lectures, but approximately one third of undergraduates and graduate students reported that they would like less time spent on group projects.

Question: Generally, which of the following would you like faculty and instructors to spend more or less time on during scheduled class time?

Figure 3B.8. Students' preferences for how faculty and instructors should spend scheduled class time



Faculty-Student Interaction

Question: Do you have any suggestions for how MIT can increase opportunities for faculty and student interaction?

A total of 326 comments were collected from students. Comments were assigned to categories by theme, five of which included 10 or more comments. These are listed below, along with specific suggestions or highlights.

1. Meals/social events (156 comments)

   "Building things together—I would love to make robots or machine things with faculty and other students."

   "Sponsor faculty seminars for mostly-student audience in each department. Food/drink after the talk will help in socializing. Maybe have 2-3 faculty present brief talks."

   "Bar nights with faculty."

   "I think the "Take faculty to dinner" program is awesome. But it only allows students to do this once per semester. Making it available to students for more than once per semester would be great."

2. Faculty sharing research, involving students (27 comments)

   "My department (EAPS [Earth, Atmospheric, and Planetary Sciences]) has taken a fantastic action, which is to require that faculty members who give a talk at the bi-weekly faculty meeting must also present the same talk independently to an all-graduate-student group. We're optimistic that this will be a fantastic educational experience!"

   "Faculty offer short-term projects to interested students (not just UROP) related to their work during summer or IAP."

   "Professor should give presentations of the work they do, in a simplified way/intro course. This would encourage students to be curious about other [professors'] work, and encourage people to ask questions, even simple, on how they could use it for their research."

3. Increased face-to-face time (25 comments)

   "Mandatory Faculty mentorship, must meet no less than 6 times per year."

   "Encourage faculty to have official 'student-time' slots when students can pop in at any time to talk."

4. New ways to facilitate communication (11 comments)

   "Common website to post office hours of every instructor and allow to also attend those hours through Skype or Google hangout."

   "Making office hours at more convenient times for students would be good."

5. Informal interactions (10 comments)

   "I think the best interactions are casual and informal. It would be really too bad if comments from this survey forced faculty to do some kind of mandatory interactions."

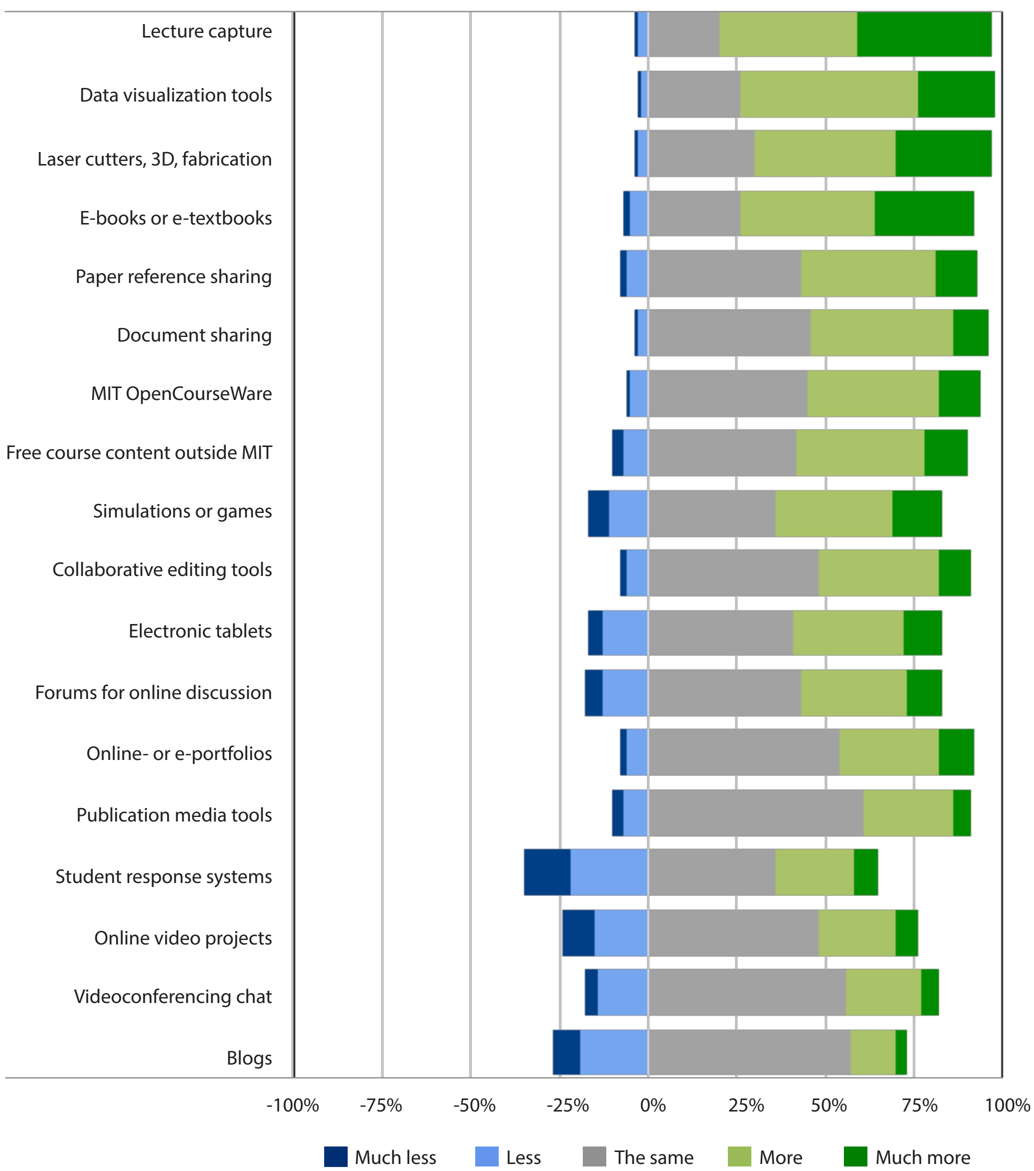
   "Have shared spaces for graduate students and professors in departments for heating up food, getting hot water, etc."

Educational Technologies, Tools, and Methods

When asked about the frequency of use of certain technologies, tools, and methods, students were strongly in favor of increasing the frequency of use of lecture capture, e-books and e-textbooks, data visualization tools, and 3D fabrication tools. Responses were mixed on the use of student-response systems (e.g., "clickers"), online video projects, videoconferencing, and blogs.

Question: Generally speaking, which technologies, tools or methods do you wish were used LESS or MORE at MIT?

Figure 3B.9. Student preferences for use of educational technologies, tools and methods



Question: Thinking about how education has evolved, what 2-3 technologies, tools, or methods could MIT provide students that you would find most useful? Please include technologies that could be used to learn, teach, advise, conduct research, or in student activities, and be as specific as possible.

This question elicited a response from 32% of survey participants, with the 10 most common themes listed below:

1. Lecture capture

   "What's most helpful to me is to not have to stress if I'm sick and I can't make a lecture. Videotaping lectures and making as much as possible available online is most important to me, even though I prefer going to lectures in person."

   "I think a captioned version of the lectures, if possible would be awesome, as well as pictures of what the professor wrote. This should probably be posted after each lecture, not before, to encourage attendance while still allowing students to have resources before a test or pset."

2. E-textbooks or free textbooks

   "Having all text books online and searchable would be very useful as would being able to watch videos of lectures after the fact."

   "Online access to textbooks—most books are way too expensive."

3. Educational or subject-specific software

   "This category included a variety of suggestions for specific software packages that, if made available, would enhance the learning experience in certain classes, departments, or the undergraduate experience as a whole.

4. Tablets

   "Taking notes on tablets directly onto lecture slides might be really awesome. I see some kids doing that and it seems really useful."

   "Because I often lose the notes I take in class, having a tablet to write with during lectures would be useful for me. Currently if I try to take notes on my laptop I have a hard time because I have to type everything, and that becomes impossible when I take equation-heavy courses."

5. Collaborative/searchable online information repository

   "MIT should develop more interactive and intuitive systems for the most efficient transfer of conceptual and technical knowledge with easily accessible resources for subsequent reference."

   "An electronic database that could contain materials such as textbooks for free, collaborations on new ideas and research; i.e. a sort of cloud system, and more open sourced software that aids students."

6. Clickers or fast-feedback tools

   "I would like to see more advanced variants of clickers, things that allow graphical (drawn) or open-ended responses."

   "Loaned student response systems (they're expensive)!"

7. Website updates/improvements

"I think many of MIT's professors need to update their websites. These are the initial sources of contact for students to find potential advisors and the current websites do an extremely poor job reflecting the true research interests and group dynamics of a professor."

"A smoother and more refined website for classes that is centralized. Mobile websites that offer the functionality of the desktop sites."

8. Virtual discussion forums

"Online forums could be valuable if used more often to ask questions. Often the TA will give feedback to students on problem sets during office hours and that feedback never gets distributed widely, forcing some students to waste a lot of time on poorly written problem questions for example."

"Better forums for general academic advice and mentorship would be nice. Online facilities for peer tutoring and finding study groups would be useful. Stellar works well for managing course materials, but there's a lot of room for improvement."

9. Integration of OCW/EdX

"OCW or youtube videos like Khan Academy PREVIOUS to the class."

"MIT EdX or OCW with lectures and self-assessment problems. So far in 3.091 this has been really useful when I am confused after a lecture to review it."

10. Broader literacy in programming skills

"Equipping everyone with basic programming skills is what I feel is a priority."

Question: Do you have any suggestions for tools that could create or improve opportunities to communicate and network with others at MIT and individuals outside MIT?

This question elicited a response from 11% of survey participants, with the five most common themes listed below:

1. Events/meals

"Student-Faculty Dinners! Professor research presentation days (where professors are able to share their research with the school). Hacking events in all fields (including EECS [Electrical Engineering and Computer Science], but not limited to it), where professors and students work in teams or professors/TAs/Grad students/Alum advise!"

"It would be great to be able to mix more with other MIT faculty outside of classes, more sort of MIT conference style knowledge sharing social events."

2. Virtual discussion forums

"Class mailing lists are under-utilized. I would love to see an MIT alternative to virtual collaboration tools that worked with Athena and was private/free-as-in-speech."

"Actually, I think we've got a great tool that is highly under-utilized: Stellar forums. I've only taken one or two classes where this was utilized to its potential for enriching discussion and answer class questions efficiently."

3. Long-distance communication tools

"Emphasis on video conferencing and collaborative documents—simulate face-to-face contact as closely as possible for those not on campus."

"It should be a mix between text messages and email. Somewhere where you can share files, have different groups for conversations, and it's not so intense as sending multiple text messages."

4. Collaborative spaces

"Having physical spaces that were designed to be hubs or places to go if you had down time and needed to do work. That way if you saw someone you knew there you could go over and talk or study together. You could choose to be alone or socialize."

"Need more breakout rooms/study rooms for small groups and teams."

5. Google tools or similar resources

"Something like Google Docs, but with Latex support (not the lame equation thing they have now), and that would show what a paper looks like in compiled form."

"I used Google Hangouts for a lot of my groupwork last semester. It wasn't always a perfect substitute for in-person meetings, but I think it was better than in-person meetings when we needed to be collaborating on documents--we could see each other and the document(s) all at the same time."

Question: How do you feel digital learning could benefit you as you study or do research?

This question elicited a response from 37% of survey participants, with the 10 most common themes listed below:

1. Review/supplemental material

"I could re visit any areas of doubt or uncertainty in difficult subjects."

"So far, for 18.03 [Differential Equations], having online courseware materials helps since it runs concurrent with the class/psets. Whenever I am stuck on something, I can quickly consult the courseware to see what I am missing."

2. Navigable resource/reference/repository of information

"Can reduce time for literature review and initial research stages when effective information search techniques are used."

"Great way to reduce paper waste, easier to carry around textbooks, easier to have a wide range of knowledge easily accessible at your hands."

3. Flexibility of physical location/time

"Digital learning reduce the spatial and temporal barrier in interacting with people you want to study/do research with."

"Digital tools allow me to choose when I am most able to learn or study. I have to go to lectures at specified times, whether I am tired/sick/unfocused or not. If the lectures were recorded and put online, I could watch them whenever I felt most prepared to absorb or review the information."

4. Not at all, unsure, not very much, or N/A

   "Only to a certain degree. Actual in-person classes and labs are a lot more efficient."

   "I personally don't like digital learning, so students should have the option of sticking with traditional lectures and paper textbooks."

5. Modularity/access to bite-sized concepts

   "There are many computational-skill-related subjects that I would have liked to learn, but no longer have time to now that I am in the lab doing research all of the time. If there were good online lectures available I might be better able to squeeze in more learning around experiments, as I do not have time to take physical classes."

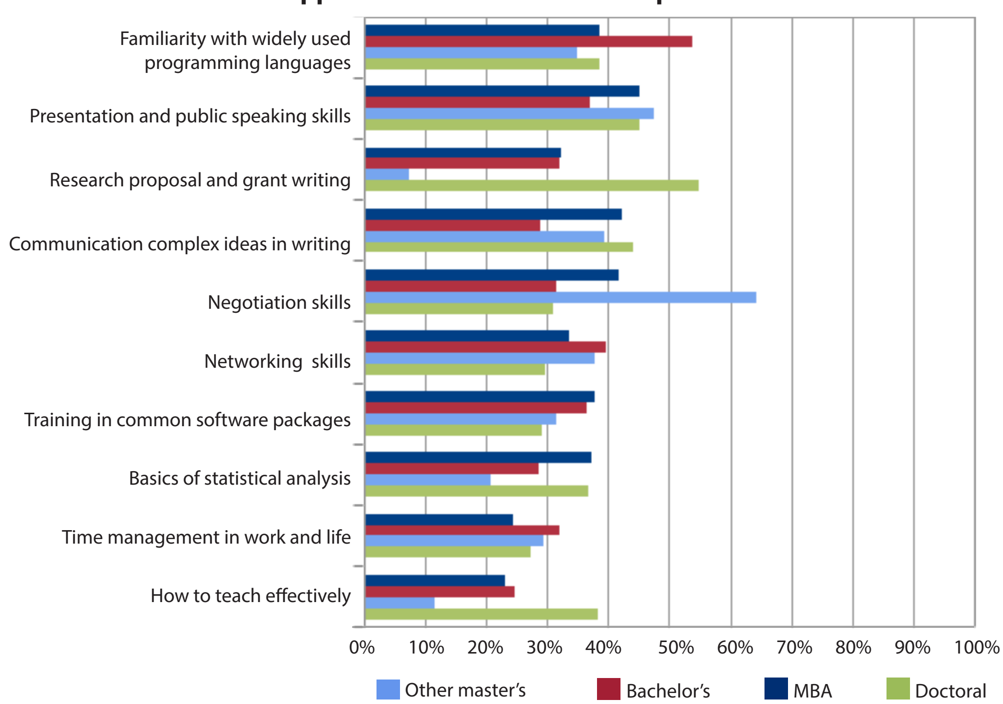
   "It would be useful for learning subjects that you can't take the actual classes for."

Opportunities for Further Development

Students were asked whether they would like opportunities to develop skills in a variety of areas. Responses varied significantly by the type of degree program in which the respondent was enrolled. For example, more than 60% of respondents in the MBA program reported that they would like more opportunities to develop negotiation skills, while this was of interest to approximately 30% of students in other programs. Doctoral students responded in significantly larger fractions that they wanted opportunities to learn research-proposal and grant-writing skills as well as teaching skills. Overall, the largest proportion of students reported that they wanted to develop a greater familiarity with widely used programming languages.

Question: In which of the following areas would you want more opportunities to develop your skills?

Figure 3B.10. Areas in which students want opportunities to further develop their skills



Appendix 4. summer@ future Program

Building on the work of the Institute-wide Task Force on the Future of MIT Education, and in collaboration with the Office of Digital Learning, MIT launched the summer@ future program, which offered five classes for credit on an experimental basis in 2014. The classes represent another step in the exploration of opportunities to enhance the residential learning experience with online educational materials and blended learning models. Only registered MIT students were eligible to participate in the program this summer. To encourage participation during this pilot experience, both the tuition for these classes and the on-campus housing were fully subsidized for registered students. There was significant interest in the program, and 129 students (113 undergraduates and 16 graduate students) participated this summer.[1]

The summer@ future program has achieved several milestones since it launched on March 20, 2014. A number of individuals from across MIT have enabled the program, including those from the Office of the Dean for Student Life, the Registrar's Office, Housing, Student Financial Services, and Institutional Research, among others. In the following sections, we present information and data to illustrate each of the following: announcement and initial interest (March 20); application process (April 8); selection process (April 30); and registration (June 6).

Table 4.1. Student application and registration data for inaugural summer@ future classes, 2014.

Class	Initial submissions	Applications	Students accepted	Students registered
2.S03 Special Subject: Dynamics I	128	65	63	50
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	96	46	20	10
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	112	56	20	13
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	179	109	40	36
8.371J Quantum Information Science II	54	23	22	20
Total	**569**	**299**	**165**	**129**

*U = Undergraduate-level class; G = Graduate-level class

Announcement and initial interest

Chancellor Cynthia Barnhart announced the program to all MIT students on March 20. In her email, the chancellor briefly introduced the summer@ future program and invited all interested students to complete the sign-up form available on the summer@ future site (http://future.mit.edu/summer-future). In the sign-up form, students were asked to share personal information

[1] Student enrollment data is accurate as of June 30, 2014.

about themselves (name and email) and their status at MIT (course of study[2], type of student, and expected graduation year); the classes they were interested in taking; and their housing needs.

Table 4.2. Details of summer@ future classes, 2014.

Class (lms.mitx.mit.edu/courses)	Faculty and instructors	Units	Initial capacity
2.S03 Special Subject: Dynamics I	Sanjoy Mahajan	6	25
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	Elsa Olivetti, Alexie Kolpak, Yuriy Roman	9	15
7.S390 (U) 7.S930 (G) Special Subject in Biology (Creating Digital Learning Materials for Biology*	Mary Ellen Wiltrout, Nathaniel Schafheimer, Sera Thornton	6	20
7.S391 (U) 7.S931 (G) Special Subject: Quantitative Biology Workshop*	Mary Ellen Wiltrout, Nathaniel Schafheimer, Sera Thornton	4	25
8.371J Quantum Information Science II	Isaac Chuang	12	25

*U = Undergraduate-level class; G = Graduate-level class

Submissions

There was significant interest in the program. On the first day of sign-ups, 160 students completed the form, and there was both sustained and moderate interest during the following weeks. We received 347 submissions from March 30 to April 15, from students who expressed interest in taking one or more classes.

Number of students

Of the 347 students who signed up for summer@ future classes, 60 were graduate students (17%) and 287 were undergraduate students (83%). These students came from almost every course of study, with the greatest participation from Course 6, Electrical Engineering and Computer Science (74 students) and Course 2, Mechanical Engineering (61 students).

[2] Courses of study at MIT are designated by the term, "Course," with an initial capital.

Table 4.3. Distribution of students signed-up for summer@ future classes, by Course.

Course	Number of students
1 Civil and Environmental Engineering	8
2 Mechanical Engineering	61
3 Materials Science and Engineering	18
4 Architecture	3
5 Chemistry	10
6 Electrical Engineering and Computer Science	74
7 Biology	39
8 Physics	26
9 Brain and Cognitive Sciences	7
10 Chemical Engineering	22
11 Urban Studies and Planning	0
12 Earth, Atmospheric, and Planetary Sciences	1
14 Economics	3
15 Management	12
16 Aeronautics and Astronautics	9
17 Political Science	0
18 Mathematics	16
20 Biological Engineering	19
21 Humanities	0
22 Nuclear Science and Engineering	2
24 Linguistics and Philosophy	0
CMS Comparative Media Studies	1
CSB Computational and Systems Biology	1
ES Experimental Study Group	1
ESD Engineering Systems Division	6
Freshman/Alumni Internship Program	2
HST Health Sciences and Technology	1
Other	5
Total	**347**

Housing needs

Students were asked if they needed on-campus housing over the summer. Two hundred eighty-six students indicated that they were interested in housing, 32 students indicated that they were not interested in housing, and 29 students said that they were not sure about housing.

Year of gradaution

The majority of the students who signed up for summer@ future classes were undergraduate students who expect to graduate between 2015 and 2017. A few undergraduate and graduate students graduating in 2014 indicated interest in summer classes.[3]

Table 4.4. Type of students who signed up for 2014 summer@ future program, and expected year of graduation.

Graduation year	Undergraduates	Graduates	Total students
2014	13	11	24
2015	71	17	88
2016	101	4	105
2017	95	4	99
2018	0	5	5
2019	0	2	2
Other	7	17	24
Total	**287**	**60**	**347**

Number of classes per student

Many of the 347 students who signed up for summer@ future classes expressed interest in taking multiple classes. The majority were interested in one or two classes, and only a few in three, four, or five classes.

Table 4.5. Number of classes that 2014 summer@ future program students signed-up for.

Number of classes	Number of students	Total number of submissions
Five	4	20
Four	4	16
Three	30	90
Two	134	268
One	175	175
Total	**347**	**569**

[3] Students who graduated in June 2014 were eligible to participate in the summer@ future classes if they were continuing a graduate program in fall 2014 and they were also able to register early as graduate students.

Number of students who signed up for each class

Of the 569 submissions received, most were for 7.S391 (U)/7.S931 (G) Special Subject in Biology: Quantitative Biology Workshop (31%), but other classes received significant submissions as well. As seen in Table 4.6, the number of submissions exceeded the initial capacity of the classes by more than 500%. In some cases, the initial class capacity was exceeded by more than 700%, which was the case for 7.S391 (U)/7.S931 (G) Special Subject in Biology: Quantitative Biology Workshop, which received 179 submissions for a capacity of 25 students.

Table 4.6. summer@ future class capacity and sign-ups, by type of student, 2014.

Class	Capacity	Undergraduates	Graduates	Total	Percentage
2.S03 Special Subject: Dynamics I	25	106	22	128	22%
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	15	77	19	96	17%
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	20	96	16	112	20%
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	25	157	22	179	31.5%
8.371J Quantum Information Science II	25	34	20	54	9.5%
Total	**110**	**470**	**99**	**569**	**100%**

*U = Undergraduate-level class; G = Graduate-level class

Application process

Given the number of sign-ups received during the initial phase, an additional application process was established to allow faculty to select the students in each of their classes. The enrollment capacity of some of the classes was also increased to accommodate more students. In all, the total capacity of the summer@ future program was increased to 200 students (Table 4.7).

Table 4.7. Initial and extended enrollment capacities of summer@ future classes, 2014.

Class	Initial capacity	Extended capacity
2.S03 Special Subject: Dynamics I	25	75
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	15	20
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	20	20
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	25	40
8.371J Quantum Information Science II	25	45
Total	**110**	**200**

*U = Undergraduate-level class; G = Graduate-level class

An application/survey was designed with the help of MIT's Institutional Research Office. The first part of the application was mandatory for students who wished to enroll in a summer@ future class, and the second part was intended to understand what motivated students to participate in the summer@ future program and their preferences for future summer session classes. This application was sent on April 8 by the Task Force co-chairs to all 347 students who completed the sign-up form. Two reminders were also sent on April 11 and April 15. The last applications were received on April 22.

Information about the applicants

Students were asked to write a short paragraph describing why they wished to enroll in the particular class and to acknowledge its prerequisites. The students were told that their responses would help faculty determine who would be accepted, especially in cases where demand for a particular class exceeded the number of students that the program was able to accommodate. The applicant information follows.

Number of students

A total of 207 students (60% of the total of students who received the application) applied for summer@ future classes; 23 (11%) were graduate students and 184 (89%) were undergraduate students.[4] Applicants came from a number of courses of study, the greatest number of which from Course 6, Electrical Engineering and Computer Science (44 students); Course 2, Mechanical Engineering (33 students); and Course 7, Biology (25 students).

Even though general response to the program remained high, we observed a decrease in the number of applications from departments that had the highest numbers of sign-ups, namely Course 6 (44 versus 74) and Course 7 (33 versus 61), from which the majority of sign-ups initially came. Submissions from other Courses, such as Course 15, Course 1 and Course 8, decreased as well.

[4] The real number of students who applied using the online survey was 204. Three additional students submitted paragraphs via email directly to the faculty of 2.S03, and were accepted to the class. Those three students didn't submit the survey (second part of the application).

Table 4.8. summer@ future program preliminary sign-up and final application numbers, by Course, 2014.

Course	Sign-ups	Applicants
1 Civil and Environmental Engineering	8	4
2 Mechanical Engineering	61	33
3 Materials Science and Engineering*	18	13
4 Architecture	3	1
5 Chemistry	10	9
6 Electrical Engineering and Computer Science	74	44
7 Biology	39	25
8 Physics	26	18
9 Brain and Cognitive Sciences	7	5
10 Chemical Engineering	22	15
11 Urban Studies and Planning	0	0
12 Earth, Atmospheric, and Planetary Sciences	1	0
14 Economics	3	2
15 Management	12	2
16 Aeronautics and Astronautics	9	6
17 Political Science	0	0
18 Mathematics	16	10
20 Biological Engineering	19	11
21 Humanities	0	0
22 Nuclear Science and Engineering	2	0
24 Linguistics and Philosophy	0	0
CMS Comparative Media Studies	1	1
CSB Computational and Systems Biology	1	0
ES Experimental Study Group	1	0
ESD Engineering Systems Division	6	3
Freshman/Alumni Internship Program	2	1
HST Health Sciences and Technology	1	1
Other	5	3
Total	**347**	**207**

Housing needs

Of the 207 students who applied for summer@ future classes, 182 indicated that they were interested in housing, 12 students indicated that they were not interested in housing, and 13 students said that they were not sure. Even though the total number of applications decreased by 40%, the percentage of students who indicated a need for housing (88%) was higher than those who did not or were unsure.

Graduating year

The majority of the students who applied for summer@ future classes were undergraduate students who expect to graduate between 2015 and 2017.

We observed that the percentage of students from different graduating years changed very little from the sign-up period to the time of the application process.

Table 4.9. Students who signed up versus students who applied for 2014 summer@ future classes, by year of graduation.

	Signed up		Applied	
Graduation year	**Number of students**	**Percentage**	**Number of students**	**Percentage**
2014	24	7%	13	6%
2015	88	25%	47	23%
2016	105	30%	68	33%
2017	99	29%	61	29%
2018	5	1%	4	2%
2019	2	1%	1	1%
Other	24	7%	13	6%
Total	**347**	**100%**	**207**	**100%**

Number of classes per student

The 207 students who applied for summer@ future classes expressed interest in 299 different classes. Most were interested in one class, with fewer interested in two or three classes. Only one student applied to five classes.

Table 4.10. Number of classes selected by students who signed up versus students who applied for summer@ future classes, 2014.

	Signed up		Applied	
Number of classes	**Number of students**	**Total**	**Number of students**	**Total**
5	4	20	1	5
4	4	16	0	0
3	30	90	18	54
2	134	268	52	104
1	175	175	136	136
Total	**347**	**569**	**207**	**299**

Number of students who applied to each class

Of the 299 applications, most students continued to be interested in 7.S391 (U)/7.S931 (G) Special Subject in Biology: Quantitative Biology Workshop; they submitted 109 applications to this class, which exceeded its capacity by more than 250%. The number of applications for 3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy, and 7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology also exceeded their enrollment limits. The number of applications for 2.S03 Special Subject: Dynamics I and 8.371J Quantum Information Science II was significant, but less than the maximum capacity.

Table 4.11. Enrollment statistics for summer@ future classes, 2014.

Class	Extended capacity	Total applicants	Percentage	Graduates	Undergraduates
2.S03 Special Subject: Dynamics I	75	65	22%	60	5
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	20	46	15%	41	5
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	20	56	19%	52	4
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	40	109	36%	102	7
8.371J Quantum Information Science II	45	23	8%	14	9
Total	**200**	**299**	**100%**	**269**	**30**

*U = Undergraduate-level class; G = Graduate-level class

Even though the numbers decreased by 40% from the initial form to the official application, interest in the different classes changed very little.

Table 4.12. Students who signed up versus students who applied for 2014 summer@ future classes, by class.

	Sign-up form		Application	
Class name	**Total**	**Percentage**	**Total**	**Percentage**
2.S03 Special Subject: Dynamics I	128	23%	65	22%
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	96	17%	46	15%
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	112	20%	56	19%
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	179	31%	109	36%
8.371J Quantum Information Science II	54	9%	23	8%
Total	**569**	**100%**	**299**	**100%**

*U = Undergraduate-level class; G = Graduate-level class

Application survey

A short, anonymous survey was also sent to the students. The survey included a few questions to help us understand what motivated students to sign up for the different classes, and their preferences regarding format (online/blended) and type of classes to be offered in future summer sessions. Students were reassured that responses to the survey were confidential and would not affect their chances of being accepted.

Once again, the students demonstrated great interest in the summer@ future experimental program, as well as future summer programs. Almost all of the students who submitted the mandatory application also submitted the optional survey. The survey yielded 203 responses, 180 from undergraduates (88.7%) and 23 from graduate students (11.3%).[5]

Motivation to join the program

From a number of options, students indicated their motivations for signing up for the class(es) that they chose:

1. Tuition and housing subsidies: 74% of the students selected “subsidized summer housing,” and 60% indicated that they wanted the “opportunity to earn credits at no financial cost”
2. Academic opportunities: 72% selected “exploring a new fields,” and 39% indicated that they were interested in “advancing towards degree”
3. Existing summer plans: 70% indicated that they were “already planning to be in Cambridge over the summer and wouldn’t mind taking a summer class”
4. Social: 16% of the students indicated that “a friend also plans to take the class”

[5] The details of the expected year of graduation and course of study for those 203 students are not included, as that information is almost the same as the applicant information at the beginning of the session.

Table 4.13. Students' stated reasons for applying to summer@ future classes, 2014.

Reason	Number of respondents	Percentage of respondents
Subsidized summer housing	151	74%
Exploring a new field	147	72%
Already planning to be in Cambridge over the summer and wouldn't mind taking a summer class	142	70%
Opportunity to earn credits at no financial cost	121	60%
Advancing progress toward degree	80	39%
A friend also plans to take the class	33	16%
Other	25	12%

Twenty-five students shared "other" reasons for applying to the summer@ future classes, including interest in learning about new topics or fields, gaining an understanding of the world, gaining programming skills while registered in Course 6, preparing for academia, contributing to MIT's educational initiatives, expressing an interest in MIT's online classes, advancing research, taking the class before graduating, and raising their GPA.

Applying to one class only

When asked why they chose not to apply for more than one class, 125 students shared a variety of reasons. In most cases, students mentioned that previous commitments (Undergraduate Research Opportunity Program [UROP], research, work, personal, etc.) did not allow them to apply to more than one class over the summer period. Fifty-four (43%) of the students mentioned that only one class was of interest or relevant to them. In some cases, students mentioned that the offerings were limited.

Table 4.14. Students' stated reasons for applying for only one 2014 summer@ future class.

Reason	Number of respondents	Percentage
Only one class was of interest/relevant (five indicated classes were limited)	54	43%
Doing a UROP	36	29%
Only qualified for one class	17	14%
Doing research over the summer	9	7%
Work	4	3%
Family or other personal commitments	3	2%
Made a mistake	1	1%
Hard to plan without knowing the workload	1	1%
Total	**125**	**100%**

Staying in Cambridge over the summer

Of the 203 students who completed the survey, 140 indicated that they were already staying in Cambridge over the summer. When asked to describe what they planned to work on in addition to their summer@ future class, the majority answered that they were doing a summer UROP, conducting research, or working at a local company. The remaining students didn't share specific plans, but mentioned the reasons for staying in Cambridge over the summer. One student indicated that "it is too expensive to fly back home, and so I really am looking for a reason to be here," and mentioned the possibility of doing a summer UROP. Further evaluation of the summer@ future program should explore whether this is the case for other students staying in Cambridge over the summer.

Table 4.15. Activities that 2014 summer@ future applicants who were planning to stay in Cambridge engaged during the summer expected to engage in.

Activity	Number of respondents	Percentage
UROP	117	83%
Research	11	8%
Work	9	6%
No summer plans	1	1%
Expensive to fly home	1	1%
Graduating and staying home	1	1%
Total	**140**	**100%**

Applying to more than one class

Students who applied for more than one class were asked why they did so; Table 4.16 lists their reasons.

Table 4.16. Students' stated reasons for applying for more than one 2014 summer@ future class.

Reason	Number of respondents	Percentage
More than one class seemed interesting (not available otherwise)	30	47%
Higher chance of getting into the program (housing)	24	37%
Wouldn't have time over regular semester	5	8%
Why not?	3	5%
Explore future degree or career options	2	3%
Total	**64**	**100%**

Interest in online/blended classes

When asked how interested they would be in taking online or blended learning classes in the future, the majority of students indicated that they would be very interested or somewhat interested.

Table 4.17. Students' indicated level of interest in online or blended learning classes.

Level of interest	Number of students	Percentage
Very interested	89	44.0%
Somewhat interested	87	43.0%
Unsure or N/A	13	6.0%
Not interested	7	3.5%
No answer	7	3.5%
Total	**203**	**100%**

Type of offerings that would be of interest in future summer semesters

When asked about specific classes they wish were offered in the summer, students not only suggested a list of classes from different Courses, but also made general recommendations about the types of offerings in which they were interested.[6] These recommendations included General Institute Requirements and electives that would allow them to explore new majors, and classes in computer science and introduction to programming; humanities, arts, and social sciences; math; machine learning and statistics; foreign languages; and management and entrepreneurship. Hands-on classes and the kinds of classes offered during the Independent Activities Period were also suggested.

Selection process

The selection process started on April 22 and students received information about acceptance on April 30, the day before pre-registration began. A list with the applications was prepared and sent to each of the participating faculty members. Information about student applications to other classes was also included for their reference. We received 299 applications for the five different classes, and 165 students were accepted (Table 4.18).

[6] A detailed analysis of the responses is needed in order to obtain the complete list of classes suggested by the students.

Table 4.18. Number of students accepted to summer@ future classes, 2014.

Class	Applicants	Accepted	Wait list
2.S03 Special Subject: Dynamics I	65	63	0
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	46	20	5
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	56	20	5
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	109	40	0
8.371J Quantum Information Science II	23	22	0
Total	**299**	**165**	**10**

*U = Undergraduate-level class; G = Graduate-level class

2.S03 Special Subject: Dynamics I

This class was taught by Sanjoy Mahajan, a visiting associate professor of electrical engineering and computer science. Professor Mahajan reviewed the applications to ensure that all students met the class prerequisites. Sixty-three of 65 students were accepted to the class[7] (59 undergraduate and four graduate students), largely representing the departments of Electrical Engineering and Computer Science and Mechanical Engineering (Table 4.19).

[7] Two students were not eligible to participate in the program: an undergraduate from Mechanical Engineering who had previously taken 2.003, and a graduate student from Civil and Environmental Engineering who was graduating in 2014.

Table 4.19. 2.S03 Special Subject: Dynamics I enrollment, by students' course of study, summer@ future, 2014.

Course	Number of students	Percentage
1 Civil and Environmental Engineering	1	1.5%
2 Mechanical Engineering	15	24%
3 Materials Science and Engineering	3	5%
4 Architecture	1	2%
5 Chemistry	2	3%
6 Electrical Engineering and Computer Science	15	24%
8 Physics	4	6%
10 Chemical Engineering	4	6%
14 Economics	1	2%
15 Management	2	3%
16 Aeronautics and Astronautics	5	8%
18 Mathematics	5	8%
20 Biological Engineering	2	3%
ESD Engineering Systems Division	1	1.5%
Freshman/Alumni Internship Program	1	1.5%
Other	1	1.5%
Total	**63**	**100%**

3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy

This class was taught by three faculty: Elsa Olivetti from the Department of Materials Science and Engineering, Alexie Kolpa from the Department of Mechanical Engineering, and Yuriy Roman from the Department of Chemical Engineering. First, the faculty looked at the students' class year, as the material is not appropriate for freshmen and graduate students. Next, they considered the reasons the students gave for applying in order to identify those who expressed greatest interest in the class content. This selection process led to a balanced group of rising juniors and seniors from a variety of relevant departments. Twenty of the 46 applicants were accepted to the class (19 undergraduates and one graduate student). Five additional students were put on a waiting list, and were later admitted after five of the initial students declined acceptance.

Fifteen students were from the faculty's home departments, Mechanical Engineering, Materials Science and Engineering, and Chemical Engineering, and together comprised 75% of the class (Table 4.20).

Table 4.20. 3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy enrollment, by students' course of study, summer@ future, 2014.

Course	Number of students	Percentage
1 Civil and Environmental Engineering	1	5%
2 Mechanical Engineering	7	35%
3 Materials Science and Engineering	4	20%
5 Chemistry	1	5%
6 Electrical Engineering and Computer Science	1	5%
8 Physics	1	5%
9 Brain and Cognitive Sciences	1	5%
10 Chemical Engineering	4	20%
Total	**20**	**100%**

7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology

This special subject in biology was taught by three instructors from the Department of Biology: Mary Ellen Wiltrout, an *MITx* technical instructor; Nathaniel Schafheimer, a postdoctoral teaching fellow; and Sera Thornton, a postdoctoral associate. The instructors reviewed the 56 applications and selected the 20 students they deemed to have the strongest reasons for applying; 19 were undergraduates and one was a graduate student. They also selected five students for a waiting list, two of whom were later accepted.

The accepted students came primarily from the departments of Biology, Electrical Engineering and Computer Science, and Biological Engineering, with the rest coming from five other departments (Table 4.21).

Table 4.21. 7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology enrollment, by students' course of study, summer@ future, 2014.

Course	Number of students	Percentage
5 Chemistry	1	5%
6 Electrical Engineering and Computer Science	6	30%
7 Biology	7	35%
8 Physics	1	5%
10 Chemical Engineering	1	5%
18 Mathematics	1	5%
20 Biological Engineering	2	10%
ESD Engineering Systems Division	1	5%
Total	**20**	**100%**

7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop

This biology workshop was also taught by Mary Ellen Wiltrout, Nathaniel Schafheimer, and Sera Thornton. They received and reviewed 109 applications and accepted 40 undergraduate students.

More than half of the students accepted for the workshop came from the departments of Electrical Engineering and Computer Science and Biology (Table 4.22).

Table 4.22. 7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop enrollment, by students' course of study, summer@ future, 2014.

Course	Number of students	Percentage
5 Chemistry	2	5%
6 Electrical Engineering and Computer Science	12	30%
7 Biology	12	30%
8 Physics	2	5%
9 Brain and Cognitive Sciences	5	12.5%
20 Biological Engineering	5	12.5%
Other	2	5%
Total	**40**	**100%**

8.371J Quantum Information Science II

This class was taught by Professor Isaac Chuang, who holds joint appointments in the departments of Electrical Engineering and Computer Science and Physics. Professor Chuang accepted 22 of the 23 students who applied for his class (13 undergraduates and nine graduate students).

Table 4.23. 8.371J Quantum Information Science II enrollment, by students' course of study, summer@ future, 2014.

Course	Number of students	Percentage
5 Chemistry	2	9%
6 Electrical Engineering and Computer Science	6	27%
8 Physics	13	59%
18 Mathematics	1	5%
Total	**22**	**100%**

Registration

Pre-registration for the summer semester began on May 1, followed by registration on June 2. Both periods were used to finalize the list of students for each summer@ future class, as well as the of students needing on-campus subsidized housing. As of June 30, 129 students (113 undergraduates and 16 graduates) were enrolled in summer@ future classes (Table 4.24).

Table 4.24. summer@ future class enrollments, June 30, 2014.

Class	Undergraduates	Graduates	Total	Percentage
2.S03 Special Subject: Dynamics I	48	2	50	39%
3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy	10	0	10	7%
7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology*	12	1	13	10%
7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop*	35	1	36	28%
8.371J Quantum Information Science II	8	12	20	16%
Total	113	16	129	100%

Students attended classes and used the *MITx* platform to access online educational materials. This platform enabled them to experience a variety of blended learning models, facilitated by the faculty and instructors. The following section provides information about student progress and the use of *MITx* for each of the summer@ future classes at the conclusion of the second week of the program.

2.S03 Special Subject: Dynamics I

Forty-eight undergraduates and two graduate students enrolled in the class.

The *MITx* platform was crucial to this class, providing students access to online lectures, recitation videos, resources on problem solving, and problem sets covering the entire standard syllabus.[8] All the equations that students needed for subsequent sessions were derived in the *MITx* materials, allowing the faculty to use the lecture time to explore the material in depth, to expand students' understanding of the equations, and to foster students' intuition for physical systems.

Students completed the two initial problem sets, primarily with high scores, and worked on the third problem set, which contained review problems for the midterm. There were a total of seven problem sets, six of them graded, and the last one included review problems for the final exam.[9]

[8] The material was originally created by Dave Gossard and his team for 2.03x.
[9] Students' final results were not available at the time of this report.

3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy

Nine undergraduate students registered and actively participated in the class. Students used the *MITx* platform to view lecture videos; answer comprehension questions (ungraded) in between video modules; and access readings, homework problem sets, and other handouts. They did not use *MITx* to turn in homework.

Initially, handouts were sent via email when the file links weren't working properly. During the second week, students participated in a blended learning workshop (solving "lab-like" problems for close to three hours after watching lecture videos), and were engaged and productive. According to one of the professors, "it seemed like they were leveraging the *MITx* materials well thus far."

7.S390 (U)/7.S930 (G) Special Subject in Biology: Creating Digital Learning Materials for Biology

Twelve undergraduates and one graduate student enrolled in this interactive and discussion-based class. The instructors used the *MITx* platform in class to deliver the lessons, which included text as well as videos. As they went through materials, instructors posed questions to the class that students answered through the discussion forum on the *MITx* platform. Then, instructors discussed answers and thoughts. The platform provided an effective means to record the discussion from class each day. Later in the course, the students edited the *MITx* site to develop parts of their projects through the *MITx* platform's studio.

Three weeks into the course, the students selected misconceptions about biological concepts, wrote learning objectives for the misconceptions, and wrote and peer-reviewed outlines for their projects. The students engaged in a workshop on Adobe Illustrator®, as well as several classes discussing pedagogy and best practices in delivering educational content online. According to the instructors, "all of the students seem very engaged."

7.S391 (U)/7.S931 (G) Special Subject: Quantitative Biology Workshop

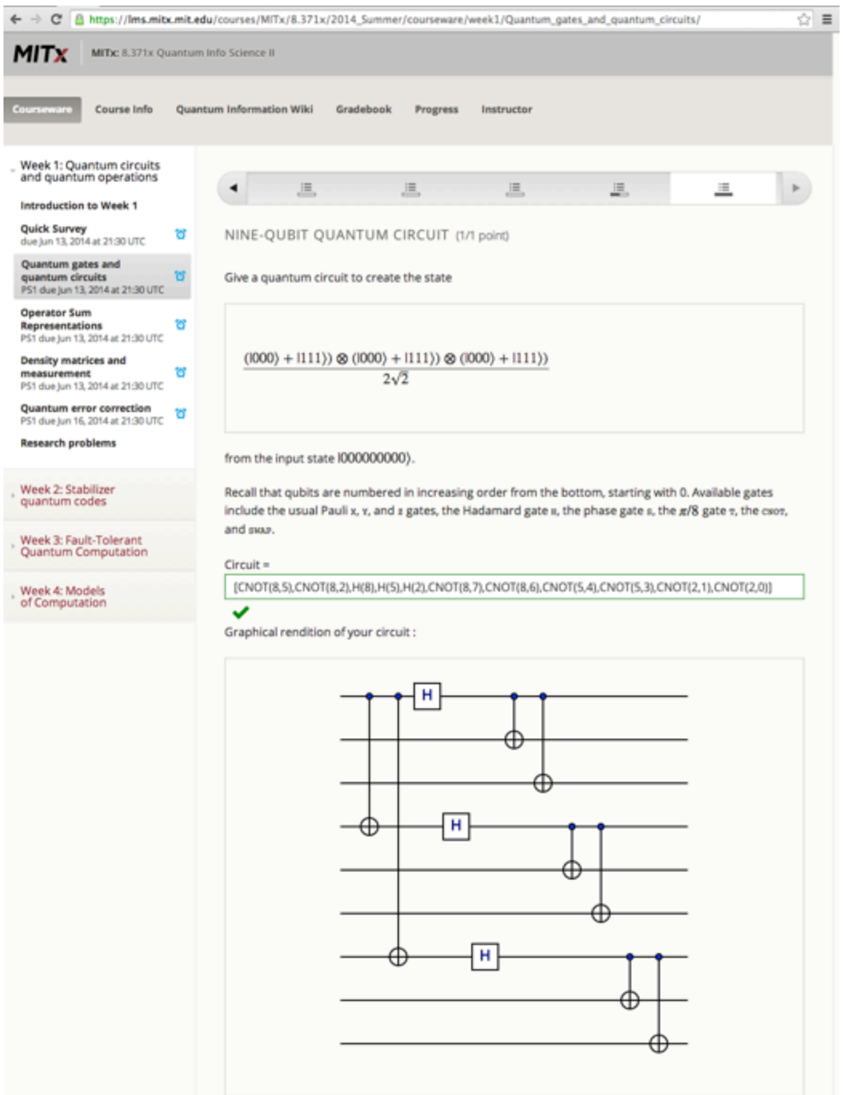
Thirty-five undergraduates and one graduate student registered for the class. The first 30 minutes of each class opened with a discussion, led by a guest speaker or one of the instructors, of how the tools that the students were learning about in class apply to research currently being conducted around campus. The last hour of class involved the *MITx* platform. In particular, students completed an assessment each week in class and also had graded homework provided on the platform. Overall, most of the course content was on the *MITx* platform, including videos and text to introduce students to the concepts or tools, as well as practice questions.

During the first three weeks, students completed a MATLAB introduction section, a MATLAB-based biochemistry section, and exercises involving PyMOL, a protein-viewing and manipulating tool. According to the instructors, "most of the students seem pretty self-sufficient working through the material." They only asked a few questions while they worked in class, and sent some emails each week about the homework. Instructors also provided additional help to one student, who did not seem to have much programming experience.

8.371J Quantum Information Science II

Eight undergraduates and 12 graduate students registered for the class. Students used the *MITx* platform for all problem sets. These consisted of about 250 auto-graded, instant-feedback questions, delivered in five units over eight weeks. The questions went far beyond simple numerical and multiple-choice questions. They included questions about the complex properties of mathematical objects, like groups and circuits, for which many answers are valid. The questions responded to student input with graphical feedback, for example, by plotting the quantum circuits that they specified. The questions also included interactive simulations, e.g., of fault tolerant system constructs (Figure 3.1).

Figure 4.1. Image of a sample problem for 8.371J within the *MITx* platform



Institute-wide Task Force on the Future of MIT Education

Preliminary Report

November 21, 2013

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INTRODUCTION

In his charge to the Institute-wide Task Force on the Future of MIT Education, MIT President L. Rafael Reif asked "that this Task Force *be bold* in experimenting with ideas that would both enhance the education of our own students on our own campus and that would allow us to offer some version of our educational experience to learners around the world." This preliminary report of the Task Force on the Future of MIT Education is intended to communicate evolving themes and to describe opportunities to strengthen the Institute's global leadership in education. It represents the exploration of a wide range of ideas that have emerged over the past six months. The possibilities for experimentation contained in this report reflect the collaborative efforts of faculty, students, and staff who brought their experience and knowledge to this work. With the guidance of advisory groups and input from the broader MIT community through the Idea Bank and group discussions, this work also reflects MIT's unwavering commitment to excellence, innovation, and service to the world.

Implementing an ecosystem to enable ongoing learning about education, and launching the experiments that will make it possible to refine and realize the vision for the future of education at MIT, will surely continue well into the future. As we begin to consider possibilities for reinventing education at MIT, we do so recognizing the global appetite for learning, and the role technological advances can have in reaching new audiences. These advances in educational technology combined with a growing public dialogue about the cost of higher education in America have brought us to this moment. Tremendous opportunities lie before us, and we need to thoughtfully and collectively evaluate the many possibilities for experimentation, and determine together how to build on MIT's legacy of educational innovation.

The History of Educational Innovation at MIT

In founding the Institute in 1861, MIT's first president, William Barton Rogers, launched a grand and daring experiment in teaching: the kind of hands-on, science-based, problem-focused engineering education that remains an MIT signature even now. Today, it is hard to imagine teaching engineering any other way. But at the time—when rote memorization was the norm in college classrooms across America—Rogers's *mens et manus* ("mind and hand") approach to teaching was a bold departure. This account from one of his early students, Robert Richards, MIT Class of 1868 and later head of the Mining and Metallurgy Department, makes the contrast clear:

> The method of teaching was completely new to all of us. We found ourselves bidding goodbye to the old learn-by-heart method, and beginning the study of observing the facts and laws of nature. We learned from experiment and experience what might be expected to happen if a given set of forces started to act. In short, our feet were set at last in the way of real knowledge. We learned, perhaps falteringly at the outset, the four steps that mark the only route to true science: how to observe, how to record, how to collate, and how to conclude. The effect on the classes was totally different from anything that I had seen in any school before.[1]

1. Richards, Robert H. *Robert Hallowell Richards, His Mark*. Boston: Little, Brown; 1936.

Rogers began this great experiment in response to an urgent need. Although the nation was experiencing rapid industrial growth, its citizens were almost completely unschooled in the scientific and engineering principles that would give them the power to improve processes and invent new solutions. His insistence on hands-on, scientifically grounded education helped accelerate America's industrial revolution, spawned countless innovations and industrial pioneers, and profoundly influenced the modern, laboratory-based approach to scientific education.

Several generations later, in the 1930s, under the leadership of MIT's ninth president, Karl Compton, MIT led a new charge to rethink engineering education by elevating fundamental science and fostering cross-disciplinary problem-solving. This willingness to embrace new ways of thinking and to combine theory with hands-on learning set the stage for all that was to come. After World War II, enabled by a new federal commitment to funding peacetime scientific research, MIT reinvented itself as a modern research university.

In 1959, MIT's eleventh president, Julius Stratton, wrote that the Institute faced a "numbers problem" as more students than ever sought out an MIT education, a trend that was putting unprecedented pressure on faculty and instructional staff. He wrote:

> We shall be faced in the future at MIT, and at comparable institutions all over the country, with the need to teach difficult, basic subjects to larger groups of students. We may be compelled to break with conventions of the past. Certainly it is time for bold and creative thinking about the methods and processes of instruction as well as about the substance. We should re-examine with an open mind the relative merits of the lecture, recitation, tutorial, and seminar methods, and we should be progressive in the use of every modern technique for the effective presentation of subject matter in classroom and laboratory.[2]

President Stratton understood MIT's value to the world and foresaw the need for creatively reexamining traditional methods of education in order to reach a larger audience of learners. In his 1959 report, President Stratton noted that the Department of Mathematics was experimenting with offering lectures through closed-circuit television, with students using microphones to ask questions. President Stratton could not have imagined the transformative power of the Internet in instantaneously connecting learners around the globe, but the principles he articulated over a half-century ago helped to define MIT as an early adopter of new technologies in enhancing the educational experience. The need for "bold and creative thinking" is what drives the Task Force now in imagining a new model of higher education for future generations of learners.

The History of Online Education at MIT

The use of online education and digital tools at MIT began in 1983 under the leadership of MIT's fourteenth president, Paul Gray, and with the launch of Project Athena, a digital experiment in providing widely distributed, client-server computing for education on campus, with a focus on undergraduate education. Athena made a variety of online educational resources available on the campus network, including:

2. Stratton, Julius. Massachusetts Institute of Technology Bulletin, President's Report, Vol. 95, No. 2, 1959: 13.

1. Networked Educational Online System (NEOS), also known as Turn-In/Pick-Up, which allows students to turn in, and their instructors to grade and return, assignments electronically;
2. Online Teaching Assistant (OLTA), a system by which students consult electronically with their TAs while logged in and working on an assignment;
3. Online With Librarians (OWL), a system by which patrons may consult electronically with reference librarians from the various MIT Libraries;
4. Tools for programmers;
5. Access to a suite of other electronic library services, databases and reference tools; and
6. Assistance through Athena Online Consulting (OLC), a service that provides support for faculty, students, and other users of the system in the form of training, documentation, consulting, and project assistance from faculty liaisons.

Of particular relevance to the evolution of massive online open courses (MOOCs) are two independent advances: the development of automatic tutors and the launch of OpenCourseWare (OCW).

MIT has a long history of trying to enhance active engagement in teaching, from the Experimental Study Group (ESG) in 1968,[3] to the development of the Technology Enhanced Active Lecture (TEAL) classroom in 2002.[4] The development of automatic tutoring systems, computer systems that can provide immediate and customized feedback to learners, made it easier for students to grasp material outside of the classroom. This was an important complement to the goal of making in-class experiences more engaging. Many automatic tutors started emerging around the world including several at MIT in the late 1990s and 2000s.[5,6,7] By 2005 it was becoming clear that online learning was a powerful tool in educating students.

The launch of OCW at MIT in 2002 was another important milestone in online learning, and brought into focus the benefits and opportunities of global online access to learning resources.[8,9,10] The mission of OCW is to make all of MIT's undergraduate and graduate courseware available openly to anyone in the world. In addition to course notes, problems and curricula, OCW also published videos of select lectures including the famous physics lectures by Professor

3. Valley, George E. "My Years in the MIT Experimental Study Group," http://www.mit.edu/~jrising/webres/myyears.pdf.

4. Belcher, John W. "Improving student understanding with TEAL," MIT Faculty Newsletter, Vol. 16, No. 2, 2003: 1–8.

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8. Long, Phillip D. "OpenCourseWare: Simple idea, profound implications," *Syllabus,* Vol. 15, No. 6, 2002: 12–14.

9. Carson, Steve. "The unwalled garden: growth of the OpenCourseWare Consortium, 2001–2008." *Open Learning,* Vol. 24, No. 1, 2009: 23-29.

10. Kumar, Vijay. "From open resources to educational opportunity," *Research in Learning Technology*, Vol. 13, No. 3, 2005: 241–247.

Walter Lewin.[11] Over the last decade, OCW has published more than 2,000 courses, and today receives more than two million users monthly, of which over a million are unique. While the architects of OCW initially expected teachers to be the primary beneficiaries of the system, it was self-learners from around the world who emerged as the main users.

MIT has also been a leader in developing technologies to support design-oriented project-based learning. For example, the ideas and technologies underlying the LEGO® MINDSTORMS™ robotics kits, now used by millions of students around the world, were developed at MIT and first tested in MIT robot-design competitions during Independent Activities Period (IAP) in the 1990s.[12]

In many ways, MOOCs were born from the convergence of many themes described above: free worldwide access, online videos, and online resources such as simulation toolkits and automatic tutors. Another important development was the emergence of the cloud, which made it possible to instantly scale up a class to serve many thousands of students. The final piece of the puzzle was social networking in the form of discussion forums, which enabled online users to interact with and help one another.

Following the work of the Institute-wide Planning Task Force in 2009 Rafael Reif, who was then Provost, charged a study group to evaluate new educational opportunities around e-learning, scalable educational platforms, educational offerings that use online tools, and opportunities to reach a greater number of students. The work of this group, chaired by Professor Dick Yue, led to the launch of *MITx* in December of 2011. It began with aspirations of an open source platform, course content with credentialing mechanisms, and the opportunity to research how people learn. At the same time, the first MOOC courses were being widely publicized with audiences of over 100,000 students.

MITx launched its flagship class, 6.002x, in spring 2012. More than 150,000 students from around the world enrolled in 6.002x, and more than 7,000 finished the class. In May 2012, MIT "spun out" the software development effort of *MITx* and, together with Harvard University, created a new not-for-profit called edX. EdX is the platform—the combination of technologies and services that host courses posted online by MIT, Harvard, and other partners. *MITx* refers to those courses hosted on edX that reflect the MIT curriculum. One might consider *MITx* courseware as the movie, and edX as the theatre in which the movie plays. In addition to developing and promoting the edX software platform to allow global access to high-quality educational material, edX has two important missions: improving residential education, and advancing teaching and learning through research. As of November 2013, edX has 29 university partners that offer over 90 courses, and it has enrolled over 1.5 million students worldwide.

EdX distinguishes itself in two ways. First, edX's partner universities offer classes of a high standard, and many commentators have described edX courses as rigorous. In describing 7.00x, The Secret to Life, taught by Professor Eric Lander, Kevin Carey of the *New America Foundation* wrote, "the experience was a welcome reminder that real education is hard work."[13]

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11. Rimer, Sara. "At 71, professor is a web star," *New York Times*, December 19, 2007.

12. Resnick, Mitchel, Fred Martin, Randy Sargent, and Brian Silverman. "Programmable bricks: toys to think with," *IBM Systems Journal*, Vol. 35, No. 3-4, 1996: 443–452.

13. Carey, Kevin. "MOOCs, robots, and the secret of life," New America Foundation, June 5, 2013. Retrieved from: http://higheredwatch.newamerica.net/blogposts/2013/moocs_robots_and_the_secret_of_life-85293.

Second, edX courses tend to have very rich assessments and simulations. The assessment tools used in 7.00x, for example, range from an online protein-folding simulator to an online genetics lab. The idea is to create an online experience that captures as much of the essence of the on-campus experience as possible. Carey comments that 7.00x is "a very close translation of a real MIT course."

The edX software has two major components. The first is a hosted system for offering online courses to hundreds of thousands of students worldwide. The second is an authoring system called edX Studio for creating an edX course so that it can be offered on the edX site. In June 2013, edX delivered on its pledge to open source its software. The same, day, Stanford University joined the open source effort and adopted Open edX as an internal platform. In September 2013, edX announced a partnership with Google to create a new site called MOOC.org, based on the edX software, to enable any entity anywhere in the world to upload a course for a global audience. MOOC.org is powered by the edX software platform, and Google also joined the open-source effort.

EdX offers classes in several modes. The standard MOOC format is for self-learner students who simply wish to learn the material for free. A portion of this population also seeks to earn certificates. For such students, edX and other MOOC providers charge a fee. EdX also offers material that has been developed for a MOOC for licensing to other universities, including recent experiments with San José State, Massachusetts Bay Community College and Bunker Hill Community College. This format is often called a small private online course (SPOC). Institutions like MIT also offer executive education (as opposed to standard curricular material meant for students) to working professionals. At some point edX may become a channel for providing such professional courses either to individuals or to those embedded in companies.

Since the software development effort of *MITx* was spun out to create edX, *MITx* has continued to develop online courses and modules on the MIT campus both for global audiences on edX and for students on campus. Today, more than 20 classes have used the edX software to experiment in various ways with the use of online methods on campus, and over 2,000 unique students at MIT have used the edX software in some form. In December 2012, MIT launched the Office of Digital Learning (ODL) as a focal point for digital educational initiatives. It serves as an umbrella organization to unite *MITx*, OCW, the Office of Education Innovation and Technology (OEIT), and Academic Media Production Services (AMPS) into a single organization focused on digital initiatives.

Trends Influencing the Future of Education

The digital revolution can be felt across a number of industries, from publishing to media to retail, with the following trends surfacing across the spectrum:

1. *Massive scale of adoption*: YouTube, for example, claims a viewership of over one billion unique viewers and over six billion hours of video watched every month.
2. *Increased potential and demand for disaggregating or unbundling products*: Newspapers have become disaggregated into individual articles available piecemeal online. These are often curated and aggregated by other online sites such as The Huffington Post

or Drudge Report. Apple unbundled music albums into 99-cent songs, and users re-aggregate individual songs into their own playlists.

3. *Blurring of boundaries*: Traditional boundaries in various media and platforms are becoming less distinct, creating new opportunities and greater potential for collaboration. The availability of online video through YouTube, iTunes, Hulu, and other sources, for example, has blurred the boundaries between traditional television programming, cable, computers, and mobile phones. Telecommuting has the same effect on the division between offices and homes. Online retail has blurred the boundaries between brick-and-mortar stores such as Walmart, electronic commerce sites such as Amazon, and auction sites such as eBay.
4. *Affordability and access*: The public conversation about the affordability of higher education and the impact of cost on access for all of those desiring to go to college is growing. There is also a growing conversation about the value of education that does not immediately result in jobs.

These trends are occurring in a political environment mired in disagreements on fiscal matters, and in the midst of a still-uncertain global economy, causing some to ask: Why does education cost so much? Some see online learning as an opportunity to make education more affordable.

Advances in online education enable learning to take place anywhere at any time, forcing us to question the meaning of the strict physical and temporal boundaries of the campus. No longer must a student be at MIT to take an MIT class. A student could leave campus for a year to start a company, or continue education well after graduating with a master’s degree. The typical time period for an academic degree becomes blurred. This blurring of boundaries shifts the focus from institutions to a learning ecosystem. Resources, relationships, and roles may need to be recast.

A learning ecosystem with permeable boundaries presents possibilities for advancing thematic education—directing education toward an understanding of big problems. It supports integrative learning—pursuing learning in more intentional and connected ways, bridging disciplines, integrating research and teaching, connecting community and college, and presenting informal and authentic real-world learning opportunities that may recast the role of the university and formal education in light of an open world.

The Uniqueness of MIT in This Space

The magic of MIT originates in its culture, defined by the values and principles embodied by and at the heart of the society of MIT. Driven by its culture, MIT provides its students with unique experiences and opportunities on campus and beyond. These opportunities span the triad of research, academics, and community and are exemplified by the power of learning-by-doing, innovation in learning, and learning by teaching. The outcomes of an MIT education can be measured in many ways, including research results, patents, employment rates, and income.

MIT graduates contribute to the world in extraordinary ways, but MIT is able to admit only a fraction of the exceptional students who wish to come to campus. Only 8.2% of undergraduates who applied for the class of 2017 were admitted, and undergraduate selectivity has increased dramatically over the past 20 years among all of MIT’s peer institutions. Clearly, there is a vast unmet need for access to high-quality education. By combining online curricula with hands-on project work and brief but intensive on-campus experiences, MIT has the opportunity to reach more people, to infuse some of the magic of MIT into online and blended learning environments, and to impact lives and society in ways not previously thought possible. MIT is in a most unique position to contribute in a meaningful way to this dialogue, and the possibilities for experimentation explored in this preliminary report represent only the beginning of this conversation about how to reinvent and transform the educational experience for students at MIT.

Task Force Working Groups

Three working groups—each comprised of faculty, students and staff—have begun to envision how MIT can build on its legacy of innovation and reinvent the residential university of the future. (See Appendix 2 for Task Force membership.)

1. Working Group on MIT Education and Facilities for the Future
2. Working Group on the Future Global Implications of edX and the Opportunities It Creates
3. Working Group on a New Financial Model for Education

FUTURE MODELS FOR MIT EDUCATION

How specifically does the increased potential for unbundling education and blurring boundaries present opportunities to rethink MIT residential education?

The key is that, if approached in the right way, unbundling can permit rebundling in new and interesting ways.

- It is an opportunity to introduce *flexibility* in the curriculum, in student experiential learning opportunities, and in each student's trajectory through an MIT degree. For example, *modularity* in the curriculum can provide increased flexibility for students to customize their degree programs. Modularity combined with online education permits students to spend a semester or a year away from campus, enriching their educational experience through internships or international experiences.
- It is an opportunity to emphasize *connections*. Modules can be connected in different ways to deepen and enrich learning by linking concepts and outcomes that might otherwise remain disconnected. For example, common modules in a topic like fluid mechanics could be offered across multiple departments, providing complementary disciplinary lenses through which to access the concepts. Integrative projects could explicitly draw on concepts from multiple modules, including project experiences that cut across traditional departmental and school boundaries. Eliciting connections is also an opportunity to establish well-defined prerequisite relationships in a more modular approach to the curriculum—with the effect (at a minimum) of informing students of their level of preparation for subsequent topics. Academic modules could also be connected to applications in the outside world—the fluid mechanics module could be coupled with a module on turbines from an aerospace company, for example.

- It is an opportunity to achieve greater *contextualization* and "education for practical reasoning".[14] For example, modularity together with a rebundling of modules might be a path to better integrate MIT curricula in the humanities, arts and social sciences with engineering and science content, thus promoting understanding of the technical world in context. Or class modules could be combined with a service-oriented field experience.

These opportunities are enabled through a combination of digital learning technologies and face-to-face pedagogical strategies. Achieving them will require a commitment to adopting new models of *blended learning*—again emphasizing the flexibility to use different pedagogies in different settings—and an investment in a diverse and flexible range of spaces that cater to different formats of learning. As we transform our pedagogies, it is also an important opportunity to explore new approaches to *assessment*, ranging from instant feedback to viva voce exams and competency-based assessments.

However, it is essential that we not lose sight of our principles and values in any future state. Indeed, in this time of disruption in higher education, MIT should explicitly establish a set of educational principles and values. These principles and values will guide us in establishing specific educational outcomes and a qualitative MIT culture to which we aspire. In this framework, flexibility then brings our students options—options to reduce or extend their time to degree, options to take a year off-campus to undertake research or obtain relevant professional experience in the middle of their studies, options to engage more deeply in service and teaching opportunities, and options to take classes online over the summer and streamline their programs—each with different pathways and different experiences, but each aligned with MIT principles and values.

Shaping the Future MIT Graduate

What are the desired attributes for the MIT graduates of the future? As we think about the future of education at MIT, we must think about developing the "future citizens" of MIT: students who meet the highest standards of academic excellence and are also able to appreciate the "big picture," understand their technical world in context, make connections across subject content, work collaboratively, communicate effectively, think critically and analytically, think and design creatively, deal with uncertainty and complexity, and nurture humane values. In short, we must complement MIT's excellent technical education and experiential learning with other attributes that position our graduates to be leaders in our future society, inspired to change the world. We already excel in some of these attributes, thanks to a rigorous and demanding curriculum and rich experiential opportunities such as MIT's Undergraduate Research Opportunities Program (UROP), MIT International Science and Technology Initiatives (MISTI), and the Edgerton Center. However, student surveys consistently show that we need to impart better communication skills to our students. The ability to communicate effectively—to advocate and educate, to work in a team, and to transfer relevant domain knowledge from one discipline to another—is a critical 21st-century skill.

14. Sullivan, William M. and Matthew S. Rosin. *A New Agenda for Higher Education: Shaping a Life of the Mind for Practice*. San Francisco: Jossey-Bass; 2008.

UROP is a highly successful program at MIT, embodying our educational principle of learning-by-doing. UROP projects contribute to our students' growth by deepening their technical skills, exposing them to the research process, and building mentee/apprentice relationships with faculty members. Over 85% of all MIT undergraduates participate in a UROP before they graduate, compared to 40% participation in similar programs at other private and highly selective research universities. Building on the success of UROP, we should explore the value of instituting other formal experiential opportunities, reaching beyond technical research experiences to programs that could foster other strengths, such as leadership, an appreciation for societal responsibility, contextualization, and communication. For example, there would be many advantages to instituting companion programs to UROP for teaching and for service.

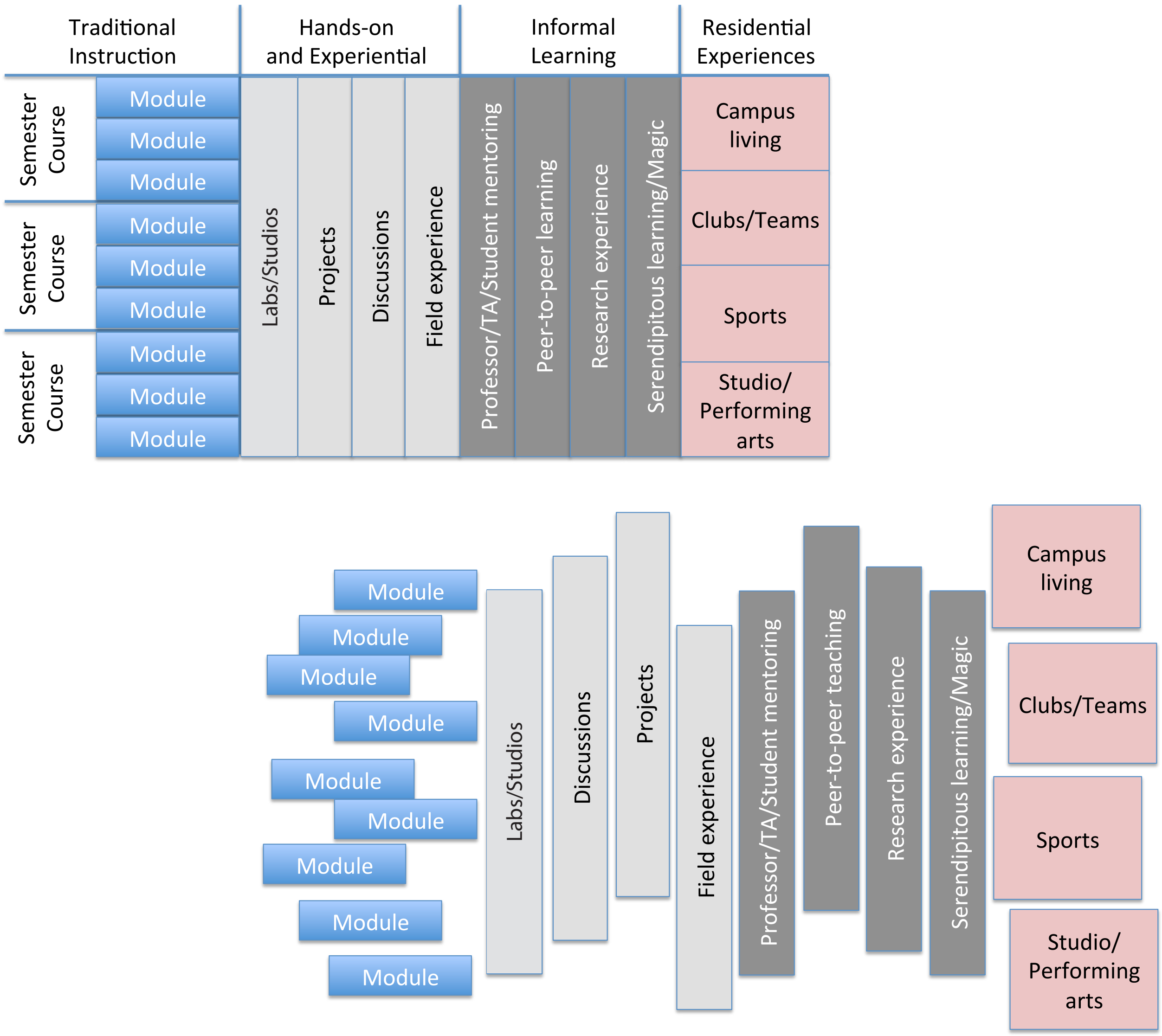
We should also ensure that MIT education and facilities for the future maintain a strong commitment to hands-on experiences and learning-by-doing. Project Athena brought about a wave of innovation in the software realm; could new Maker Spaces together with a reinforced commitment to learning-by-doing create the next generation of tinkerers, fluent in advanced manufacturing and rapid prototyping techniques?

Modularity

Modularity is a key enabler of unbundling (Figure 1) and rebundling in the MIT undergraduate curriculum. We define a module as a self-contained unit comprising a set of outcomes. An outcome is what the student will know or be able to do as a result of a learning experience. Outcomes are intended to drive the instruction and assessment for the module. The size of modules can vary, ranging from an entire class to a portion of a class or a series of lectures. We propose here that a module is defined by its corresponding outcomes.

There is a spectrum of approaches to achieving greater modularity in the MIT undergraduate curriculum, from a top-down approach that decomposes existing courses into modules to a bottom-up approach that re-engineers a curriculum by identifying the core concepts and associated modules that underlie them or build upon them. In addition to providing increased flexibility for students to customize their degree programs, increased modularity also presents other opportunities to improve MIT education and even may address some existing faculty resource limitations. Among the most important opportunities are competency-based assessment, better-defined prerequisite relationships, shared faculty/instructor resources for common content across departments, and an increase in undergraduate teaching opportunities.

Figure 1. Unbundling of education



Spaces and Places

The classroom is evolving from a room-with-a-blackboard to an online forum blended with hands-on activities. Teaching is evolving from speaking at a podium to activities that center on the interactive engagement of students. Assessment materials are evolving from weekly paper problem sets to instantly graded, interactive questions and simulations, with evaluations from multitudes of peer learners. Information delivery is giving way to interactive learning.

The momentous rise of digital learning, on campus and beyond, enabling learning anywhere at any time, inspires us to imagine what MIT's facilities for the future could be—combining online activities with in-person interactions and hands-on experiences. It is exciting to envision *academic villages* that provide environments for enhanced interactions to occur both inside and outside of the classroom and laboratory settings. Composed of classrooms, breakout spaces, study spaces, technical support, food services, and library facilities with integrated faculty offices and laboratories, academic villages are designed to promote serendipitous interactions among students and faculty members.

Villages would be complemented by a system of small, focused *maker spaces* strategically located around campus, further enhancing the experiential learning so integral to an MIT education. Maker spaces build on lightweight rapid fabrication tools and techniques, such as 3-D printers, laser cutters, and open source hardware.

These two ideas—village places and maker spaces—are detailed in the report of Working Group 1 from the perspective of digital learning at MIT. These concepts and additional opportunities to open up grand spaces on the main campus that would accommodate new methods of teaching will be further explored as the Task Force continues its work.

MIT'S INTERACTION WITH THE WORLD

The digital education revolution has the potential to alter the way MIT interacts not only with its on-campus students, but with an entire globe of learners. Working Group 2's report on the global implications and opportunities of edX describes the distinct benefits for traditional learners and for those outside of the MIT campus. In many cases, there are synergies between these two audiences; where the global audience might benefit from increased access to MIT students, faculty, and resources, increased exposure to the world at large would similarly be of value to those on the MIT campus. We describe some of those synergies here.

First, more in-depth interaction with the world will generate massive amounts of data that will allow educators to better understand how different students learn and what methods are most effective in teaching some kinds of on-campus classes. There are both quantitative data, which is easy to pull from the edX platform, and qualitative data, which can be collected from in-person engagement with edX communities as well as from the discussion forums. Perhaps one of the most exciting developments since the launch of edX has been the proliferation of more than 860 local edX communities around the globe. MIT has already begun to build on the success of these communities. For instance, MIT recently ran an experiment with the city of Chicago called ChicagoX, in which MIT alumni served as mentors to students in Chicago who took a computer science class offered by *MITx*. The value of alumni's role in mentoring and coaching students in this kind of setting is clear; there is also great value to MIT. The alumni are able to collect and relay feedback about the students' experience and about the software platform. This kind of engagement strengthens MIT's ties with its alumni, creates new connections with potential MIT applicants, and generates information that could be used to improve *MITx*.

Second, edX presents new opportunities for MIT students to engage in meaningful international experiences while also providing invaluable access to MIT for *MITx* students in local communities. During summer 2013, MISTI placed 10 MIT students trained on the edX platforms in four countries during their internships. The students served as coaches, mentors, and teachers, providing a tangible connection to MIT for the *MITx* learners and creating an opportunity for MIT students to develop valuable skills that could be applied when they return to campus. *MITx* presents the potential for an initiative akin to the Peace Corps by which MIT students would gain hands-on experience interacting with *MITx* learners around the globe, and global learners would benefit from increased in-person interaction with MIT students.

Third, the opportunity to engage with a global audience in new and interesting ways provides more in-depth insight that could be of great value to our faculty in both teaching and research. Again, the benefit to the local communities is clear—access to MIT faculty and curricula is extremely valuable and sought after—but the benefit for those on our campus is equally significant. An instructor would gain immediate feedback, whether direct or indirect, from an audience of thousands of learners, allowing the instructor to immediately strengthen the class for both global and residential audiences. Similarly, increased global access allows MIT faculty to better understand the challenges that most keenly need MIT's attention. Research decisions and pathways are based on exposure to a problem; that is, researchers decide which challenges to address based on what they hear or see. Faculty are already experimenting with education in interesting ways as part of MIT's overall global strategy, through participation with the Singapore University of Technology and Design (SUTD), the Skolkovo Institute of Science and Technology (SkTech), the Masdar Institute, and the MIT Portugal Program. With new avenues for interaction, faculty will be closer to the world's problems, providing greater insight and informing their research decisions.

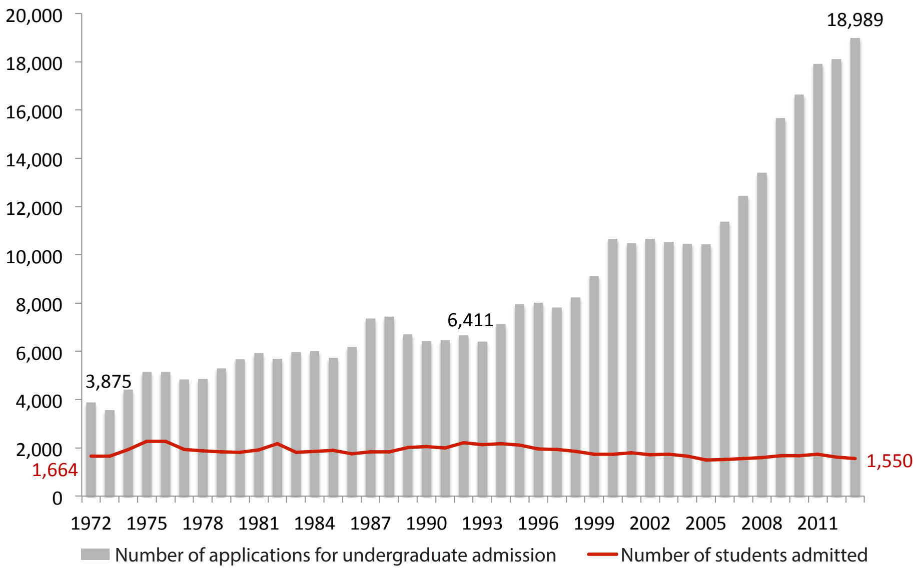
All of these opportunities for engagement with the world hinge on the idea of leveraging increased exposure to large-scale audiences. Through placement of members of our community—whether faculty, students, or alumni—around the globe, we have a greater opportunity to serve the world, strengthen *MITx* and edX, and enrich the educational and personal experiences for the members of our immediate community. The potential benefits of utilizing edX to engage the world are endless.

THE NUMBERS BEHIND AN MIT EDUCATION

MIT graduates contribute to the world in extraordinary ways, but MIT is able to admit only a fraction of the exceptional students who wish to come to campus. Today, MIT educates a little over 11,000 students at any given time.

In 2013, MIT received over 43,000 student applications, and only 10% gained admission to their program of choice. Undergraduate applicants numbered 19,000, and only 8.2% were admitted (Figure 2). By contrast, *MITx* enrolled just over 300,000 unique students in the academic year beginning fall 2012 through spring 2013.

Figure 2. Undergraduate applications and admissions, AY1972–AY2013



Source: MIT Admissions

Presented with these statistics, we must stop to wonder:

- Can we advance the mission of MIT by educating more students?
- Can innovations in online learning improve access and affordability?
- What is the value of an MIT education, residential or online?
- How will the adoption of online learning, by MIT or others, impact the financial model of MIT?
- How has MIT's financial model evolved?
- Is the current model sustainable?

To begin to answer these questions, Working Group 3 has constructed a series of historical data sets related to finances, people, and space at MIT to increase our understanding of how MIT's financial model has changed over time. We are evaluating how students finance their educations, articulating the outcomes of an MIT education, and developing approaches to modeling the scenarios that will emerge from the Task Force discussions. The questions we are trying to answer are complex and nuanced, and further work is needed to provide appropriate and detailed answers. We are developing a financial model that focuses on the Institute's faculty members and their various activities—teaching undergraduates, training graduate students, employing postdoctoral researchers, and raising research funds—to obtain new insights on cost drivers and revenue sources that may help us to better predict and guide MIT's future. We are confident that the best approaches for continuing to enable MIT to carry out its mission for generations to come will emerge through continued discussions and analysis, but we want to share preliminary observations at this early stage.

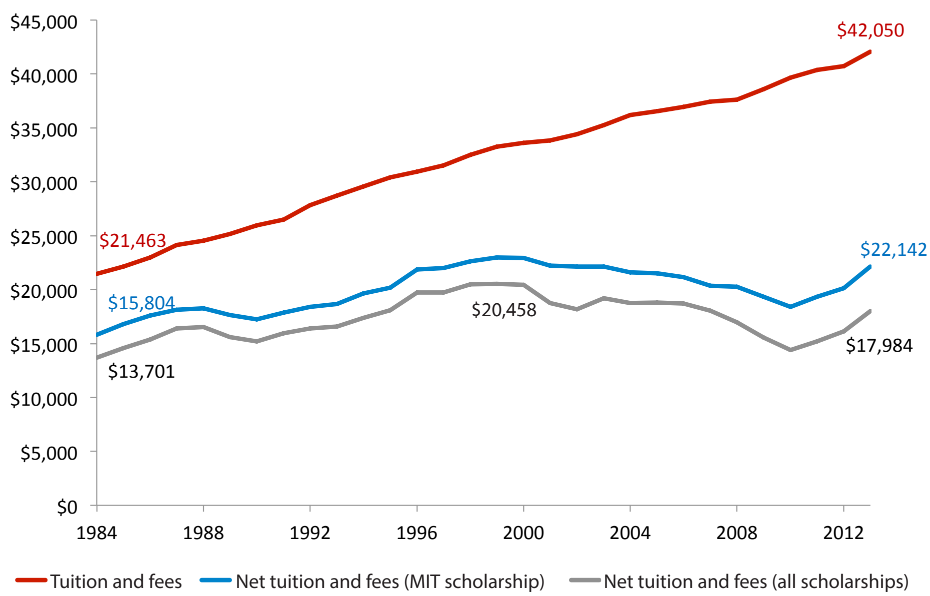
Improved Affordability and Desirability of an MIT Education

As noted above, the public conversation about the affordability of higher education and the impact of cost on access to a college education is growing. While it is true that higher education is expensive, MIT remains committed to need-blind admissions for undergraduates, and to providing those who are admitted with the aid needed to complete their MIT degrees. Nonetheless, the true cost of educating an undergraduate student at MIT is nearly three-and-a-half times the average net tuition (average cost paid by an undergraduate after MIT scholarships). At the same time, the true average tuition paid by an MIT undergraduate today when considering scholarships from all sources is lower in real dollars than in 2000.

In fall 2013, while MIT's tuition rate with fees was $43,498, the average net tuition paid by undergraduates was half that amount, or $22,208, because of MIT's need-based undergraduate scholarship program. More important, the tuition rate is considerably less than the cost of delivering an MIT education. Since 1998 the growth in MIT's undergraduate tuition rate has exceeded inflation, but the growth in MIT's undergraduate scholarship budget surpassed the tuition rate growth. In real dollars, the tuition rate grew about 31% from 1998 to 2013 while the average net tuition paid by MIT undergraduates decreased 3.1%.

The gap between the price of the tuition and fees charged by MIT and the average net tuition and fees paid by students after receiving MIT scholarships demonstrates MIT's commitment to making an MIT education as affordable as possible for students from all socioeconomic backgrounds (Figure 3).

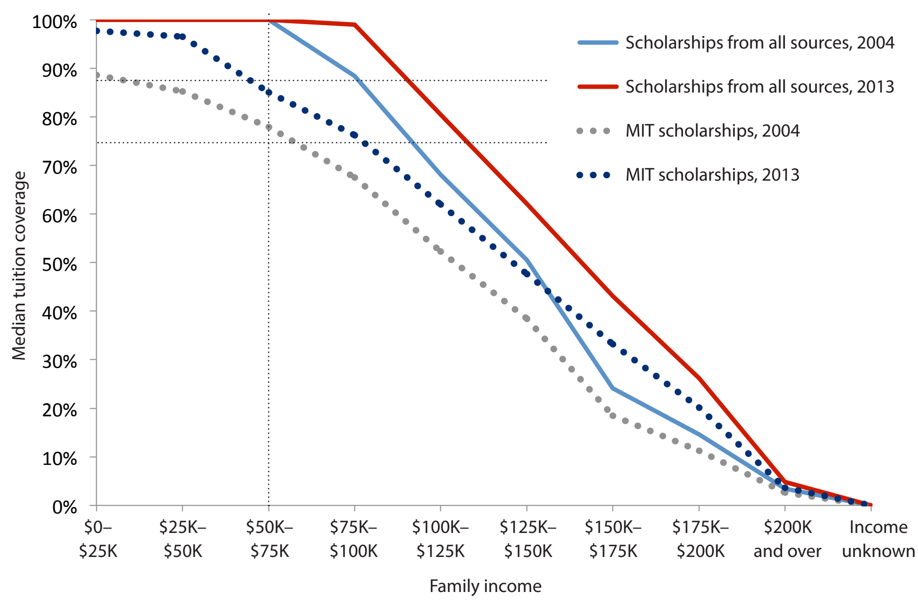
Figure 3. Net undergraduate tuition and fees, AY1984–AY2013 (inflation adjusted $2012)



Source: MIT Student Financial Services

The percentage of students receiving scholarships covering the full tuition price has increased over the past 10 years (Figure 4). During the 2003–2004 academic year, 75% of undergraduate families with incomes of less than $75,000 received MIT scholarships covering the full tuition price. During the 2012–2013 academic year, 88% of families at this income level received MIT scholarships covering the full tuition price.

Figure 4. Median undergraduate tuition coverage by scholarships, AY2004 vs. AY2013 (inflation adjusted $2012)



Source: MIT Student Financial Services

MIT has a significant impact on educating some of the brightest engineers, scientists, and businesspeople of our time, and graduates from MIT have performed exceedingly well in their life pursuits. The average starting salary of an MIT undergraduate upon graduation ($66,800 in 2012) has been consistently higher than the U.S. median family income ($62,035 in 2012). Twenty years after receiving their MIT degree, most MIT alumni across all programs earn between $150,000 and $200,000 per year excluding bonuses, with positive impact on the U.S. economy.

At the same time, undergraduate debt has been dramatically reduced since the late 1990s. From 1998 to today, the percentage of undergraduates borrowing has decreased from 66% to 40%, and the mean borrowed amount has been cut in half, from $22,500 to $11,000.

Edward B. Roberts, Class of ’57 and founder of the MIT Entrepreneurship Center, led a study of MIT-alumni-founded companies. In a 2009 report, “Entrepreneurial Impact: The Role of MIT,” Roberts described the regional and national economic impact of alumni who create their own firms. At that time he estimated that “if the active companies founded by MIT graduates formed an independent nation, their revenues would make that nation at least the seventeenth-largest economy in the world.”[15]

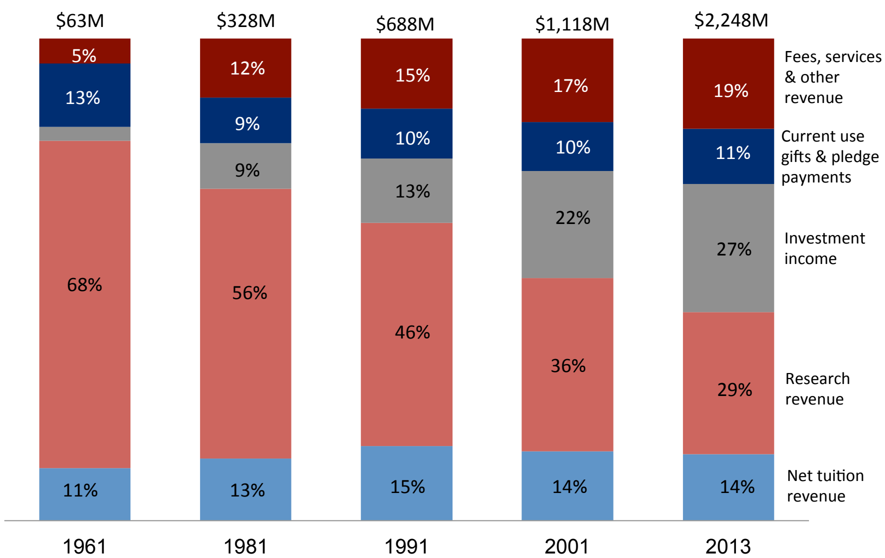
15. Roberts, Edward B. “Entrepreneurial Impact: The Role of MIT,” Kauffman Foundation of Entrepreneurship, 2009.

Sustainability of MIT's Model

By any measure we have studied, an MIT education is increasingly in demand. Paying for an MIT education, however, is costly. Our model today depends primarily on the ability to continue to attract significant research funding and philanthropic support and to generate high real investment returns.

The campus revenue mix has changed significantly from 1961, when research funding comprised 68% of revenue (Figure 5). Sixty-five percent of faculty members have active research programs today, and this percentage has remained fairly stable since 1997. Average research expenditures per faculty member have grown in constant dollars (2013) from $634,103 in 1997 to $815,596 in 2013. Median research expenditures in constant dollars have grown from $323,197 to $476,640 during this same time period. Today, while research expenditures have grown significantly, the percentage of campus revenue has dropped to 29%, with investment income growing from 3% of total in 1961 to 27% today.

Figure 5. Evolution of campus revenue mix, FY1961–FY2013



Note: Excludes the Broad Institute, Lincoln Laboratory, and the Singapore-MIT Alliance for Research and Technology.

Source: MIT Vice President for Finance

MIT has been quite fortunate in competing for available research dollars, attracting the very best students and growing the endowment through philanthropy and market returns. These results have allowed our vibrant research university to flourish beyond its initial conception.

At the same time, we face significant challenges.

1. Constrained federal funding has forced the Institute to grow and diversify its sponsored research portfolio to include greater portions of industrial and international support. As the overall pool of federal research funding shrinks, the mix of campus research

sponsorship changes. Federal funding of campus research has declined from close to 100% 50 years ago to 69% today.

2. Endowment returns and gift flows have typically followed macroeconomic trends, and we face a still-uncertain global economy and implied volatility. Investment support and gifts represent 38% of all campus annual revenues.
3. Academic and research space on campus has grown significantly over the past decades, to 5 million net assignable square feet, in order to accommodate the expansion of research and educational activities. We face the need to maintain and improve a great fraction of our world-class teaching and research infrastructure at considerable expense.
4. We also face the challenge of maintaining competitiveness in the recruitment of top talent without offsetting gains in productivity. This effect, known as Baumol's cost disease,[16] is caused by the need to compete for skilled workers in industries experiencing productivity gains.

Preserving and enhancing MIT's extraordinary research and educational environment is likely to require that we both strengthen existing income sources and consider new revenue opportunities. It may be possible to raise the level of development activity to support increases in charitable gifts, expand the scope of institutional and corporate partnerships, widen the menu of summer programs, and broaden executive education activities. One potential new source of revenue is the use of digital learning technologies to leverage on-campus course instruction, coupled with some form of paid certification. We will need to balance our desire to not limit access with the need to create a sustainable financial model.

The importance of increasing the resiliency of MIT's future financial model is paramount as the challenge is vast. We will need to broaden our revenue base to balance volatility. We will need to increase the efficiency of the MIT educational model without disrupting the outcomes and exceptional quality that characterize an MIT education. We will need to maintain physical laboratories and spaces of a high standard, so that we continue to attract the best faculty and students to keep advancing scientific discoveries, knowledge, and innovation. And we will need to address the challenges of affordability and access, while adopting a financial model that can withstand the impacts of shifts in research funding or significant endowment volatility.

WHAT WE ARE HEARING

As we have worked to engage the community through the Idea Bank, advisory groups, surveys, and face-to-face meetings, we have noticed a tension between, on the one hand, a desire to preserve many of the qualities that define an MIT education and, on the other, a push to make grand, sweeping changes to MIT's very core. We are hearing a desire to achieve greater flexibility in the way we educate students: flexibility in our curriculum, in time-to-degree, and in experiential learning opportunities. Several faculty and students, for instance, have suggested that now is the time to consider eliminating or drastically altering the General Institute

16. Baumol, William J. and William G. Bowen, *Performing Arts: The Economic Dilemma*. New York: The Twentieth-Century Fund; 1966.

Requirements (GIRs). Others feel that the GIRs are more important than ever to produce well-rounded graduates who have the skills to effectively interact with the world at large. Some suggest that MIT will be able to utilize digital learning to shorten its undergraduate program to three years, while others are adamant that reducing the time to a degree would do our students a disservice. Some concerns have been expressed that online courses might impact faculty slots, but rather than replacing the faculty, online courses deployed in blended classrooms can help make a faculty member more effective. Furthermore, launching edX as a not-for-profit, open source effort gives stakeholders an opportunity to drive this mission in a considered and thoughtful way. As we continue our discussions in the coming months, we will work together to balance these views, to openly address concerns, and to blend opportunities into meaningful experiments that will further inform our work.

CONTINUING THE TASK FORCE WORK

Task Force discussions described in this preliminary report represent only the first step in a continuing dialogue. This report describes a number of possible experiments and pilot approaches, and a range of opportunities that MIT may choose to explore. These possibilities, drawn from brainstorming discussions, may include many ideas that should not be pursued. During phase two of the Task Force work, we will examine these possibilities for experimentation more closely, together with feedback from the MIT community. Only then will we be able to fully evaluate these opportunities and prioritize those that hold value for MIT. The magic of MIT and the values and principles that we as a community hold true will guide us in evaluating opportunities and in charting the best path forward for the Institute.

Working Group 1

MIT Education and Facilities for the Future

In short, to stay true to our educational values, we must seize the opportunity to reimagine what we do and how we do it.

—President L. Rafael Reif

THE MAGIC OF MIT

> *The more I think about MIT, the more it presents itself not as a collection of buildings, of professors, of students, of courses, of papers and catalogues, but as a living vital entity—a being with a character, a personality, a philosophy, a mode of action, a heritage of ideas and methods that have made a deep impression on all who come to know it.*
>
> *—Julius Stratton, MIT's 11th President*

There is something special about being a student at MIT, in participating in the institution that is MIT, and in experiencing the spirit of MIT. This special magic is an essence that is intrinsically tied to residential education at MIT and is a hallmark of close student interactions with faculty and staff. This magic originates in the culture of MIT, is embodied by institutional opportunities at MIT, and is at the heart of the society of MIT.

At MIT, students develop the tools they will need to be lifelong learners. They learn how to work in groups, how to extract information from numerous sources, how to deal with uncertainty, and how to develop creative solutions to unexpected problems.

The culture of MIT is driven by its values and principles, as expressed by William Barton Rogers. Four principles guide what we do at MIT: (i) the educational value of useful knowledge, (ii) societal responsibility, (iii) learning-by-doing, and (iv) combining liberal and professional education.[17] These principles are reflected in the institutional features of residential education at MIT, which span the "triad" of research, academics, and community. They are exemplified by (i) the power of learning-by-doing, (ii) innovation in learning, and (iii) learning by teaching. Factors that lead to MIT's excellence include first-rate minds, passion, creativity, diversity, transparency, meritocracy, egalitarianism, and compassion.

Reflecting the *mens et manus* motto, students at MIT engage in the UROP program, lab courses, entrepreneurial endeavors, and apprenticeship experiences both on and off campus, as well as many other opportunities where they learn by doing. Students are involved in advanced research, engage with concepts firsthand, team up with students from other departments to assess marketization of new innovations, research new technologies, and do externships all around the world. In all of these opportunities, students are exposed to real-world applications and issues, connecting them to societal needs and preparing them to be valuable contributors when they leave MIT.

MIT is also a leader in innovative learning, reimagining the educational experience through several longstanding programs and frequent experiments with new pedagogical strategies. This effort is exemplified by the Experimental Study Group (ESG) and Concourse programs, and by efforts such as Technology Enabled Active Learning (TEAL). ESG has been a leader in active learning pedagogy, in which teaching is seen as a two-way process. Classes are self-paced when possible and have frequent student/faculty interaction. Similar to ESG, Concourse offers MIT freshmen small classes focusing on the integration of the disciplines within the broader human framework. The program focuses on the interconnectedness of concepts to provide students a

17. 1996 Task Force on Student Life and Learning report, http://web.mit.edu/committees/sll/tf1.html.

more complete training and view of the world, which runs counter to many current practices that promote hyper-specialization instead. TEAL is probably the most well-known educational experiment conducted at MIT in the recent past. The TEAL class integrates lecture, recitation, and hands-on experiments within a single session. Instructors deliver 20-minute lectures interspersed with discussion questions, visualizations, and pencil-and-paper exercises. Students use animated simulations designed to help them visualize concepts, and carry out experiments in groups during class.

Driven by the principle of societal responsibility, MIT students are encouraged to teach, not just at MIT, but around the world. Two examples of this are programs at the Edgerton Center and the MISTI teaching programs. The Edgerton Center engages students in K-12 hands-on science, technology, engineering, and math (STEM) education through on-site workshops and intensive summer programs for youth, distribution of curricula developed at the Center, and professional development workshops for teachers. MISTI Global Teaching Labs attracts top students looking to share MIT's unique approach to science and engineering education. Select students are matched with foreign high school hosts for three weeks in January. At each location, students prepare tailored courses on STEM subjects that complement the school's curriculum and highlight MIT's hands-on approach to education. Students prepare for their experience through workshops on effective teaching and classroom techniques.

The MIT educational experience is not constrained to institutional learning opportunities. On the contrary, much of an MIT student's education takes place through interactions within MIT's social fabric. These interactions take place in many forms, but many fall under the umbrellas of extracurricular activities, the Independent Activities Period (IAP), and academic villages.

Not only are MIT students excellent scholars, they are also very energetic, ambitious, and enterprising beyond the classroom. The surprisingly large number of student-initiated and student-driven activities and teams on campus proves this. Not primarily initiated by the administration or faculty, and not part of the regular curriculum, these activities are generated and sustained by students themselves. Students enter into extracurricular activities for many reasons, but most do so primarily because they are interested in changing the world and applying their theoretical knowledge to challenging real-world situations.

FUTURE MODELS FOR MIT EDUCATION

Task Force discussions on future models for MIT education encompassed personal and professional development of students, flexibility, modularity, pedagogy, and assessment. As we discuss each item, we describe possible experiments and pilot projects exploiting opportunities both on campus and online. It is important to note that this preliminary report provides a summary of brainstorming discussions, which may include many ideas that should not be pursued. Phase 2 of the Task Force will revisit these ideas together with new input received from the MIT community, and evaluate and prioritize them.

Shaping the Future MIT Graduate

What are the desired attributes for MIT graduates of the future? As we think about the future of education at MIT, we must think about developing the future citizens of MIT: students who meet the highest standards of academic excellence while being able to appreciate the "big picture," understand their technical world in context, make connections across subject content, work collaboratively, communicate effectively, think and design creatively, deal with uncertainty and complexity, and nurture humane values. In short, we must complement MIT's excellent technical education and experiential learning with other attributes that position our graduates to be leaders in our future society.

We already excel in some of these attributes through a rigorous and demanding curriculum and through rich experiential opportunities such as UROPs, MISTI, and the Edgerton Center. On other attributes we can and should do better.

For example, data consistently show that MIT students' communication skills lag those of their peers.[18] The ability to work and communicate effectively in a team is a critical 21st-century skill, as is the ability to transfer relevant domain knowledge from one discipline to another. The resources MIT will need to achieve these goals are grounded in small class sizes for fostering one-on-one instruction in writing and presenting, including support for faculty critique and review. In addition, faculty time must be dedicated to engaging students with broad reading outside of their technical disciplines, such as the news, literature, and serious nonfiction.

Structural modifications are needed to curriculum organization and teaching schedules to promote faculty awareness of connections among courses (especially, but not limited to, Communication Intensive classes as well as synergies across disciplines). To do this effectively, the Institute will need to support dedicated faculty time for cross-departmental faculty engagement and faculty continuing education. And, importantly, we will need to allocate time in students' schedules for "time on task" in the area of communication skills development.

UROP is a highly successful program at MIT, embodying our educational principle of learning-by-doing. UROP projects contribute to students' growth by deepening their technical skills, exposing them to the research process, and building mentee/apprentice relationships with faculty members. Over 80% of all MIT undergraduates participate in a UROP before they graduate.[19] We should ensure that MIT education and facilities for the future maintain a strong commitment to hands-on experiences and learning-by-doing. As discussed in the section Spaces and Places, new maker spaces all over campus, together with a reinforced commitment to learning-by-doing, could create the next generation of tinkerers, fluent in advanced manufacturing and rapid prototyping techniques.

Building on the success of UROP, we should explore the value of instituting other formal experiential opportunities, reaching beyond technical research experiences to programs that

18. 2011 MIT Enrolled Student Survey, Office of the Provost, Institutional Research.

19. Dean for Undergraduate Education President's Report 2012, http://web.mit.edu/annualreports/pres12/2012.17.00.pdf, p. 60.

could nurture other strengths, such as leadership, an appreciation for societal responsibility, contextualization, and communication.

For example, one can imagine many advantages to instituting a companion program to UROP for teaching: students re-engage with material from the instructor side to deepen understanding, they develop better technical communication skills, they forge mentor relationships with younger students, and in some cases they could contribute to improving STEM education nationwide. The success of peer instruction as a critical component of the learning process in the literature supports the notion that we learn concepts more completely when we are required to teach them.[20] In a teaching role, students have an opportunity to revisit material, understand the details so they can present it in a coherent manner, and contextualize it in the grander curriculum and the real world to make it relatable for their students. Undergraduate teaching opportunities could encompass a teaching experience related to an MIT or *MITx* class. They could also extend into schools within the United States or even abroad, building on successful programs such as the Educational Studies Program (ESP).[21,22]

Another example is a program with an emphasis on service, contributing to the development of future societal leaders. A formal service opportunities program could formally pair students with a faculty advisor to provide guidance and mentoring in the context of a specific service project. Again, such a program would offer opportunities to develop communication and leadership skills, as well as a firsthand appreciation of the value of contributing to society.

There would also be many advantages in establishing a more formal and coordinated Institute-wide program in teaching opportunities for graduate students. Graduate students cite many different motivations for wanting to engage more deeply in teaching:[23] to complement or substitute for TA duties; to obtain teaching experience for academic job preparation; to disseminate one's own research outcomes and build research collaborations; personal fulfillment; and financial incentives. A mechanism to enable graduate students to contribute educational offerings (e.g., delivered over IAP or during the summer, possibly using the edX platform) would tap into the creative resource of graduate (and potentially undergraduate) students as teachers and pedagogical innovators. Classes could be, for example, research-oriented, or tutorials on advanced topics that are hard to find in existing classes.

Successful programs already exist that organize large-scale student-taught classes. One good example is the MIT ESP, whose volunteer teachers (mostly undergraduate and graduate students within MIT) reach hundreds of high-schoolers, through one-hour workshops to semester-long classes. Any effort should build upon and adapt from proven models such as ESP.

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20. Ramaswamy, Shri, Ilene Harris and Ulrike Tschirner. "Student peer teaching: an innovative approach to instruction in science and engineering education," *Journal of Science Education and Technology*, Vol. 10, No. 2, 2001: 165–171, http://www.jstor.org/stable/40186621.

21. Breslow, Lori. "Surveys for the MIT Graduate Student Teaching Certificate Program," 2008–2013, unpublished reports by the MIT Teaching and Learning Laboratory.

22. http://esp.mit.edu/.

23. MIT Graduate Student Council Digital Learning Subcommittee, http://gsc.mit.edu/committees/arc/dls/.

Another largely untapped resource at MIT is the growing postdoctoral population. A formal mechanism by which postdocs can become engaged in educational experiences will be valuable both for MIT classes and for the career development of the postdocs themselves.

Finally, there is a need to better develop our students' ethical skills. This encompasses ethical behavior and academic honesty as it relates to their conduct in education and research—an even more pressing issue with online classes—as well as the broader ethical issues arising in their technical disciplines. A greater emphasis on contextualizing the technical education is one possible way to address this issue.

The following is a list of brainstorming ideas for pilot projects and experiments related to "shaping the future MIT graduate" discussed by the Working Group on MIT Education and Facilities for the Future:

- Encourage the Subcommittee on the Communication Requirement (SOCR) or other relevant body to assemble materials on best practices for teaching effective communication skills as a resource for faculty and staff.
- Support development, deployment, and assessment of online modules on written and oral technical communications that could be used in Communication Intensive subjects across departments.
- Support faculty time for cross-departmental faculty engagement and faculty continuing education on communications skills.
- Explore blended learning models for Communication Intensive classes that enable smaller student-faculty ratios for face-to-face class components.
- Pilot an Undergraduate Teaching Opportunities Program.[24]
- Pilot an Undergraduate Service Opportunities Program.
- Establish an Institute-wide teaching minor at the graduate level.
- Pilot a program for graduate students to contribute mini-classes taught over IAP or summer.
- Pilot a program for graduate students to partner with faculty members to contribute pedagogical innovations to MIT and *MITx* classes.
- Facilitate teaching experiences for MIT postdocs.
- Assess the need for and potential value of establishing an MIT honor code.

Flexibility

More and more, technology is allowing us to customize our environments, our schedules, and our engagement. For example, we no longer need to watch TV shows on a prescribed, cyclical schedule; we can record them for later viewing or watch them online whenever we want. Technology is offering a similar opportunity to customize educational experiences. Just as there is no teaching space or teaching style that fits all academic subjects, there is no one academic trajectory that is optimal for all MIT students. Greater diversity and flexibility could improve the MIT educational experience.

24. Building on a proposal first developed by Professor Travis Merritt and Dr. Lori Breslow in the early 2000s.

To make MIT education more flexible, we should investigate whether departments should be more flexible and adaptable. Should the GIRs be more flexible, for example by allowing Advanced Placement (AP) credit for *MITx* classes or by providing more choices via modularity? In a more flexible educational future, how do we strike the right balance between depth of disciplinary study and cross-disciplinary breadth and "big ideas"?

We could also consider making time-to-degree more flexible. While precedent shows that many students want to do "what others are doing" (the four-year undergraduate program), if more flexibility were available, other standards might emerge with which students could identify themselves. Today, many MIT students could graduate one or two semesters early (e.g., around 25% of MIT freshmen are eligible for early sophomore standing), yet only 5% to 7% do so.[25] Instead of graduating early, our students fill their four years with double majors, minors, UROPs, and international experiences. Some students might prefer to complete their studies in three years, perhaps to reduce financial pressures. Others might want to get an advanced degree in four years.

Our challenge is to use our principles and values to guide us in establishing specific educational outcomes and a qualitative MIT culture to which we aspire. From there, flexibility brings to our students options—options to reduce or extend their time to degree, options to take a year off-campus to undertake research or get relevant professional experience in the middle of their studies, options to engage more deeply in service and teaching opportunities, and options to take classes online over the summer and streamline their programs.

One important question is how this kind of flexibility might impact our MIT culture. As noted above, in the past three years, around 25% of MIT freshmen have been eligible for early sophomore standing; roughly half of those students elect to take it. Roughly 50% of students change their major during their freshman year; around 30% of students even change the school of their intended major.[26] As we consider more flexible models of MIT education, we need to carefully weigh the value of the current common freshman year.

The following is a list of brainstorming ideas for pilot projects and experiments related to flexibility discussed by the Working Group on MIT Education and Facilities for the Future:

- Evaluate the implications and opportunities of offering AP credit for *MITx* classes.
- Explore expanding the offerings of BS/MEng programs, like the 6-P program in Electrical Engineering and Computer Science (EECS).
- Explore opportunities for offering online courses for credit over the summer. This could include classes taken entirely online, as well as classes that combine an online summer portion with an on-campus portion offered in spring or fall.
- Consider bold experiments that permit different tracks within GIRs to give students more flexibility in choosing their degree curriculum.
- Consider bold experiments that permit flexibility in the GIRs through modularity.
- Review faculty policies that restrict innovation in education.

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25. MIT Institutional Research, http://web.mit.edu/ir/index.html.
26. Ibid.

Modularity

We consider here the opportunities associated with greater modularity in the MIT undergraduate curriculum. We define a module as a self-contained unit comprising a set of outcomes. An *outcome* is what the student knows or is able to do as a result of a learning experience. Outcomes are intended to drive the instruction and assessment for the module. Modules can vary in size from a portion of a class meeting to many lectures.

Modularity could be achieved in the MIT undergraduate curriculum in a number of ways. A top-down approach would decompose existing courses into modules; a bottom-up approach would re-engineer a curriculum by identifying the core concepts and associated modules that underlie them or build on them. Because some aspects of the curriculum are more easily modularized than others, modularization should be implemented selectively and carefully.

In addition to providing increased flexibility for students to customize their degree programs, increased modularity presents other opportunities to improve MIT education and even may address some existing faculty resource limitations. Among the most important opportunities are competency-based assessment, better-defined prerequisite relationships, shared faculty/instructor resources for common content across departments, and expansion of undergraduate teaching opportunities.

Flexibility in Curriculum

Introductory classes within many courses are intended to construct a foundation of general department-specific knowledge upon which students can build when they select electives, or even register for graduate-level classes, down the road. Given the soaring popularity in flexible degree programs,[27] however, students are demonstrating a desire to further customize their undergraduate experiences. Offering smaller modules, each focusing on a set of outcomes, will permit students more flexibility in customizing their degree programs. This could be achieved by creating new modules or by decomposing existing classes into smaller modules. Modules could be "vertical"—where module order matters—or "horizontal"—where there are multiple interchangeable orders of learning.

Modularization via decomposition is currently being implemented in the redesigned mechanical engineering flexible 2-A degree program. The new program replaces four traditional 12-unit core courses with eight modular six-unit core courses, thus giving all 2-A students exposure to the full range of subjects considered core to the mechanical engineering degree.

Flexibility in Pedagogy

Modularization also offers flexibility in pedagogy. For example, some aspects of a class may be amenable to online learning or to a particular blended learning model, while other aspects are not. Constructing resources in a modular way offers opportunities to tailor media and pedagogy to the material at hand. It also lowers barriers to faculty experimentation with different media and teaching models.

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27. For example, the flexible 2-A degree has increased tenfold over nine years, http://web.mit.edu/registrar/stats/yrpts/index.html.

Competency-Based Assessment

Currently it is possible for a student to fail a portion of a class and still achieve a passing grade (or even an A or B) in the class. When subsequent classes depend heavily on that prerequisite material, the student is ill-prepared to continue. Greater modularity in the curriculum would permit competency-based assessment—evaluation based on a student's level of mastery on specific capabilities—which could be related to the outcomes comprising a module. This in turn could be used to guide a student's progression through downstream modules.

Prerequisites

Prerequisite relationships can be further delineated with greater modularity in the curriculum. If Class A is a prerequisite for Class B, it is almost never the case that every topic of Class A is a prerequisite for each topic of Class B. In the move to greater modularity, the prerequisite relationships between sections of content in classes will need to be defined in detail. This discovery process will improve students' ability to customize their degree programs, identify commonalities across class offerings, and improve knowledge transfer from upstream classes by raising awareness for faculty and students alike.

Commonalities Across Departments

Viewing content at the modular outcome level, many commonalities exist across classes in different departments. For example, many departments in the School of Engineering offer introductory-level classes on fluid mechanics, each containing essentially the same core material, augmented by department-specific concepts and applications. With greater modularity, the core material can be offered as one module to students across departments, while the department-specific content can exist as separate modules under the auspices of each department. For the common content, faculty/instructor resources can be shared, reducing burden on faculty.

Shared teaching modules could also enhance student learning. The process of reducing the material to its fundamental components would likely reveal multiple ways to present the same material, which could result in materials that reach a wider student audience. Instructors could present concepts in multiple ways—for example, through text, graphics, or illustrations—to reach a wider swath of students effectively.[28] Harvesting the application-specific content and examples would also provide students with examples not only from their own department, but also from other departments, giving students a well-rounded understanding of the core concept and a deeper appreciation for its universality.

Undergraduate Teaching Opportunities

Greater modularity in the undergraduate curriculum may introduce more undergraduate teaching opportunities. Undergraduate teaching assistants are typically chosen from a select group of students demonstrating a high level of mastery of class content. If classes were broken into modules, a student could more easily achieve that high level of mastery on particular

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28. Halpern, Diane F. and Milton D. Hakel. "Applying the science of learning to the university and beyond: teaching for long-term retention and transfer," *Change*, Vol. 35, No. 4, 2003: 36–41.

modules, resulting in many more opportunities for students to teach and thus reinforce and deepen their learning.

Brainstorming Ideas

The following is a list of brainstorming ideas for modularity-related pilot projects and experiments discussed by the Working Group on MIT Education and Facilities for the Future:

- Modularization is already happening in many departments around the Institute (e.g., Mechanical Engineering, EECS). Explore how to take a more strategic approach to identifying modularization opportunities, including opportunities that cross departments.
- Explore further opportunities for synchronous modularization, which is already used in Sloan, Physical Education, and Literature. Are there concerns with pace and pressure issues?
- Revisit Institute rules, e.g., on REST subjects. Is there an advantage to permitting four 6-unit REST subjects vs. two 12-unit subjects?
- Explore how modularity might impact the graduate curriculum through minicourses, which are currently being considered in Brain and Cognitive Sciences.

Transforming Pedagogy: Contextualizing, Connecting, Blending, and Assessing

In combination with new pedagogies, unbundling and modularity permit rebundling of an MIT education in new and interesting ways. They provide an opportunity to emphasize connections and to achieve greater contextualization and "education for practical reasoning".[29] These opportunities are enabled through a combination of digital learning technologies and face-to-face pedagogical strategies. Achieving them will require a commitment to adopting new models of blended learning and an investment in diverse typologies of spaces that cater to different formats of learning. As we transform our pedagogies, it is also an important opportunity to explore new approaches to assessment.

Contextualizing—Understanding the Technical World in Context

MIT alumni contribute to the world in many different ways. Future MIT education must reinforce our commitment to the value of societal responsibility, emphasizing how MIT students can use the gift of their education to make the world a better place, and helping to create the principled leaders that humanity needs. Contextualizing what students learn is an important part of achieving this. Students should understand the societal impact of their decisions and appreciate the ethical considerations that guide those decisions. This could be achieved in part through an increased emphasis on weaving societal impact and ethical considerations throughout the technical MIT curriculum. Modularity and rebundling could be a path to better integration of HASS subjects with science and engineering subjects, resulting in an education that remains rigorous but emphasizes the connection to and the value of humanities. Modularity combined with online modalities also opens the possibilities for more

29. Sullivan, William M. and Matthew S. Rosin. *A New Agenda for Higher Education: Shaping a Life of the Mind for Practice*. San Francisco: Jossey-Bass; 2008.

open-ended, big-picture projects rather than focusing in narrowly on class-specific problem solving (e.g., through projects conducted off-campus in an immersive contextual experience).

Connecting—Across Concepts and Across Departments

If we move toward greater modularity with unbundling, it will be important not to lose the connections among concepts, ideas, and tools. In fact, greater modularity should not break apart the curriculum into standalone pieces but rather elucidate the connections between them. There are already some attempts to draw out connections between components of classes across the Institute (e.g., crosslinks, EECS Curriculum: A Dynamic Graphical Display). By providing advanced recognition of downstream requirements, students will appreciate the importance of what they are currently learning. In downstream courses, students can link back to prerequisite material to refresh their memories.

Identifying linkages among concepts may also reveal commonalities among classes across departments. For example, many departments in the School of Engineering and some in the School of Science offer sophomore-level classes on fluid dynamics. Each course covers essentially the same foundational material, but with applications that differ among the departments. These common concepts can be covered jointly by a number of departments, which would allow some cross-fertilization of the main concepts among students from several disciplines. As more departments adopt flexible degrees, exploiting these common elements may become more relevant and useful.

Blending—Leveraging Online Technologies Together with an On-Campus Experience

Unbundling and modularity offer new opportunities in digital learning. In particular, blended learning models that include presentation of material entirely on-campus, entirely online, and anywhere in between will improve flexibility for students and faculty. Use of blended learning at a modular level also creates an opportunity for faculty to engage in the digital production process with smaller and more manageable units of content. Offering some modules entirely or mostly online would help students pursue opportunities off campus, such as starting a company, gaining valuable work experience, or performing community service. Offering portions of modules online would free up time in face-to-face class meetings in which professors could explore more active learning exercises.

Incorporating digital technologies through blended learning models would also enable more educational research. Blended learning supports different learning styles, as students choose the modality that best suits them, but it is yet unknown whether blended learning is more or less effective than traditional formats; we still have much to discover.

A further challenge is in finding effective ways to bring hands-on experiences to online learning. Virtual and online labs offer expanded access to machinery and equipment and remove the need to be on campus. Virtual labs are simulations that visualize physical phenomena. Online labs (or iLabs) provide an interface to remote machinery and equipment. MIT's roster of virtual and online labs is extensive (it includes classes in courses 2, 4, 5, 6, 7, 8, 10, 20, 22, and MAS) and should continue to grow.

Assessing—Exploring Competency-Based Assessment

What new assessment strategies become available with a move toward unbundling and rebundling in MIT education? With competency-based assessment, students are evaluated on specific abilities that can be related directly to the measurable outcomes for a class or module. Evaluating students at the module level, in coordination with better understanding of prerequisite relationships between modules, can help students and advisors understand students' preparedness for subsequent offerings. Competency-based assessment, as well as other new assessment strategies, will be explored further before the final report.

Brainstorming Ideas

The following is a list of brainstorming ideas for pilot projects and experiments related to "transforming pedagogy" discussed by the Working Group on MIT Education and Facilities for the Future:

- Consider having an "e-learning week," an experiment run annually in the past five years by the National University of Singapore, in which many or all classes are offered online for the week.[30]
- Provide support across the Institute for preparing new courses/modules utilizing blended learning models: encourage sharing best practices among faculty, give general guidelines at the departmental level, and foster and incentivize faculty collaboration.
- Create a mechanism to encourage and support faculty in proposing "real" educational experiments with definitive outcomes, with the caveat that there are many methods to assess outcomes and not everything can be assessed by A/B experiments. Care is also needed on metrics, in particular to distinguish between short- and long-term gains and to guard against compromising authentic learning for better test scores, or compromising enjoyment or socialization.
- A possible experiment could identify narrower vs. broader concepts (e.g., in physics) and assess concept type pairing with media types.
- Have an anthropologist study ESG/Concourse vs. a regular freshman class.
- A possible experiment could assess live lectures vs. online prerecorded lectures, and look narrowly at knowledge gain.
- A possible experiment could assess the benefits of calling out the conceptual linkages and relationships between upstream and downstream classes. For example, a number of MIT classes could be broken down each into a number of modules, and the prerequisite relationships among each module from class to class identified. Extra competency-based assessment of students for each of the modules could indicate whether performance on prerequisite modules is an indicator of performance on subsequent modules.
- Pilot an Educational Innovation Initiative, fueled and run by students.

30. http://www.cdtl.nus.edu.sg/tech-in-he/.

Design-Oriented and Project-Based Learning Experiences

Many of the best learning experiences occur when students are engaged in design-oriented, project-based activities—going through an iterative process of developing, testing, and refining prototypes. MIT has been a leader in providing students with opportunities to engage in design-oriented projects, from the design competitions in Mechanical Engineering to the capstone projects in Aeronautics and Astronautics to design-oriented UROP projects across the Institute. MIT has also led in the development of new technologies to support design-oriented, project-based learning. For example, the ideas and technologies underlying the LEGO® MINDSTORMS™ robotics kits, now used by millions of students around the world, were developed at MIT and first tested in MIT robot-design competitions during IAP in the 1990s.

As MIT develops new online courses and activities, for use inside MIT and around the world, it should build upon this tradition of design-oriented, project-based learning. Many of today's MOOCs focus primarily on delivering video-based instruction to large numbers of students. MIT should aim to develop its own distinctively-MIT approach to online education, not simply by adding MIT content to MOOCs (though that is, in itself, an important contribution), but also by exploring ways to integrate design-oriented, project-based experiences with online learning. The ultimate goal is to create online experiences that are firmly aligned with the principles, values, and strengths of MIT education.

Online On-Demand Graduate Education

Graduate education differs from undergraduate education in at least three significant ways. First, graduate students often enroll in classes to learn material required to advance their research. As a result, the demand for many graduate-level classes is intermittent and sometimes time-sensitive for students. Second, since graduate-level classes involve specialized advanced topics, the enrollment for classes is much smaller than most undergraduate classes. This leads to some classes being offered every other year, resulting in long wait times for some students. Third, graduate students are often more motivated learners, since they have greater flexibility to select their courses than undergraduate students.

Many graduate-level courses would benefit from online incarnations in which students could engage with the material on demand. Furthermore, with content experts in these specialized areas spread across the country and the world, sharing teaching resources among peer institutions would enrich the MIT graduate curriculum and allow graduate students to learn from the leaders of the field in a wider variety of topics. These and other ideas will be further explored by the Task Force, building upon the recommendations of the recent report from the Task Force on the Future of Graduate Education in the Context of *MITx* (TFGEM).[31]

31. http://odge.mit.edu/about/committees/sponsored-by-odge/future-grad-ed/.

SPACES AND PLACES

> *When colleges and universities build, they don't just add to their inventories of floor space. They reveal—sometimes unwittingly—their prevailing values, aspirations, and preoccupations. Campuses are evolving, continually contested representations of the communities they house.*
>
> *—William J. Mitchell, in* Imagining MIT: Designing a Campus for the Twenty-First Century, *2007*

How should spaces and places at MIT evolve to support, and build upon, future directions in education on campus? The 2012 Report of the Working Group on the Future of Campus Teaching and Learning Spaces (Professor John Brisson, chair) carefully and thoughtfully addressed this question. Following this, in fall 2012, MIT announced *MITx*, a major new initiative seeking to expand access to education for students worldwide through online learning, while reinventing campus education through blended models. In its first 18 months, *MITx* educated over a million students in 190 countries. On campus, over 2,000 MIT students, and two dozen classes, have now used *MITx* for a wide range of learning activities, from individual problem sets to full flipped courses.

The momentous rise of digital learning, on campus and beyond, motivates a second look at facilities for the future of MIT. This working group presents two findings. First, the main recommendation of the Brisson Report, that MIT focus its renovation plans on developing "academic villages," is timely and prescient in the new light of digital learning. Second, MIT's anchor in the tide of online learning is its dedication to hands-on work; sustaining this calls for establishment of a system of "maker spaces" to ensure that experiential learning remains deeply tied to the lifeblood of education on campus.

These two ideas, village places and maker spaces, are detailed below, from the perspective of digital learning at MIT.

MIT classroom photo, Andrew Chen, 2001.
Stata Center Student Street photo, Daniel Jackson.

Academic Villages

Boundaries between traditional learning spaces and informal learning places have long been shifting at MIT, driven inexorably by the growing ubiquity of information access and the advent of digital learning tools. The classroom is evolving from a room-with-a-blackboard to a laptop with a network connection to the cloud and an online forum—blended with in-person hands-on activities. Teaching is evolving from podium-based knowledge broadcasting to interactive small-group discussion. Assessment materials are evolving from weekly paper problem sets to instantly graded, interactive questions and simulations, and evaluations from multitudes of peer learners. Training is giving way to apprenticeship; information delivery is giving way to interactive learning.

Above all, there is a blending of approaches, and a richness of variety and experimentation. In flipped classrooms, students watch lectures beforehand and meet with the instructor for discussions and problem sessions. Blended classrooms explore everything in between: administering assignments online but retaining traditional lectures, for example, or combining video lectures with in-class experimental design lab sessions among small student teams.

This evolution poses institutional challenges for spaces and places. What kinds of classrooms best support such blended learning? How are classrooms best configured to support discussions and teamwork? Where should classrooms be located to accentuate and grow the magic of on-campus (versus online) education?

The answer proposed by the Brisson Report is the *academic village*:

> A village could include classrooms, breakout spaces, study spaces, technical support, light food services and library facilities. Faculty offices and laboratories could be integrated into and about these spaces. A village should be designed to promote serendipitous interactions between students and faculty members, inviting and attracting students and faculty to linger and work in the academic areas of campus rather than withdrawing to their more distant living spaces. These spaces should support pre- and post-class conversations.

This idea—that blended learning needs blended spaces—is prescient. As the Brisson Report observes,

> Research into Science, Technology, Engineering, and Mathematics (STEM) teaching and learning over the last several decades has led to a new understanding … that learning is a dynamic process, and that when students are actively involved in their own learning, that learning improves. This leads the Working Group to believe that there will be demands for different kinds of classrooms in the future.
>
> A number of pedagogies have been developed based on this new paradigm. Together, these methods are sometimes referred to as “active learning” or “pedagogies of engagement.” They include peer learning, problem-based learning, project-based learning, service learning, or student learning communities. As a group, these pedagogies require spaces that are more flexible and configurable than traditional lecture halls have been.

Here, we call out three specific points from the Brisson Report that gain near-term urgency in light of digital learning:

1. *MITx* is projected to grow substantially, and the digitization of course content is significantly enabled by low-cost, self-service video (and whiteboard) lecture capture. This capability should be widely available, among a large range of classrooms in and near academic villages, in contrast to existing distance education classrooms, which are expensive to use, hard to book, and isolated from informal communities.
2. Blended teaching experiments will likely grow in number, and will require classrooms different from the traditional. The most effective format for such experimental learning environments has been the TEAL classroom. It is recommended that two to three TEAL-style classrooms, each seating 60 to 80 students, be constructed. These should be strategically located throughout the campus; be flexible, comfortable, and easily configurable; be integrated into academic villages; and be available after class hours as student study space.
3. Residential campuses like MIT's increasingly need to deepen the connection between student residences and campus education. Surveys show that an increasing amount of learning is happening in dorm rooms and common areas due to the accessibility of course content online. The apocryphal story of an undergraduate who earned five degrees in four years by holing up in his Burton-Conner dorm room, leaving only for exams, may become a more common reality, in the absence of stronger academic ties to residences. Build a vibrant West Campus academic village. Elevate the locale around the Stratton Student Center to provide formal as well as informal learning.

Maker Spaces

Virtualization of learning increasingly draws students away from the hands-on activities that are core to MIT's values. MIT's founding idea, *mens et manus*, combining principled understanding with mastery of practical application, underlies the primacy of Institute laboratory courses and experiential learning opportunities on campus. However, labs are increasingly turning into simulations (e.g., 6.004 and 6.111, which both now revolve around software), and students increasingly enter and graduate from MIT having mastered far fewer practical skills, as memorialized by a video documentary[32] showing fresh MIT engineering school graduates struggling with how to wire up a light bulb to a battery.

Today, we face an increasing challenge in giving our students the knowledge and experience of reducing theory to practice, given the rise of digital learning. How many MIT students can readily make a computer control the lights in a room? Or build and connect sensors to gather environmental data? There is great excitement and desire among our students for learning such real-world skills, and need from faculty for such skilled students, particularly for UROPs. Today, the number of student users of the Edgerton Shop and the Hobby Shop are at all-time highs, and the number of users of the Media Lab shop has grown by an order of magnitude in the last decade. However, at the same time, many shops around MIT sit unused or are being

32. Schneps, Matthew H. and Philip M. Sadler, *Minds of Our Own*, Harvard-Smithsonian Center for Astrophysics, 1997 [DVD].

decommissioned, while many student activities such as the Solar Electric Vehicle Team have had to move off the main campus for lack of space.

The tide of online learning may engulf MIT in the next decade, but our educational principles and values can be held steady given an anchor in experiential learning and practical arts. The anchor proposed is a system of *maker spaces*.

Maker spaces are places for communities of people who have a passion for making things, and who want to share that passion by making with others. Crucially, maker spaces build on lightweight rapid fabrication tools and techniques such as 3-D printers, laser cutters, and Arduino microcontrollers, in contrast to traditional machine shops housing heavy equipment such as lathes and milling machines. In fact, maker spaces are to traditional machine shops much as early Athena clusters—with mini- and microcomputers—were to central computing facilities.

Maker spaces focus on personal fabrication and, importantly, on innovation and "experimental play":[33]

> The JPL managers went back to look at their own retiring engineers and … found that in their youth, their older, problem-solving employees had taken apart clocks to see how they worked, or made soapbox derby racers, or built hi-fi stereos, or fixed appliances. The young engineering school graduates who had also done these things, who had played with their hands, were adept at the kinds of problem solving that management sought. Those who hadn't, generally were not. From that point on, JPL made questions about applicants' youthful projects and play a standard part of job interviews. Through research the JPL managers discovered that there is a kind of magic in play.

This kind of experimental play with cutting-edge technology was exactly what Project Athena enabled at MIT in the 1980s. It gave students a chance to play with personal computers, unleashing a torrent of creativity heralding the modern age of software.

Project Athena fishbowl, circa 1988. Photo: Isaac Chuang.

Maker spaces at MIT could bring to personal fabrication, in the next decade, exactly what Project Athena did for computation at the end of the last century. Maker spaces around the world are now providing

33. Experimental play as described by Stuart Brown and Christopher Vaughan in, *Play: How It Shapes the Brain, Opens the Imagination and Invigorates the Soul*. New York: Penguin; 2009.

hobbyists and students with the means and experience to access cutting-edge personal fabrication technology. This technology has deep roots at MIT. This is where one of the first 3-D printers was created, one of the leading waterjet cutters was invented, and the software tools for Arduino-class microcontrollers were first envisioned. And much of this spirit is inspired by the "How to Make Almost Anything" course taught at MIT, which teaches fabrication skills to students of all backgrounds.

Imagine a system of maker spaces at MIT. A series of small, focused maker spaces is strategically located around campus (much like early Athena clusters). These may be general-purpose, located within an academic village, providing a suite of standard rapid fab equipment; their purpose would be to get students started and to feed growing efforts into larger and more specialized shops such as the Hobby Shop (in the Stratton Student Center), the Edgerton Shop, and the Media Lab shop, which are some of the best "organically grown" maker spaces at MIT. All the spaces would be maintained either centrally or by departments, labs or centers, with particular care to student safety and with strong ties to courses and student activities.

Working Group 2

The Future Global Implications of edX and the Opportunities It Creates

Today, I ask that this Task Force be bold in experimenting with ideas that would both enhance the education of our own students on our own campus and that would allow us to offer some version of our educational experience to learners around the world.

—President L. Rafael Reif

INTRODUCTION

The digital revolution can be felt across a number of industries, from publishing to media to retail. While the adoption of digital technology presents its own set of opportunities and challenges in each industry, several overall trends have surfaced across the spectrum. First, and most obvious, is the massive scale of adoption. YouTube, for example, claims a viewership of over one billion unique viewers and over six billion hours of video watched every month, with 70% of the traffic originating outside the United States.[34] Second, the industries have seen increased potential and demand for disaggregating, or unbundling, their products. Newspapers, for example, have become disaggregated into individual articles available piecemeal online. These are often curated and aggregated by other online sites such as The Huffington Post or Drudge Report. Apple unbundled albums into 99-cent songs, and users aggregate individual songs into playlists. Third, traditional boundaries in various media and platforms are becoming less distinct, creating new opportunities and greater potential for collaboration. The availability of online video through YouTube, iTunes, Hulu, and other sources, for example, has blurred the boundaries between traditional television programming, cable, computers, and mobile phones. Telecommuting blurs the line between offices and homes. Online retail has blurred the boundaries between brick-and-mortar stores such as Walmart, e-commerce sites such as Amazon, and auction sites such as eBay.

The digital revolution has transformed how our students communicate, access information, conduct research, and collaborate. However, until recently, the impact of the Internet on the framework of higher education, which pioneered many of the digital technologies that have impacted the world, has been relatively minimal. Online education itself is not new. Massive open online courses (MOOCs), however, are less than 10 years old. MOOCs represent a new phase in the evolution of online education because they address student populations at a scale inconceivable even five years ago. MIT's launch of *MITx* and edX marked the entry by traditional not-for-profit residential universities into the realm of MOOCs in an emphatic way. Many of the trends that have affected other industries are becoming relevant to institutions such as MIT. We examine the implications in this report.

EdX has already enabled MIT professors to reach hundreds of thousands of students in a year, a number that exceeds MIT's student population by more than an order of magnitude. An MIT professor might reach more students in a single edX class than in a lifetime of conventional teaching. This creates opportunities and implications not unlike those faced by other industries affected by the digital revolution. Meanwhile, the demand for education—as a basic human need—continues to grow. Over 400 million individuals of tertiary-education age around the world aren't enrolled today. Meanwhile, the value of education in developing individuals, cultures, and societies is unquestioned. Simply stated, educational access is an important global need.

Reaching out to the global community has repercussions for all facets of MIT. The MIT community engages in a variety of activities—undergraduate education, graduate education, research, thought leadership, extracurricular activities, innovation, entrepreneurship, technology transfer, and international collaborations, to name a few—and each of these may both contribute to and be impacted by the global implications of new digital learning

34. http://www.youtube.com/yt/press/statistics.html.

technologies. We address four strategic implications of digital technology on MIT: implications of *MITx* and edX on the world, opportunities for MIT resulting from engagement with the world, implications of disaggregation on residential and online education, and possible implications of blurred boundaries on MIT.

IMPACT OF *MITX* AND EDX ON THE WORLD

The range of innovations possible can be understood by considering three broad sets of options: the different audiences for *MITx* classes delivered over edX, the different modalities by which students could learn the material, and the different outcomes to which students could aspire. We examine each below.

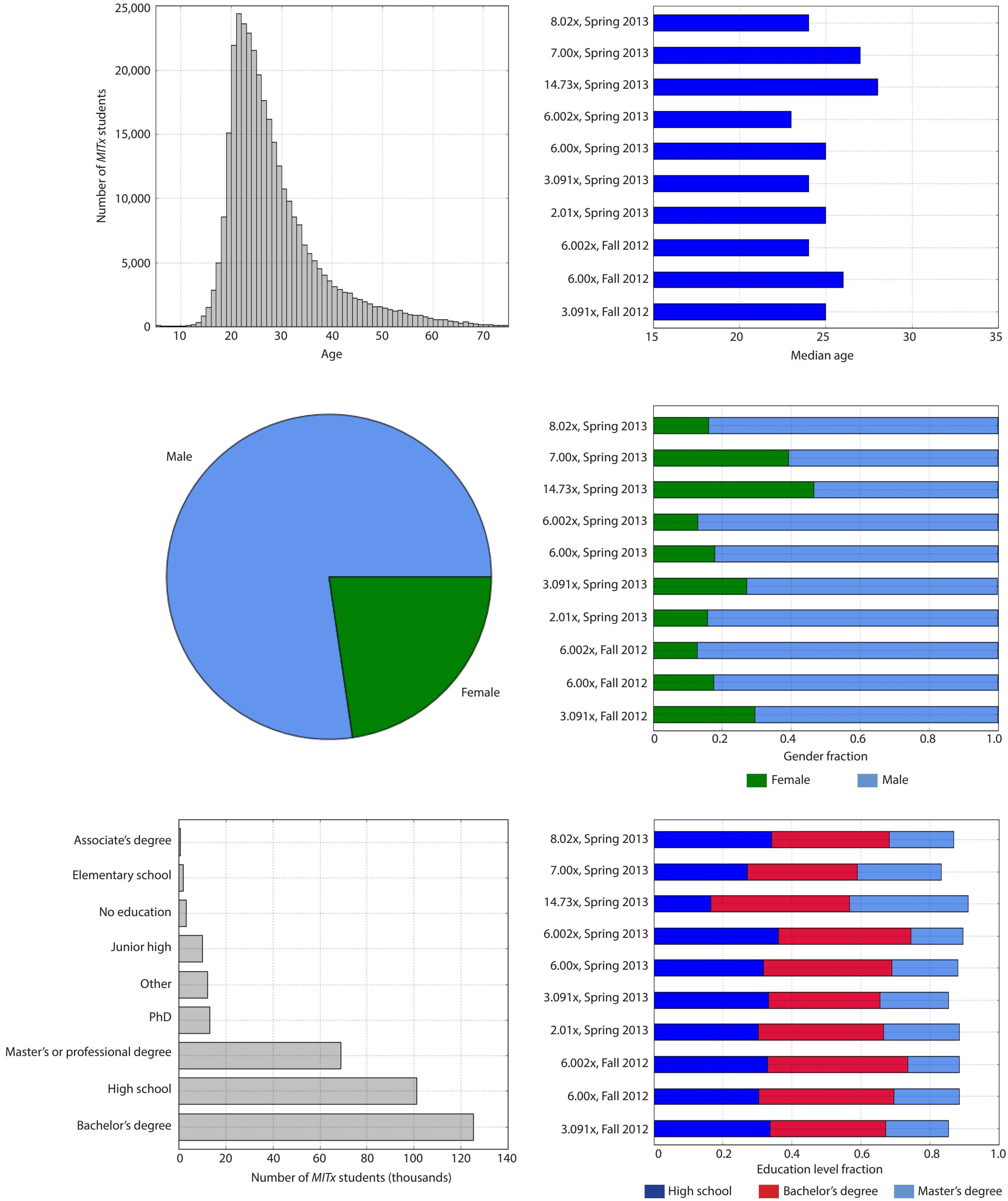
MITx Audience Demographics

Figure 6 shows the demographics of *MITx* students from fall 2012 through spring 2013.

Although all of the classes are at the undergraduate level, the median age of the overall population is about 25, and the mode is 21. A further examination of the highest undergraduate degrees attained by students prior to taking *MITx* classes indicates that a substantial number of students study online while they are working—either for professional development or simply to “catch up” with the latest thinking. Primary and secondary school teachers are another demographic whose role will be affected significantly in the years ahead. Already, 8.MRev, offered by *MITx* over edX in summer 2013, offered continuing education unit (CEU) credits to U.S. high school teachers. With these insights, and with anecdotal information gathered from surveys, we segment the student population as follows. We specifically do not consider MIT students in this section—we will look at MIT students later.

- Primary and secondary school students
    - While embedded in school
    - Self-learners
- College students outside MIT
    - Through the college/university
    - Self-learners
- Professionals (MIT alums or other)
    - Working professionals learning materials through their companies
    - Self-learners
- Educators
- Individuals seeking personal enrichment

Figure 6. Demographics of *MITx* classes, fall 2012 to spring 2013



All figures courtesy Daniel Seaton and Isaac Chuang, MIT.

Examination of the surveys submitted by edX students reveals a few other motivations that are only partially covered by the classification above. For example, a few students in countries such as Russia who are very familiar with physics might enroll in a physics class to practice English instead of physics. These groups are small, and we set them aside for the time being.

The demographic data also show that a majority of the students were male. Of the classes, two had significantly higher female fractions: 14.73x, The Economics of Global Poverty, and 7.00x, The Secret of Life (a biology class). Furthermore, of the classes listed, only two had female instructors: 14.73x and 2.01x. None of the classes was taught by a member of an underrepresented minority group. These issues will need to be addressed in upcoming offerings of *MITx* classes. It will be important for classes offered on *MITx* to represent the diversity that makes MIT a special place.

***MITx* Delivery Modalities**

The typical *MITx* class offered on edX involves videos, assessments (which may range from multiple-choice questions to games or simulations such as protein folding), and links to other resources, all of which are online. However, other modalities are also possible, and we examine them below.

Hands-On Experiences

The Institute-wide Task Force was fortunate to benefit from the work of an earlier *MITx* task force on hands-on activities chaired by Professor Jesús del Alamo, which described a number of hands-on elements that could be introduced to students taking *MITx* classes through edX around the world. There are two approaches here: remote labs, such as MIT's iLabs concept, and home kits for edX students to perform experiments or build units wherever they are.

iLabs are real labs that can be manipulated over the web.[35] Students can log in to an iLab and perform experiments such as testing the performance of an RC circuit. A real RC circuit runs in the background, connected by instrumentation to the interface the student sees, often including a video camera pointed at the experiment.

Home kits are not new, and they can be purchased in most educational supply facilities. Our proposal, however, is to develop advanced home kits for classes such as chemistry and robotics with which students can perform advanced design and experimentation. An example of such a kit might be the LEGO® MINDSTORMS™ robotics kit, of which a key developer was Professor Mitchel Resnick, a member of the Institute-wide Task Force.[36] It is conceivable that *MITx* classes taught through edX could be linked to activities on home kits. Although these kits might be too expensive for individuals, they could be made available through schools, colleges, and libraries. Such possibilities may enable online education to bridge the gap between the online world and real-world experiences.

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35. Harward, V. Judson, Jesús del Alamo and Vijay Choudhary. "iLab: a scalable architecture for sharing online experiments," International Conference on Engineering Education, 2004.

36. Martin, Fred, et al. "To Mindstorms and beyond," *Robots for Kids: Exploring New Technologies for Learning*, Morgan Kaufmann, San Francisco, 2000: 9–33.

Local Fabrication and Partner Universities

The advent of 3-D printing has galvanized a new community of manufacturing and hobbyist aficionados who refer to themselves as makers. We recognize the importance of this movement and the opportunity to leverage it to encourage learning. Maker facilities are now developing around the world. In particular the fab lab consortium spearheaded by Professor Neil Gershenfeld has installed fab lab maker facilities at over 200 locations around the world, including Jalalabad, Afghanistan, and Paramaribo, Suriname.[37] These facilities can be incorporated into *MITx* curricula to enable students to gain the hands-on experience so important to MIT's *mens et manus* ideals.

The idea of local fab labs can be expanded to include local universities. MIT has several university partnerships around the world. *MITx* classes could be taught in collaboration with MIT and xConsortium partner universities so that students could receive hands-on instruction at these facilities.

The iLab and fab lab models directly challenge our traditional notions of educational supply and demand in two ways. First, labs are expensive to maintain and run, but an iLab arrangement allows institutions to share labs. The time and expense associated with configuring lab experiences can suddenly become more widely distributed, and the latencies in lab usage are reduced. Overall, we can see the implications for positively affecting the economics of education through the availability of lab experiences at much higher magnitudes, including more sophisticated labs and more lab time to users. Second, these types of initiatives facilitate the creation of communities of learners around the world who access the same labs, exchange ideas, and bring new contexts into the learning space. It is a very powerful shift, and it represents the type of pedagogical change that open initiatives can enable.[38]

Alumni, Mentors, and Local Learning Communities

Early experiences with edX taught us that students seek community. Communities first formed in online forums but quickly moved to physical "meetups" in places as diverse as Cairo and São Paulo. There are over 860 known local communities around the world today (shown on a map in Figure 7) that are managed by edX through a community organization function. The thirst for interpersonal interaction is also not surprising given the literature on the topic.[39]

MIT alumni can play an important role in these communities by acting as nucleating agents and catalysts, and serving both as anchors to the community and as coaches and mentors. Partner universities could also play a role in this regard.

In fact, we have already tested this idea through a project with the city of Chicago called ChicagoX. MIT alumni acted as mentors to students in Chicago who took a computer science

37. Gershenfeld, Neil. "How to make almost anything: the digital fabrication revolution," *Foreign Affairs,* Vol. 91, No. 6, 2012: 58.

38. Kumar, Vijay, "The new landscape for innovative transformation of education," *Social Research: An International Quarterly*, Vol. 79, No. 3, 2012: 619–630.

39. Mackey, Katherine R.M., and David L. Freyberg. "The effect of social presence on affective and cognitive learning in an international engineering course taught via distance learning," *Journal of Engineering Education* Vol. 99, No. 1, 2010: 23–34.

Figure 7. EdX communities worldwide, November 2013

Source: http://www.meetup.com/edX-Communities/

course offered by *MITx* through edX. The experiment was a success, with alumni reporting mostly good experiences and a willingness to try again. The alumni were also able to give MIT constructive feedback about the experience and about the software platform. We intend to try a larger-scale experiment in spring 2014.

MIT students can also benefit by visiting learning communities around the world, acting as local coaches and mentors and creating a sense of connection with MIT. We experimented with this in summer 2013, when 10 MIT students trained on the MISTI (MIT International Science and Technology Initiatives) platform visited four countries and acted as *MITx* ambassadors during their MISTI internships. We believe this form of learning by teaching will be a new and growing opportunity for MIT students in the same way that the Peace Corps was a generation ago.

MIT/Partner University Visits

It is also conceivable that students who take *MITx* classes could visit MIT for an intensive weeklong class or a summer camp. The idea of campus visits could also be extended through xConsortium partners; for example, a student taking an *MITx* class from China could visit a Chinese xConsortium partner university. This idea could also be combined with the idea described above, so that MIT alumni or current MIT students would participate in intensive camps that provide enhanced coverage, hands-on activities, and discussions about the topics being taught.

Outcomes of an *MITx* Class

There are many possible outcomes of an *MITx* class. A basic outcome is personal enrichment. The desire for this is already borne out by the success of OCW, which receives over two million visitors a month. However, there are other creative outcomes, many of which are also being considered by edX and all its partner universities. Although edX is a not-for-profit, there is a desire to make it self-sustaining. There may therefore be a fee associated with some of these other outcomes. We will not discuss them here because they are decisions for edX, its partners, and its board to make.

Certificates

As with many MOOC providers, certificates are routinely given at the completion of an edX class today. The question of academic honesty is being addressed in a number of ways, ranging from physically proctored exams to electronic proctoring. While MIT does not currently offer credit for certificates received on the edX platform, several institutions have started to do so. An alternative to certificates is badging, in which students receive badges for more granular achievements such as finishing a problem set. This gamification of the class results in goal-seeking behavior that may be more effective at promoting perseverance.[40] A modest experiment with badges was conducted as a part of the ChicagoX program. Badges also have implications for aggregating competencies. Competencies were discussed in the report of Working Group 1, and we will discuss aggregation later in this section.

Sequence Certificates

If a course earns a certificate, can there be a certificate for a sequence of courses? President Reif hinted at this in his inaugural address. Sequences can be thought of as "minors" that offer greater depth in a field than a single class. At the time of writing, *MITx* has launched two sequence certificates.

A natural next question is whether this reasoning could lead to an online degree. Georgia Tech has announced an online degree in computer science with Udacity and AT&T.[41] Since the objective of this report is to list possibilities, we leave the question on the table for MIT.

MIT as an Outcome

An additional outcome for a student who does well in a class may be a semester at MIT, a transfer to MIT, or even admission to MIT. While this is not MIT policy, and may never be, it has already occurred informally. A few successful edX students have in fact already been admitted to MIT in part on the strengths of their edX performances. One of them, Battushig Myanganbayar of Mongolia, was mentored by an MIT alumnus in Ulan Bator.[42]

Several MIT faculty members have expressed concern about the potential negative consequences of this emerging possibility. Concerns stem from the fear that high school students, who are already under pressure to overachieve to get into a good college, will now implicitly be expected to excel in MOOCs as well. On the other hand, online courses may be a "sensor" enabling MIT to detect talent and merit among students before they apply to MIT. Taking *MITx* classes may inform students of the great benefits of attending MIT, thereby greatly increasing the talent pool MIT draws from. This form of outreach may also help MIT reach minority populations. MIT may be able to approach luminaries from different communities who, by publicly taking or promoting an MIT class, may be able to encourage young people to consider an engineering education—preferably at MIT.

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40. Goligoski, Emily. "Motivating the learner: Mozilla's open badges program," *Access to Knowledge: A Course Journal*, Vol. 4, No. 1, 2012.

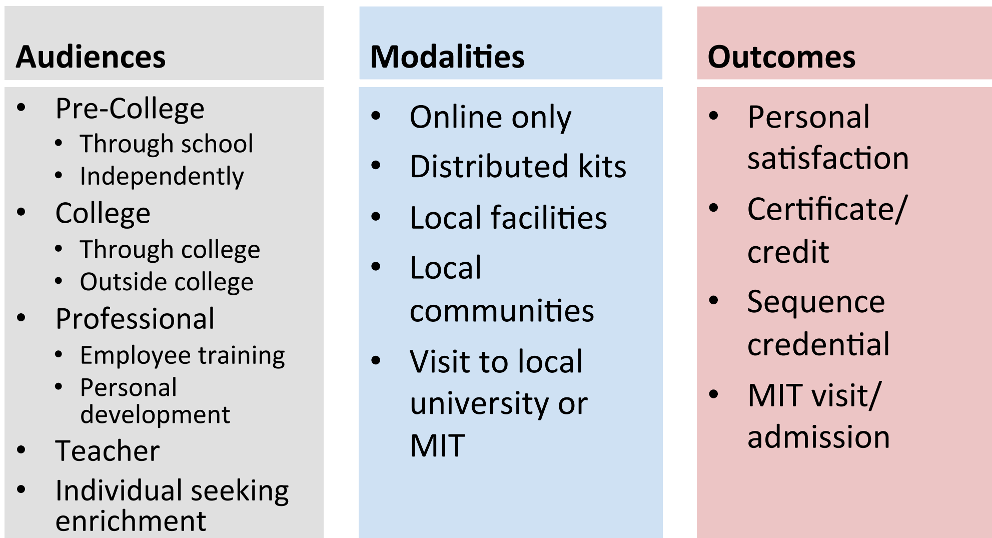
41. Lewin, Tamar. "Master's degree is new frontier of study online, *New York Times*, August 17, 2013.

42. Pappano, Laura. "The boy genius of Ulan Bator," *New York Times*, September 13, 2013.

Combining the Possibilities

We believe that many of the new opportunities in the global realm will come from combinations of the three categories: (a) addressing different audiences, (b) with different modalities, and (c) considering different outcomes. We show this in Figure 8.

Figure 8. The range of options for *MITx* classes

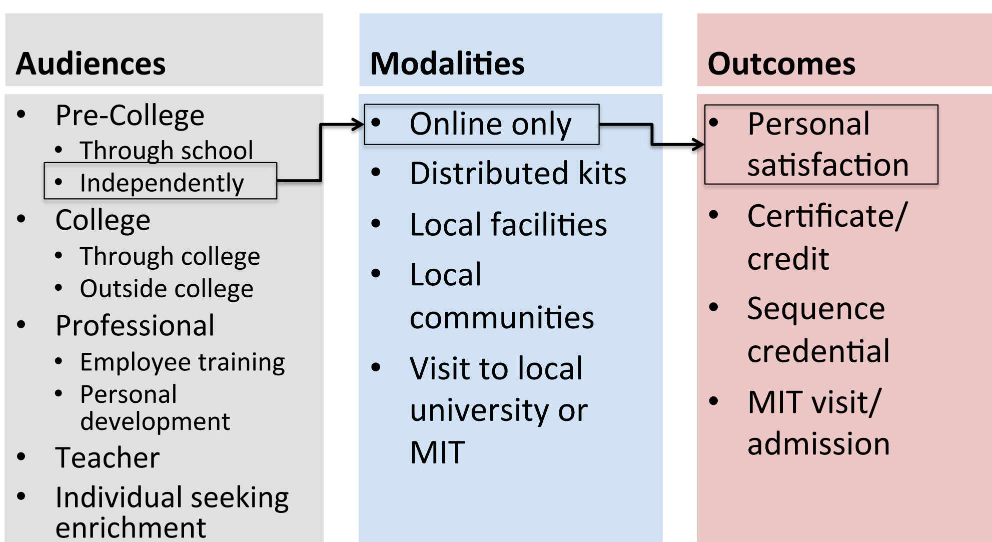


This framework enumerates several opportunities for *MITx*. We examine some scenarios below.

High School Student Takes a Class for Personal Edification

A student attending high school in Pennsylvania takes 6.00x, Introduction to Computer Science and Programming, outside her school. She does this entirely for her personal edification. This is the basic case shown in Figure 8a.

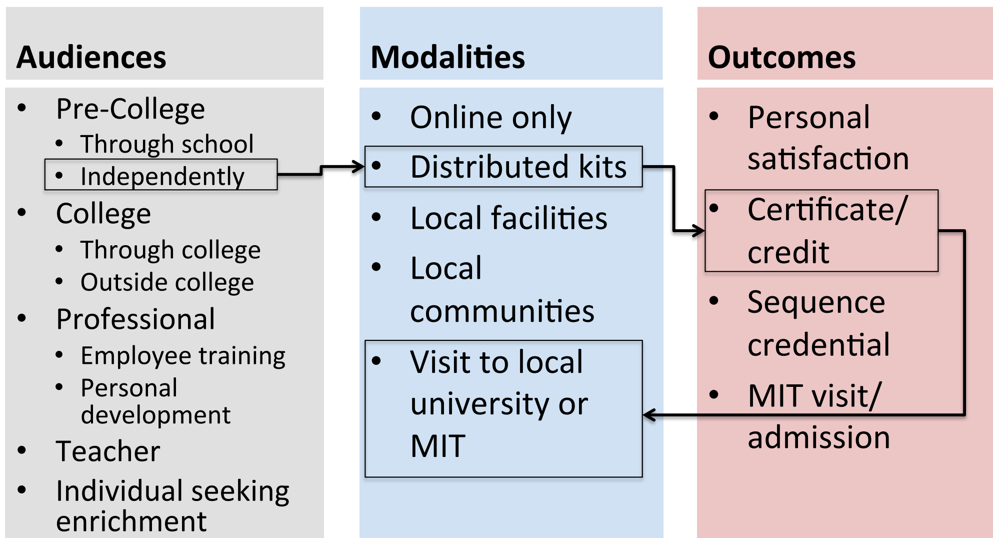
Figure 8a. Student takes a class for personal edification



High School Student Visits MIT for One-Week Summer Camp

A student at high school takes a robotics class, gets a certificate, and requests credit at her school. The class involves distributed kits for programming robots. She does very well, and she also visits MIT for a three-week summer camp for an intensive session on programming video games. This is shown in Figure 8b. Many examples exist of this summer activity approach, including Johns Hopkins University's Center for Talented Youth.[43]

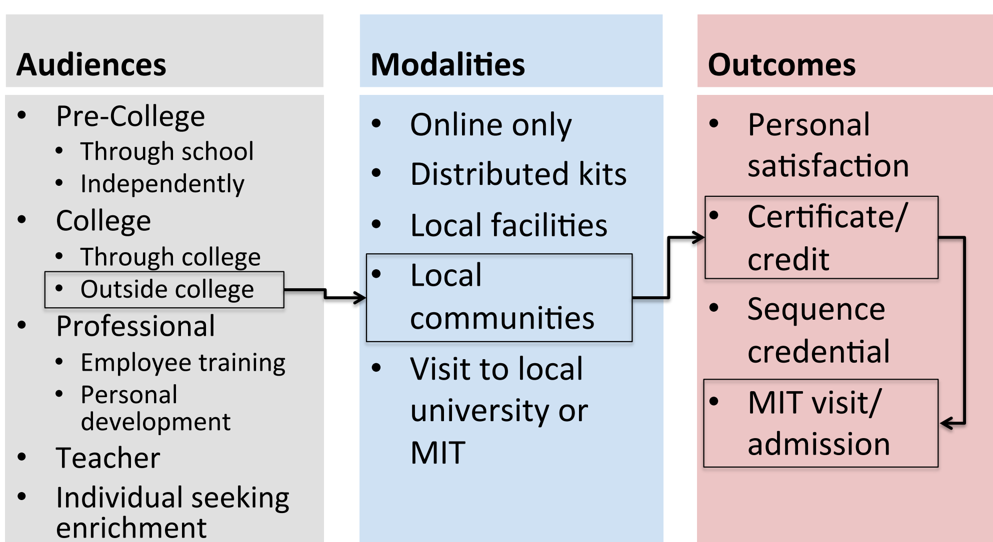
Figure 8b. High school student attends a summer camp at MIT



College Student Takes MITx *Class, Excels, Transfers to MIT*

A student at the Indian Institute of Technology, Campus X, takes 2.01x, Elements of Structures. In taking the class, she engages with a local community of learners mentored by an IIT professor who happens to be an MIT alumnus. She receives credit and subsequently works on a project with her professor that is of interest to a colleague at MIT. Armed with her excellent grades, her project, and her 2.01x performance, she applies for transfer to MIT. She is accepted, and she continues her education at MIT. This trajectory is shown in Figure 8c.

Figure 8c. Student excels, transfers to MIT

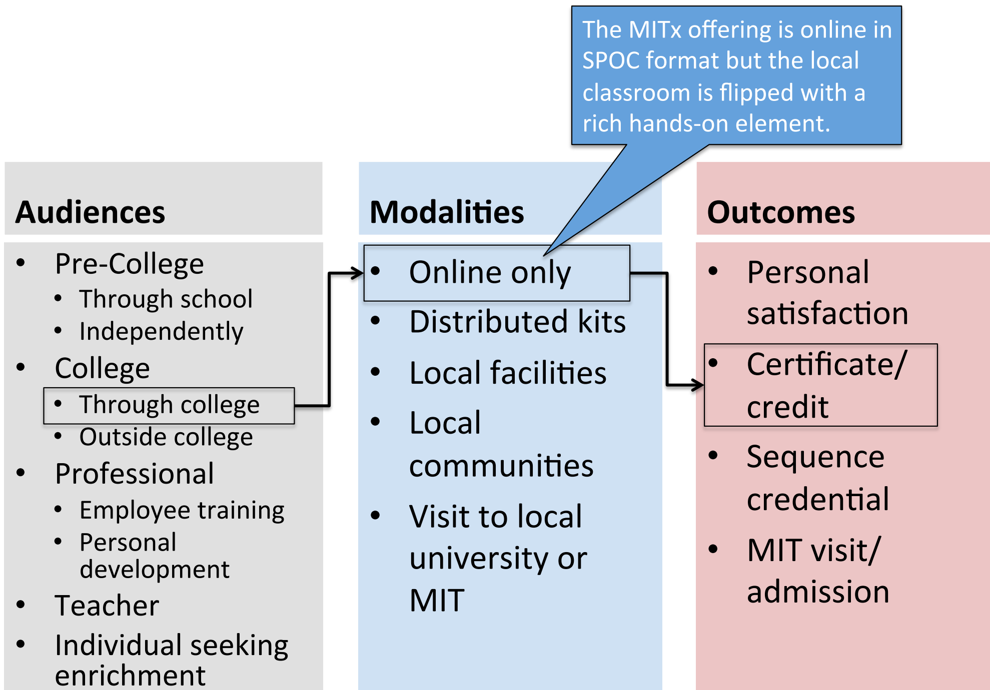


43. http://cty.jhu.edu/.

College Student Takes MITx *Class Through License at Her Institution*

A university in Brazil licenses 8.02x, Electricity and Magnetism, and delivers it to its students as a small private online course (SPOC). A student takes the class while embedded in the university. The university gives the student a grade in the class. The class itself is taught in blended format, because this university, which is new, is modeled on this cutting-edge pedagogy. This is shown in Figure 8d.

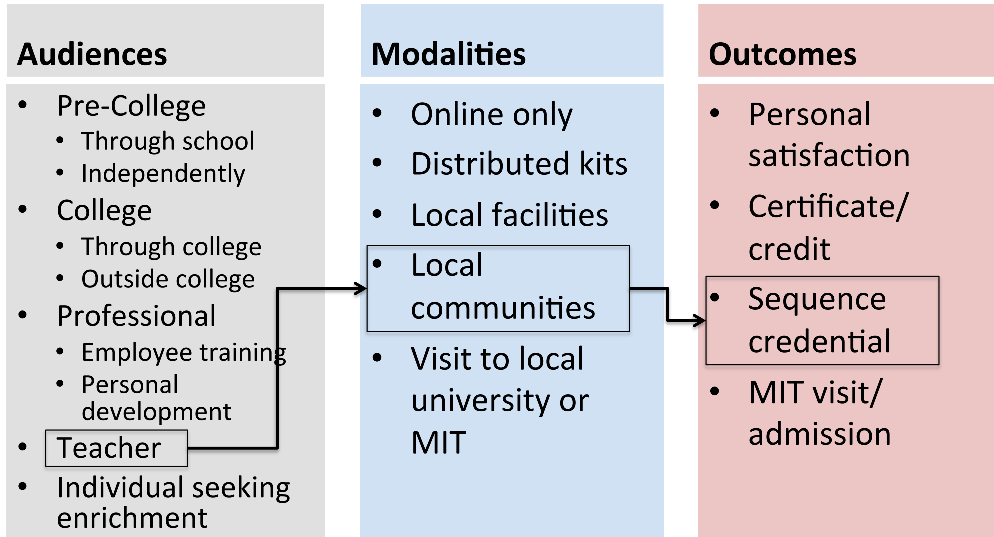
Figure 8d. Student takes a class in SPOC form while embedded in institution



A Teacher Takes a Class to Enable Him to Innovate in His Classroom

A professor at the same university in Brazil wishes to flip his classroom in physics. He seeks to understand best practices, as well as credibility, to persuade the university to support his experiment. He takes 8.MRev, developed by Professor Dave Pritchard and his team, to explore other ways to teach the material. He works with a local community of professors and passes the course, receiving a certificate. He also takes the underlying classes, 8.01x and 8.02x, and seeks a sequence certificate that MIT offers titled “Physics Teaching Series.” This is shown in Figure 8e.

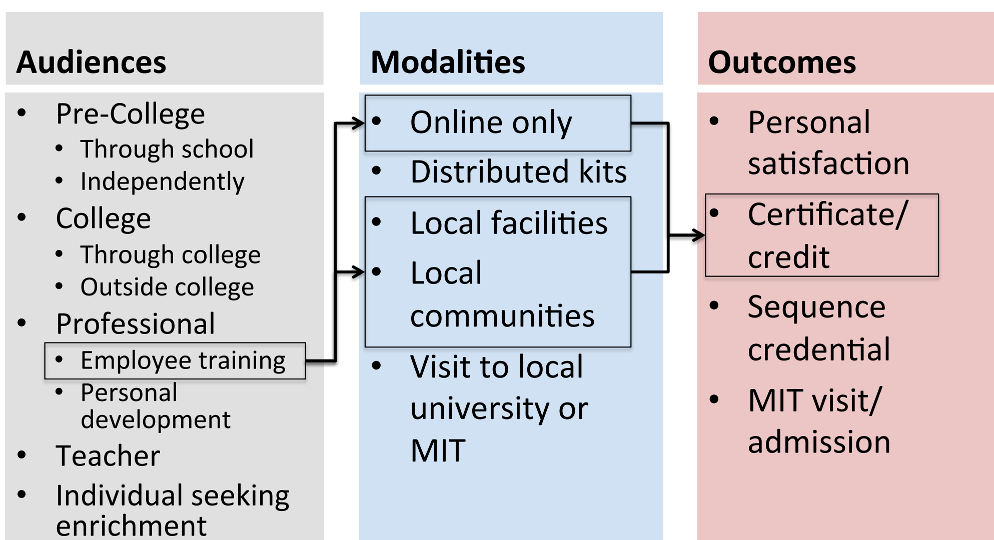
Figure 8e. Teacher takes a course sequence, gets a sequence certificate



A Professional at a Company Takes a Continuing Education Class Through the Company

Engineers at a medium-sized enterprise take a design and manufacturing class with the sponsorship of the company. They form a local community and are mentored by local MIT alumni. They also access a local fabrication facility so that they can make parts and receive hands-on experience. Leaders in the company sponsor this class because they want their engineers to become experts in manufacturing so that they can bring it in-house. This is shown in Figure 8f.

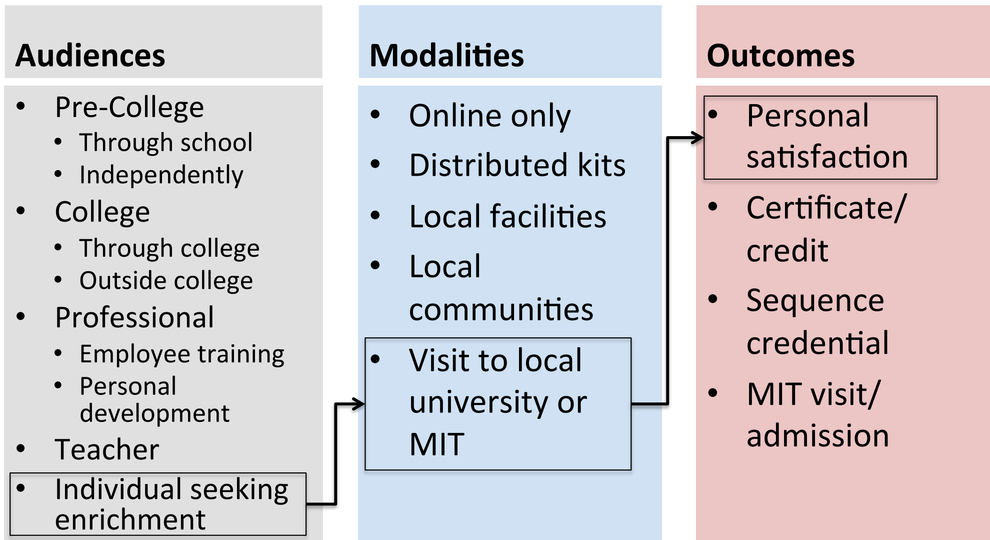
Figure 8f. Professional takes a class while embedded in a company



Retiree Seeks to Learn About the Aerospace Industry Before Visiting the Smithsonian Museum

A retired engineer becomes interested in the aerospace industry. He takes an *MITx* class on the history of the industry, perhaps created by Professor David Mindell, before taking his grandson to the Smithsonian Air and Space Museum for his birthday. He does this entirely out of an interest in personal enrichment. This is shown in Figure 8g.

Figure 8g. Retiree takes an *MITx* class



Other Scenarios

We have developed a framework for looking at different scenarios, as well as enumerated a number of them. There are other activities that MIT could pursue for engaging the world. The concept of an online degree is also one that must be listed for intellectual completeness. Current MIT regulations require at least a semester of residency, but we must consider, even if we reject it, the option of changing that rule.

MOOC.org + OCW = Customized Build-Your-Own MOOC

MITx is not the only international access project at MIT. Another such project, mentioned previously in this report, is OCW. The interplay between *MITx* and OCW creates several opportunities. Although OCW and *MITx*/edX both use the word “open,” they mean different things. “Open” in OCW indicates education resources that may be distributed using a Creative Commons attribution-noncommercial-share alike license. Anyone may download the material and reuse it according to that license. EdX, on the other hand, uses “open” to mean freely accessible web-based classes. A MOOC may not make its videos, for example, downloadable for reuse, and OCW does not offer a course that may yield a certificate. These two independent functions, though, may eventually converge. OCW materials may, in the medium term, become the building blocks for anyone in the world who wishes to build a customized MOOC. A university could “mash up” material from OCW with its own material, significantly reducing the cost of producing a MOOC for any university. A university in Brazil, for example, could combine OCW’s “Technology in Transportation” and “Internal Combustion Engines” with material on ethanol engines to create a course that is uniquely localized.

The announcement of MOOC.org by edX and Google makes this possibility especially real.[44] MOOC.org, supported by Google and powered by the edX platform, enables any user to upload a course for world consumption. This enables a democratization of MOOCs at a grand scale.

IMPACT UPON MIT OF ENGAGEMENT WITH THE WORLD

EdX's global reach can significantly enhance teaching, learning, and research opportunities for the MIT community. The audience that edX touches has the potential to better position the MIT community to solve the world's greatest problems in large part by deepening understanding of global challenges in a broad cultural, socioeconomic, and political context. Through edX, the MIT academic community will gain exposure to unique instrumentation, methodologies, expertise, and perspectives that otherwise would remain inaccessible, and learn from different academic, pedagogical, and scientific styles.

Opportunities for MIT Students

Over the years MIT has developed a robust infrastructure for students to engage with the global community; edX has the potential to build on these programs and initiatives in profound and interesting ways.

Internships and Learning

EdX has grown the classroom from several hundred seats to several hundred thousand. With increased potential for global academic study come new opportunities for real-world learning and interaction. More than ever before, MIT's student body comes from all corners of the world. This demographic shift means that we are educating students who have a great interest in combining a world-class MIT education with a meaningful and productive international academic experience. EdX presents great opportunities to place MIT students around the world to interact with the global community of *MITx* learners and innovators.

"Going further, students on international exchange or a co-op placement might still be able to participate in an MIT on-campus course during the time they are away," wrote Dean Daniel Hastings, Professor Hal Abelson, and Dr. Vijay Kumar in a 2011 report. "Similarly, we could accommodate intense *on*-campus experiences, such as letting students spend a couple of weeks in an immersive UROP project and make up for the missed work later."[45]

In the section of this report titled "Impact of *MITx* and edX on the World," we describe opportunities for MIT students to serve as ambassadors by visiting different learning communities around the world. Clearly, this kind of initiative has benefits for the global community, but the benefits for the students themselves are perhaps even more significant. Students can gain real-world teaching experience, working in multinational teams and communicating across cultural and linguistic boundaries. Operating in such an environment

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44. Fowler, Geoffrey A. "EdX, Google to create new online education site," *Wall Street Journal Tech*, September 10, 2013.

45. Hastings, Daniel, Hal Abelson, and Vijay Kumar. "Technology enabled transformation in the MIT learning experience," MIT Faculty Newsletter, Vol. 23, No. 5, 2011, http://web.mit.edu/fnl/volume/235/

imbues students with self-confidence and team-building skills and exposes them to different pedagogical opportunities and challenges. The notion of *MITx* ambassadors also presents new opportunities for personal and professional development, expanding a student's global network and career opportunities.

As noted previously, during summer 2013, MISTI placed 10 MIT students trained on the edX platform in four countries during their internships. These students' experiences should provide invaluable insight into the feasibility of more closely tying edX with MISTI, one of MIT's outstanding international programs, to create an initiative we might call "MISTIx." MISTI is already an extremely popular and successful program that provides students with real-world experience in corporations, universities, and research institutes around the world. By connecting these experiences to *MITx*, not only would the global *MITx* community benefit, but MIT students would also have the opportunity to develop their teaching, research, problem-solving, and language skills. With greater exposure to a global student population, MIT students would develop a more meaningful connection with the world, improving their skillset and gaining a deeper understanding of the challenges that most keenly need MIT's attention.

In addition to MISTI, a number of academic departments offer international internship programs. EECS, for instance, encourages students to take advantage of growing opportunities for incorporating an international internship experience into their EECS education. Through initiatives like the department's 6-A International Program, students are positioned to conduct research with learners and instructors around the world. *MITx* has the potential to build on programs like 6-A to incorporate real-world international engagement into the requirements of an *MITx* class.

The "infinite classroom" idea of D-Lab, where students can blend technology with international development, and the Sloan Action Learning Labs, which translate classroom knowledge and theory into practical solutions for real organizations across the globe, both have elements that could be enhanced by the vast potential of edX.

Student Teaching

Teaching assistants are an integral component of the on-campus classroom experience, providing invaluable support to instructors and students alike. As the classroom goes global, TAs continue to add value, but the benefits they reap increase as well. We might think of TAs in this new setting as "*MITx* TAs" or "*MITx* Global TAs." These students would serve as teachers in global communities for *MITx* while gaining real-world experience. We envision students working in this capacity to facilitate meet-ups at remote instructional sites or partner universities.

Student Research

MIT has a successful International Research Opportunities Program (IROP) that places undergraduate students in faculty-mentored research settings around the world. IROP experiences help students enhance their communication and leadership skills and refine their collaborative and decision-making capabilities while increasing understanding and awareness of global challenges. Through on-the-ground international research opportunities, a student might be able to conduct firsthand analysis and investigate solutions to a problem being discussed in an *MITx* class.

The writers of *Mens et Manus et Mundus* (2009) of the MIT Global Council envisioned a new initiative they called the Global Scholars Program; though the program has not yet been developed, its potential is even greater in an increasingly digital world. As the Council articulated its vision, a student would have the opportunity to "identify a country or region to study in depth and in person from the start of their time at the Institute. The student, working with his or her advisor, would then identify six classes in humanities, arts, and social sciences that focus on the country; they would be encouraged but not required to take the relevant language classes as well." The Council also suggested that students would attend monthly dinners with students and faculty interested in that region. Again, there are opportunities to integrate a Global Scholars Program into the global learning potential of edX.

Executive Education

While an MIT student is typically thought of as preprofessional, the Sloan School's executive education programs create opportunities for MIT to reach students who are established in their careers and are eager to gain knowledge that will improve their effectiveness on the job. Sloan's part-time professional master's programs (such as the Executive MBA and System Design and Management programs) educate students who are already employed. Instructors in these classes give assignments that are directly connected to students' professional responsibilities. With distance education, instructors can build on the success of these programs with students from far away and in interesting settings.

While we view all of these international opportunities as worthy of examination and analysis, it grappled with two philosophical questions that will need further attention:

- How do we free up time for students to carry out more activities abroad (field work, research, internships, semester abroad) while staying connected and engaged in MIT's curricula?
- If *MITx*, combined with a meaningful international experience, compresses an MIT education into a three-year undergraduate degree program, will our students be fully prepared to go out into the real world or on to graduate school? Three years is likely insufficient for the maturation one typically experiences during college.

Opportunities for MIT Faculty

Teaching

With a global audience at an instructor's fingertips, one might imagine the world as a laboratory in which MIT faculty can experiment with new teaching methods and collect data to inform and improve on-campus education.

Perhaps the greatest benefit of edX for an MIT instructor is the immediate feedback he or she receives about which methods are effective in a class, and which ones aren't. As the residential classroom is transformed, a faculty member can incorporate these lessons into the MIT campus teaching model to teach students more effectively. Whereas an instructor has traditionally had to wait until the end of a semester to collect student feedback, and from only relatively few participants, the analytics built into edX allow one to immediately gauge student learning and to constantly assess and adjust.

As MIT faculty develop new teaching partnerships with instructors around the world, it will be essential to devise some common infrastructure to ensure cohesiveness and effective collaboration. We recommend establishing a platform for interactive sharing between faculty of best practices and effective resources for distance teaching and learning. Collaborative distance teaching and learning inherently imposes different technology constraints than local residential teaching and learning, but it offers the opportunity for considerably more interaction and collaboration than the structure of MOOCs provides. For this reason, a common platform will be invaluable.

Finally, no longer will content delivery occur in one direction, from teacher to student. Similar to Wikipedia, which relies on the community to provide content, edX creates new opportunities for crowdsourcing or community-sourcing, allowing students to answer questions and collaborate in new and interesting ways. Relying on thousands of creative minds to provide innovative solutions will be invaluable to educators, and students will gain real-world exposure to enhance the learning experience. This will be a new form of crowdsourced teaching. Material could be made for free—by an intellectual commons not unlike Wikipedia.

Research

The increased exposure edX will provide for research is equally compelling. MIT faculty research will benefit from more in-depth interaction with society at large, positioning faculty to be more effective in identifying research opportunities with a real-world application. There will also be greater exposure to different perspectives with first-class researchers from around the globe, creating new and exciting opportunities for collaboration.

DISAGGREGATION: UNBUNDLING OF THE TRADITIONAL INSTITUTION

Central to a well-rounded and high-quality education are the synergies that develop across concepts, courses, and disciplines. That is, an education is greater than the sum of its parts. Residential universities perform many functions in the education of a student, ranging from coursework to sports, and from labs to social activities. Digital and online technologies could enable these functions to be unbundled. We explore the consequences of disaggregation in this section. Consider a university curriculum, for example. EdX represents an unbundling of the curriculum into individual courses. However, the unbundling can be much more extensive. Courses can be unbundled into modules, which we describe in the section titled "Modularity."

In 2011–2012 the MIT Council on Educational Technology (MITCET) conducted three experiments that can be used to inform modularity in MOOCs. The focus of the experiments was to better understand the role of the Internet in providing learning experiences that are flexible in time and geography. The Council envisioned modularity as creating opportunities to personalize the educational experience through flexible majors and alternative or adaptive learning models. Briefly, the experiments were as follows:

1. In spring 2012, faculty oriented two aero/astro courses (16.20 Structural Mechanics and 16.90 Computational Methods for Aerospace Engineering) around mini-lectures, focusing on topics that proved to be challenging to students, and collaborative sessions in which students worked on problems or programming assignments together. Students were expected to review course notes before attending class, and were given the option of attending class remotely.
2. In 2012, 2.002 Mechanics and Materials II was offered concurrently to both remote and residential students. Course materials were modularized into an introductory core and four major components (plasticity, viscoelasticity, fracture and fatigue, and rubber). After completing the core module, students were able to study the remaining components in any order.
3. The Chemistry Bridge project developed self-paced modules to assist mastery of key concepts outside the classroom setting. Students visited the Chemistry Bridge website to take a pretest to assess their understanding of the subtopics that constitute a core concept. Upon submitting their responses, students were presented with a learning pathway—a curated set of websites, videos, and simulations selected to address the student's learning goals. After completing the steps in the pathway, students took a post-test to assess how well they understood the concept.

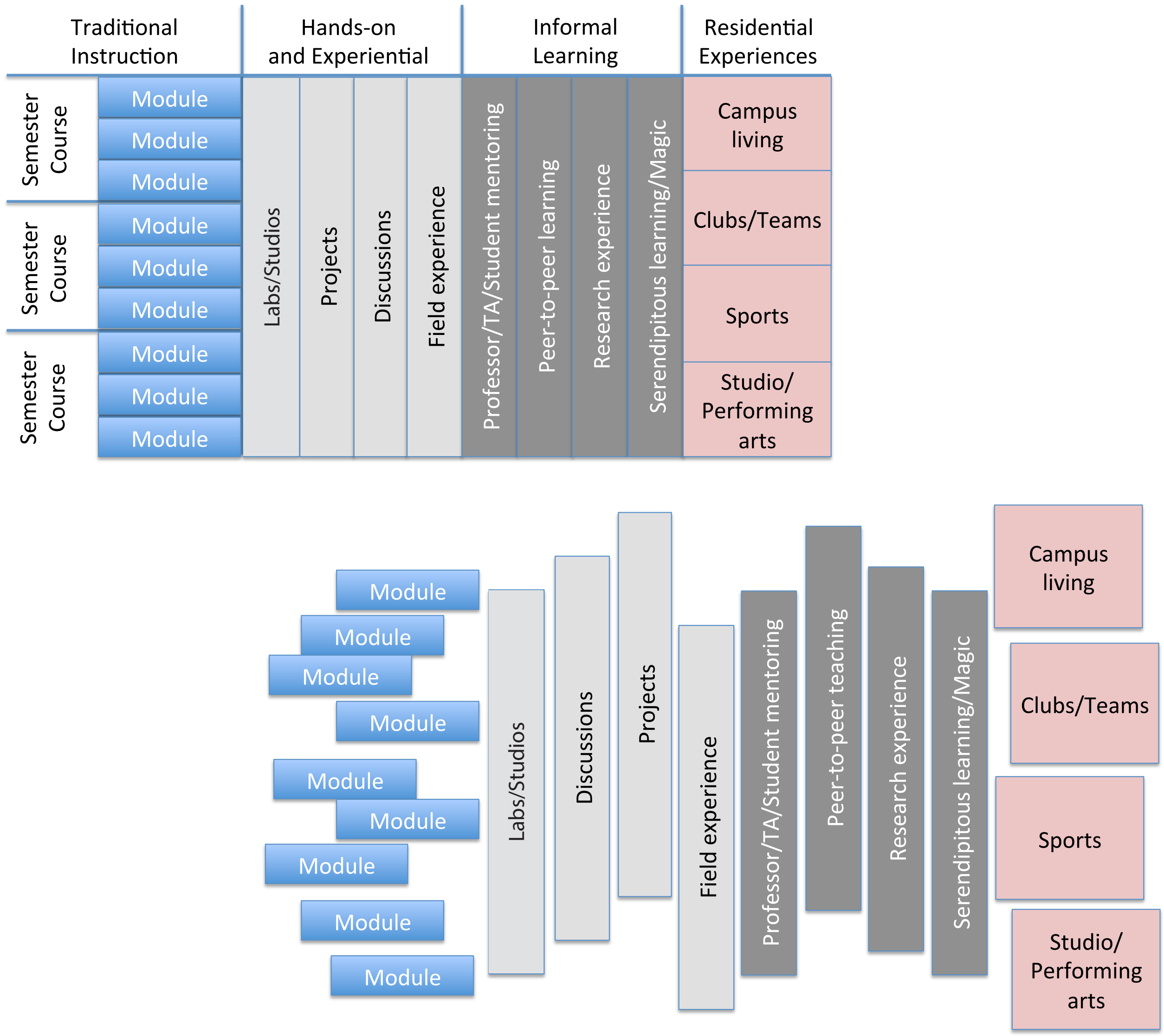
In the MOOC world, 80-minute lectures themselves have already been unbundled into 10-to-15-minute vignettes. All of this is enabled uniquely by digital learning technologies. The logistics of 10-minute lectures on a residential campus would be infeasible—the setup time and the time to walk between classrooms would be too great. Similarly, it is difficult to take classes from different universities. While students at MIT and Harvard do cross-register, the logistics of travel from one campus to another limit the extent to which this is practical. Online makes it possible for students to take classes from across universities more conveniently. We examine disaggregation here, starting with modularity.

Distributed Education

Each line in Figure 9 represents a possible parting line for the university. Universities and colleges in the United Kingdom and elsewhere have historically straddled different lines of the figure. In most university-college systems, universities maintain the degree program and credentialing. Unified university exams provide a standard assessment across the system. Colleges, on the other hand, can provide different combinations of services. In some situations, colleges are merely residential establishments. Often colleges provide tutoring, and in some cases they may also provide lectures and teaching of the content. Colleges can specialize along disciplinary lines. Sports and clubs may be either college-wide or university-wide. In most such systems, colleges are located in proximity to the university.

An institution such as MIT can thus be seen as an aggregation of functions that have not always been together. Disaggregation therefore is not necessarily a new phenomenon, but one that becomes more relevant with online technologies.

Figure 9. Unbundling of education



Distributed U

Online education will enable new models of distributed universities. MIT might consider creating affiliated campuses around the world, with students in different campuses sharing online content and forums. There is a growing trend of satellite campuses belonging to major U.S. universities. For example, Carnegie Mellon University has a campus in California, and Cornell University is establishing a campus in New York City. Meanwhile, Yale University has established a campus in Singapore, New York University has established a Shanghai campus, and Georgia Tech has one campus in Metz, France, and is opening another in Shenzhen, China. INSEAD has campuses in Fontainebleau, Abu Dhabi, and Singapore.

Today, because satellite campuses require traditional lectures, standards and offerings can vary across campuses. Online education and blended learning will enable more uniform teaching in satellite campuses. This idea mirrors the earlier “Global Tech” idea mooted at MIT during the creation of OCW.

Flipped University

An unaffiliated university could also base itself on cutting-edge online content. Students at the campus could use SPOCs but receive the hands-on education, discussions, informal curriculum, and residential experiences at their local institution. We refer to this as a "flipped university." New universities may use this approach to significantly enhance the university experience for their students, focusing on labs, mentorship, projects, and personal development. The online instruction in this case would be used just as MIT might use the material to flip its classroom.

MIT's long history in international programs enables it to lead this movement. The aggregation of content development will enable best-in-class, up-to-date pedagogical tools that can also be continuously improved using aggregated data.

Disaggregated Credentials

We have already discussed the disaggregation of the degree into smaller credential units such as course credentials, sequence credentials, and even badges. It is also conceivable that the credentialing entity may be different from the institution that offers the course. For example, a company could license SPOCs on several different topics from *MITx*, and offer its own credential to students who take a certain selection of classes. Over time it is not inconceivable that virtual universities will form that offer themed credentials by buying and reselling content from other players.

Modularity: Fragmentation of Coursework

A module is a unit of learning smaller than a full course. The notion of online learning units is appealing for many reasons. Learners are more likely to complete an online course if it can be taken in increments rather than as a full course, making modular learning more accessible to a wide audience. Modules are helpful for learners looking for specific conceptual or technical information, or for teachers looking for material with which to build or augment a course. In theory, customized or interdisciplinary courses can be put together from modules. Thus, a module repository would be a valuable resource for teachers and learners alike. Modules are cheaper to produce than full courses, and easier to update than a full course. We define "smooth modules" as standalone units, and "sticky modules" as those designed to be part of a course.

Modules can be put together "vertically," i.e., in obligatory order to make a course or module sequence, or "horizontally," where any order is acceptable to make up the course. Over the next three years, we suggest an action plan that includes the goals to: identify any new or existing *MITx* course that could be produced as modules; produce the "sticky" modules associated with these subjects; define a limited set of standalone ("smooth") modules and produce these; put in place a well-organized repository of existing and new modules and define guidelines for building and credentialing customized courses. The outcomes of this effort will increase accessibility of MIT course material. The audience includes residential MIT students and those away from campus, student and professional learners across the world, and teachers at many levels.

Introduction

For some time, it has been feasible to look up anything online and almost instantly obtain access to a short video explaining the query. Many of these videos are a minute or less in duration, some are longer, and many are very helpful. The notion of "modules" or self-contained learning units is thus pervasive and useful.

Traditionally, MIT subjects have been taught as a single course, encompassing a semester and many lectures. However, within a subject, one or a few lectures often encompass a specific topic. Thus many subjects can, in theory, be broken into units (modules) that could be studied separately. Multiple modules could be strung together in a defined or random order to construct a course. As we will discuss, deconstruction of courses into units can have interesting and useful outcomes.

Learning in units or modules could impact how a subject is studied through *MITx* or edX. We have concluded that the modular approach will make MIT-level subjects more accessible to many learners. The approaches we describe will benefit MIT students, on campus and off, and other learners across the world.

Setting the Framework with Some Definitions

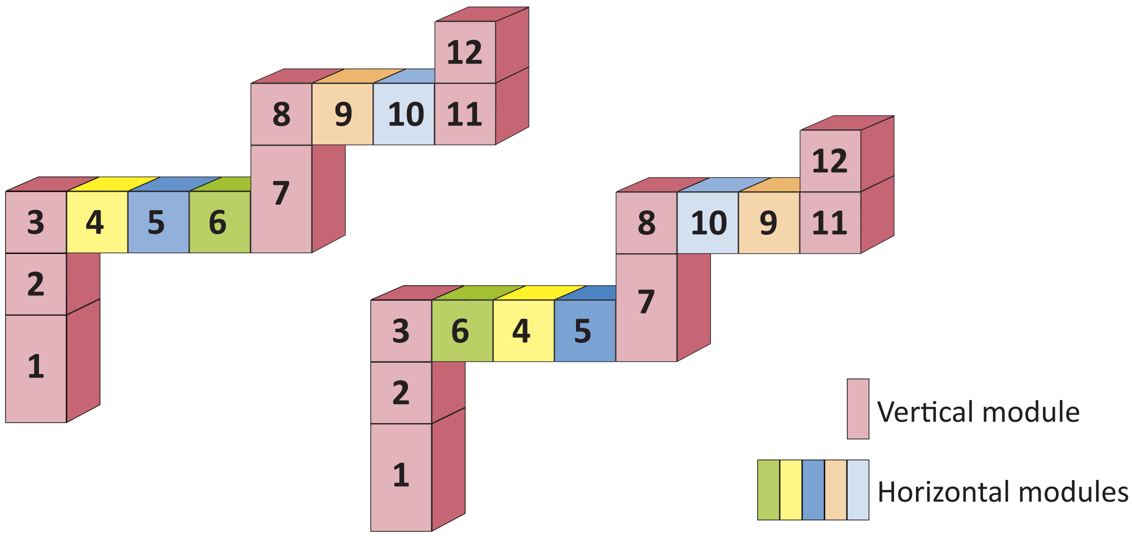
We define a module as a learning unit. The unit can be a single lecture, part of a lecture, several lectures, or a half-semester of perhaps 10 or more lectures. For example, the notion of ATP as an energy source in the cell could be discussed at an introductory level in a 15-minute module, but the broader subject of biochemistry would require several lectures to convey even an introductory understanding.

Modules change our idea of what a course is. A course can be deconstructed into modules, or constructed from modules. For some courses or for part of a course, the order of learning modules is important, and we define "vertical" modules as those that need to be studied in a particular and invariant order, such that material learned in module 1 facilitates the learning in module 2, and so on. A sequence of vertical units could form a larger "module sequence." For example, a vertical module sequence would place biochemistry after a module concerning principles of organic chemistry, and before a module about metabolism. In contrast, for some courses, modules can be studied in any order, and we term these "horizontal" modules. In practice, most courses are likely to comprise a mix of sequential vertical units and horizontal material (see Figure 10).

We define "sticky" modules as those that are designed to be linked to form a course, and that usually contain some indication that the modules are part of a course. For vertical modules, this would include reference to previous modules and indication of how the preceding material fits into the topic of the specific current module. For horizontal modules, this could include references to the overall learning goals of the course.

A related designation is the notion of "smooth" modules to indicate standalone learning units that are not necessarily part of a course and that would not contain references to course goals or preceding or subsequent modules. A smooth module should present its own preamble, and the

Figure 10. Modules in different orders



learner should emerge with a clear increment of learning. Sticky modules can form the basis for smooth modules, and vice versa.

Deconstructing a subject into modules would be a top-down approach. A bottom-up approach would build modules without a course in mind. It would be up to the learner or the teacher to determine how to use these. In each case, we would envision that a module would be associated with homework problems that would allow the student to evaluate the learning outcome.

What Is the Status of Modular Teaching at MIT, and What Lessons Are Emerging?

While the formal notion of modularity is not widespread at MIT, most subjects are organized in terms of learning units, and there has been an effort among certain departments (chemistry and mechanical engineering) to break up a subject into smaller units. This deconstruction may be associated with choices, letting a student decide to study only a fraction of the total topics offered. Many faculty consider it feasible to break their courses into modules.

Useful Outcomes

The useful outcomes of modularity fall into four overlapping categories.

Ease of Production and Updating

A clear advantage of modular units over full courses is that each unit can be produced independently, with clear positive outcomes. A unit thus takes less time and resources to produce, allowing units to be gathered more readily than full courses.

Modular organization makes it easy to include multiple faculty members in the teaching of a course. This lowers the barriers for teaching a course through *MITx*.

If a course is composed of modules, updating a unit is much simpler than having to update an entire course in which only part of the material has changed. This ease of updating is likely to be critical for keeping MOOCs "living," and addresses a major concern that online subjects will become static after the initial excitement of live lectures.

Accessibility of Learning

Incoming MIT students, especially at the graduate level, would use modules to get up to speed before entering a program. This would offer students of different educational backgrounds an opportunity to succeed optimally at MIT. Using modular units to help study for preliminary exams would also be a strong benefit. Similar considerations would apply to MIT postdocs and faculty seeking refreshers or explanations of unfamiliar topics. Modules can enable both conceptual and technical learning.

An MIT student away from campus could take a subject incrementally through *MITx* without disrupting commitments associated with an internship or break elsewhere.

Modularity is likely to increase the success of non-MIT learners as well. A course broken into modules that can be independently completed would allow students to work at their own pace, which could increase completion rates. Smaller increments of learning would also make MIT-level material more relevant to learners at the high school level or to those without relevant background to complete the entire course.

In all cases, a well-organized repository containing *MITx* and edX-derived modules will be essential.

Learning Innovation

Modules allow new teaching tools to be readily incorporated into a course, if only a module or two needs to be changed. Where multiple teachers are involved, each can bring their own teaching innovations and unique style to the subject.

Online modules offer a duration of teaching that the classroom cannot. In-class lectures must be of standard durations, but there is no barrier to producing a 20-minute digital module.

Modules can reduce redundancy of MIT subjects in a new way, where material in one department can be substituted for similar material in another department. There could be a common entry set of modules that present fundamentals, after which different subjects could diverge to focus on specific aspects of a field. For example, thermodynamics (20.110J / 5.601J / 2.772J) includes a common core of approximately one-third of the material taught at the start of the semester, after which the subject diverges into a continuation of a chemistry-based or bioengineering-based subject. This approach would be cost-effective, and it would benefit both residential and global learners.

Probably the most popular innovative notion of modules is that of do-it-yourself courses, where a student or teacher assembles a course from existing modules. This type of approach can also bring together material from one department or field. For non-MIT pre-college or college students, pertinent aspects of a subject could be included at the students' specific levels. For professionals, a personalized or customized course could focus on specific aspects of learning relevant to their fields.

Modules could also facilitate the teaching of interdisciplinary, interdepartmental, or inter-university super-subjects. For example, say that a faculty member wants to teach a course called Frontiers of Regenerative Biology that includes foundational material from his own course as well as material from three other MIT subjects in two different departments (involving at least three other faculty members) to incorporate multiple perspectives. The faculty member also invites faculty from another edX university who teach a specialized course on mammalian stem cell methods. The course is put together in modules, and it becomes the definitive course on regenerative biology. It can be easily updated to stay current with the rapidly evolving field, and new material or teachers can be added. Some of the modules also have the capacity to be standalone, and these are reformatted for this purpose. For learners who don't want to take the full course, a module sequence comprising about one-third of the course is suggested. Notably, this course could only exist online.

Tools for Teachers

Many useful teaching tools associated with modularity are also presented in the preceding section, "Learning Innovation."

Modules provide teachers with units of learning that can be incorporated into a subject taught in a classroom at MIT or elsewhere. Where a course is being taught at another institution, a modular organization allows a teacher to choose which material should be incorporated. This can accommodate both the level of the learners and the desired focus for the course.

The ability to access several modules with similar content but different teaching styles or example types allows teachers to present material in ways that suit different learning styles.

An important tool relates to teaching assistants at the graduate, undergraduate, or postdoctoral level. Organization of a complex course as modules can allow specialization and make teaching opportunities more accessible, as teaching stints could be shorter than a full semester.

Challenges

Modularity presents both pragmatic and conceptual challenges.

Conceptual Considerations

It will be necessary to identify which new *MITx* courses can be made modular, and which existing *MITx* courses could be reworked into a modular format. Which key courses should be tackled first? Which modules derived from courses are important enough to be reworked into a standalone or "smooth" format?

One key question is whether and how modules can be built into customized courses. Once an annotated module repository was established, there would be no barrier to a learner picking some modules and viewing them in sequence. However, more productive learning would include guidance as to what modules are likely to work together to give a specific learning outcome.

It might be preferable to answer questions of modularity before approval for a new *MITx* course is given. Guidance on possible departmental courses would come from faculty or instructors within a field or department. Interdepartmental or interdisciplinary material would require an interdisciplinary team. This organization would need to be streamlined.

Pragmatic Considerations

Modules need to be produced, and the mechanism by which existing *MITx* courses could be broken into modules needs to be addressed.

A well-organized module repository would be essential, including a system both to catalog and to allow ready access to material. The repository would need to indicate whether modules are standalone or part of a course. Intellectual property considerations with regard to using edX modules must be addressed.

Credentialing is not an issue if a single subject is produced as a modular course. However, for customized or personalized courses, credentialing might be done incrementally or in a customized fashion. However, it may not be possible to give credit for personalized courses due to staffing considerations.

Reaggregation

Disaggregation of functionality in other industries has been followed by reaggregation, often by other players. This may happen in education as well.

Student-Centric Reaggregation of Education Systems

Students may be able to aggregate the functions of a university around themselves by picking and choosing fragments from the new ecosystem of disaggregated education. A student could receive instruction online, register at a fab lab to receive training in manufacturing, attend a study group to discuss a philosophy class, commute to a university on weekends to use chemistry labs, and so on. In rural areas, science-lab buses could offer students access to the equipment they need on a periodic basis.[46] The content the student receives may itself be a mash-up of modules drawn from different providers to create localized flavor. There may be agents—virtual universities—that bundle such functionality together for students to make the experience more seamless. New players may emerge who offer aggregated credentials under an accreditation umbrella. Perhaps MIT could become a leader in this area.

Some versions of this idea have begun to find practical adoption. For example, Kepler, an education project in Kigali, Rwanda, uses the reaggregated model of education to create a low-cost, blended learning environment for local students.[47] Creative solutions of this type seem both inevitable and welcome. MIT can play a role in shaping such a future, especially in conjunction with projects such as D-Lab.

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46. Cardia, Alexandria. "Street smarts: the BioBus brings a rolling science lab to resource-strapped schools," *Scientific American*, February 6, 2010.

47. O'Neil, Mega. "Rwandan degree program aims for a 'university in a box'," *Chronicle of Higher Education*, September 16, 2013.

MOOC.org + OCW = Reaggregated Content

The interplay between *MITx* and OCW creates several opportunities. First, although OCW and *MITx*/edX both use the word "open," they mean different things. "Open" in OCW indicates education resources that may be distributed using a Creative Commons attribution-noncommercial-share alike license. Anyone may download the material and reuse it according to that license. EdX, on the other hand, uses "open" to mean freely accessible web-based classes. A MOOC may not make its videos, for example, downloadable for reuse. Similarly, OCW does not offer a course that may yield a certificate. These two independent functions may eventually converge, however. OCW materials may, in the medium term, also become the building blocks for anyone wishing to build a customized MOOC. They may mash up material from OCW with their own material. This could significantly reduce the cost of producing a MOOC for any university. A university in Brazil, for example, could combine OCW's "Technology in Transportation" and "Internal Combustion Engines" with material on ethanol engines to create a course that is uniquely localized.

The announcement of MOOC.org by edX and Google makes this possibility especially real.[48] Supported by Google but powered by the edX platform, MOOC.org enables any user to upload a course for world consumption. This enables a democratization of online content at a grand scale.

BLURRING OF BOUNDARIES

The concept of learning "anywhere, at any time" gives rise to questions about the meaning of a campus—both in terms of location and in terms of time. Time, location, and people can be blended in a way that was infeasible in the past.

Time and Space Boundaries for MIT Students

The time boundaries of an MIT education today are sharp. A student's formal affiliation starts on the first day of classes and ends on graduation day. Online may change this paradigm, enabling more blurred statuses.

First, pre-college students may be able to take *MITx* classes from edX and get credit before they come to MIT. To date, MIT has been very hesitant to permit such a credit transfer, but we list the possibility here because the implications are significant. Students completing a number of credits before they come to MIT could decrease their time at MIT and therefore reduce the cost of their education.

Second, students today have limited opportunities to travel or work away from MIT during their tenure. Many students have summer internships, and a few take a semester off, but long breaks to get substantial experience or launch a startup are not ideal, for two reasons. First, long periods may complicate student-loan and financial-aid statuses. Second, students may "lose their edge" during long absences, forgetting the core concepts they need to graduate. Online education may be able to address both problems, offering more flexibility to students who wish

48. Fowler, Geoffrey A. "EdX, Google to create new online education site," *Wall Street Journal Tech*, September 10, 2013.

to follow more unconventional paths. Today's more brittle approach may well be incompatible with the emerging needs of MIT students, who have a much more dynamic palette of options from which to choose.[49] This idea was also anticipated in the creation of OCW, where it was called "Flex Tech."

Finally, it is conceivable that graduation from MIT could confer an ongoing online benefit—a lifelong membership to a font of continuous education. This idea was anticipated by the earlier study during the creation of OCW and called "Forever Tech."

Boundaries with Outside Partners

Both research and education at MIT have long had deep ties to the outside world—be it governments, various intellectual communities, or industry. One of the benefits of an MIT education is the rich variety of real-world case studies that MIT professors present to students. However, the mechanism for achieving this today is informal. MIT's vast network, which consists of MIT alumni, sponsors, members of the MIT Industrial Liaison Program, and personal contacts of MIT's faculty, can contribute to both education and research in a much more direct way using online education. They could do so by producing case studies that faculty can link, at their discretion, to regular curricula. Outside experts may also be able to leverage online technologies to regularly give presentations and lectures that provide a different perspective. Finally, this increased interaction with the outside world could also enable experts to come to MIT as executives or researchers in residence. This is not a new idea, but it could be much more closely integrated with teaching and mentorship.

The presence of a large cadre of outside experts will also enable MIT to create lifelong-learning content that is crafted specifically for outside partners. This idea is similar to the "tech-tech" idea presented in the OCW report.

Implications for an Innovation Hub

By blurring boundaries, changing the residential campus, and merging *MITx*/edX strategy with an overall strategic goal of being the global innovation leader in higher education, MIT can truly be the center of creativity and innovation. Picture the MIT community as we have described in this section: with alumni, students, researchers, professors, and industry influencing each other uniquely within the MIT ecosystem, we will have the ability to understand education and innovation with much greater resolution. International collaborators in such places as Singapore, United Arab Emirates, and Russia will want to participate regularly in this hive and glean from our latest understanding. Domestically, MIT will be the clear choice for national innovation and research policy, as the breadth and depth experienced and centralized in Cambridge will have no equivalent elsewhere.

With online education inducing a more innovative education and experience in Cambridge, a vibrant international hub can be created that gives international collaborators an opportunity to engage with the residential experience and participate in regular international innovation forums. MIT will be able to supply a unique experience that will only exist in Cambridge, even

49. Dembosky, April. "Dropouts look to learn from Zuckerberg," *Financial Times*, June 25, 2011.

though all supporting materials and publications will eventually be published internationally through edX courses and other online publications. MIT can therefore supply a new strategy for these partners: develop your own domestic MIT over time, by learning, training, and achieving desired performance through participation in the international hub. Each country's local MIT can thus ramp up appropriately as progress in training and innovation is made in Cambridge, resulting in an ecosystem in each country consisting of both MIT Cambridge and their local embryonic MIT. This idea echoes the earlier thoughts of a "Venture Tech" mooted during the creation of OCW.

Summary

The Working Group noted that while edX enables unprecedented outreach to the world, it also have several attendant impacts. First, the outreach to the world will also enable significant benefits to the campus. Second, online technologies have enabled various forms of unbundling and disaggregation in other industries—and academe must take advantage of such disruptions rather than ignoring them. Third, online access blurs the boundaries of the university because material can be accessed at any time from anywhere.

Access to the World

The group felt that since the opportunities in online access to a world population were likely to be rich and diverse, it would be more fruitful to develop a framework, which could capture the opportunities, rather than to enumerate them as special cases. To that end, the group looked at three categories of options: the global audiences of edX, the modes of online education and the possible outcomes. In global audiences, the group considered pre-college students, college students, working professionals outside educational institutions, teachers, and individuals seeking enrichment. Amongst these, we further distinguished students and professionals as either taking edX classes through their institutions or companies, or privately on their own. Amongst modes of online education, we listed not simply taking courses online, but also "extra" options such as enhancing the online experience with distributed experimental kits (such as LEGO® MINDSTORMS™), visiting educational universities on weekends for coaching or access to equipment, receiving mentorship from local experts such as MIT alumnae, and perhaps even visiting MIT or partner universities for intensive week-long or month-long immersions. Amongst the outcomes, we listed the satisfaction of personal enrichment, certificates, certificates for sequences of classes, degrees, awards of visits to MIT, and the opportunity to be admitted to MIT. We felt that permuting these options could reveal most of the possibilities of online education were likely to yield.

Impact of the World

The involvement of individuals from around the world will create a number of unique opportunities for MIT students and faculty. First, MIT students will be able to participate in teaching worldwide, be it as TAs in far-flung destinations or as the teachers running the courses from MIT. Second, MIT students could use the partnerships and reach engendered by *MITx* to engage in research and fieldwork at a scale that has been difficult to conceive in the past. Both of these opportunities will further enhance students' experiences by giving them global exposure and real-world experience. This is consistent with the emerging new theme for MIT: *mens et manus et mundi*. These opportunities will also extend to faculty, who will similarly be able to inform their teaching with global experience and feedback. Faculty will also be able to both communicate to and extend their research to encompass global audiences.

Disaggregation

The group noted that traditional institutions such as MIT offer a bundle of services such as courses, labs, studios, tutoring, a living community, clubs, teams, and sports. These services can be unbundled in the future. Students around the world can access instruction online unbundled from the other aspects of the Institute. Similarly, and perhaps more immediately, courses themselves can be unbundled into modules that will enable a great deal of flexibility and "portability" of material for both students and faculty. Unburdened by the logistical constraints of the in-class instruction, students can pull information rather having it delivered to them serially. Modularity will also promote flipped classrooms, as well as more fluid project-based and problem-based learning. Finally, modularity will make the development, maintenance, and reuse of online material more efficient.

Blurred Boundaries

Online tools enable learning anywhere at any time. This blurs the physical and temporal boundaries of the university. Students can take classes not just on campus, but while they are at companies doing internships, or before they "join" the institution, or after they graduate. In fact, "admissions" as we know it may be replaced by "membership" at MIT; alums, for example, can take classes through edX long after they graduate. Similarly, practicing alumni may be able to develop material for campus, and the research enterprise may become more commingled between corporations and universities, enabling a new innovation ecosystem.

Working Group 3

A New Financial Model for Education

Evaluate the future strength and sustainability of MIT's current financial model in this evolving context and propose alternative or complementary approaches.

—President L. Rafael Reif

THE NUMBERS BEHIND AN MIT EDUCATION[50]

MIT is a world-class institution where research and teaching are integrally connected, where hands-on learning and relevance to the world are key values, and where advancing knowledge and educating students is the overarching mission. Today, MIT educates just over 11,000 students.[51]

In 2013, MIT received over 43,000 student applications, and only 10% gained admission to their program of choice. Undergraduate applications topped 19,000, and only 8.2% were admitted. By contrast, *MITx* enrolled just over 300,000 unique students in the year beginning in spring 2012.

Presented with these statistics, we must stop to wonder:

- Can we advance the mission of MIT by educating more students?
- Can innovations in online learning improve access and affordability?
- What is the value of an MIT education, residential or online?
- How will the adoption of online learning, by MIT or others, impact the financial model of MIT?
- How has MIT's financial model evolved?
- Is the current model sustainable?

To begin to answer these questions, we examined a myriad of records and constructed a series of historical datasets related to finances, people, and space at MIT. With this historical perspective, we are increasing our understanding of how MIT's financial model has changed over time. We are evaluating how students finance their educations, articulating the outcomes of an MIT education, and developing approaches to modeling the scenarios that will emerge from the Task Force discussions. We have immersed ourselves in discussions and challenged assumptions and findings, and we are confident that the best approaches for continuing to enable MIT for future generations will emerge.

However, the focus of this preliminary report is on laying out the range of opportunities and possibilities that online learning, edX, and *MITx* offer MIT. The questions we are trying to answer are complex and nuanced, and further work is needed to provide appropriate and detailed answers. Debate and analysis will continue in the coming months leading up to the issuance of the final report of the Task Force, but we want to share preliminary observations at this early stage that put our conversations and work in context.

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50. Data provided by MIT's Office of Institutional Research and Admissions Office.

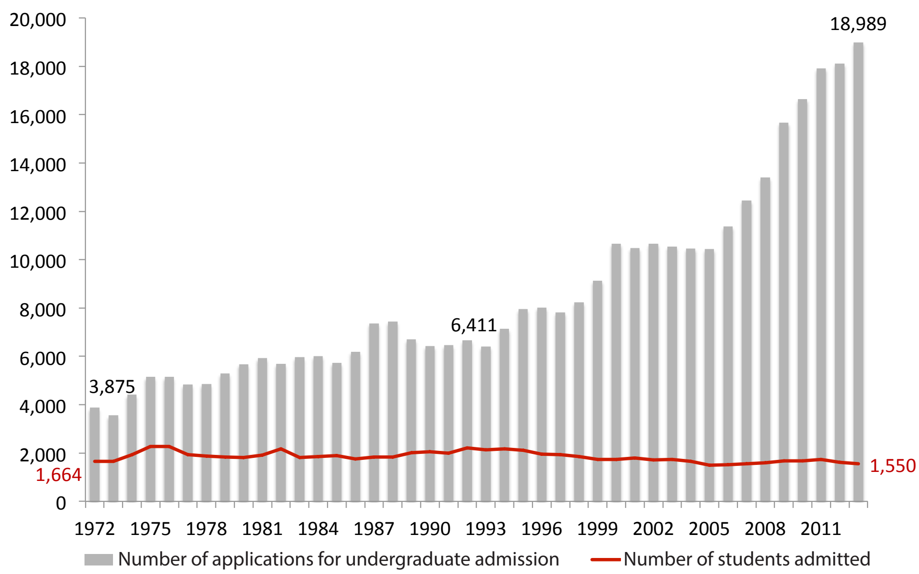
51. In 2013, MIT had 1,022 faculty, 4,503 undergraduates, and 6,686 graduate students. In addition, MIT had 789 instructional staff, 1,441 postdoctoral scholars, 1,173 research staff, 1,308 visitors (including 745 visiting students), and 4,549 other staff members (excluding affiliates).

INCREASED DESIRABILITY OF AN MIT EDUCATION

MIT graduates contribute to the world in extraordinary ways, but MIT is able to admit only a fraction of the exceptional students who wish to come to campus. Undergraduate selectivity has increased dramatically over the past 20 years among all of MIT's peer institutions. MIT has admitted students at a very low rate for many decades as applications for both undergraduates and graduate students have grown significantly.

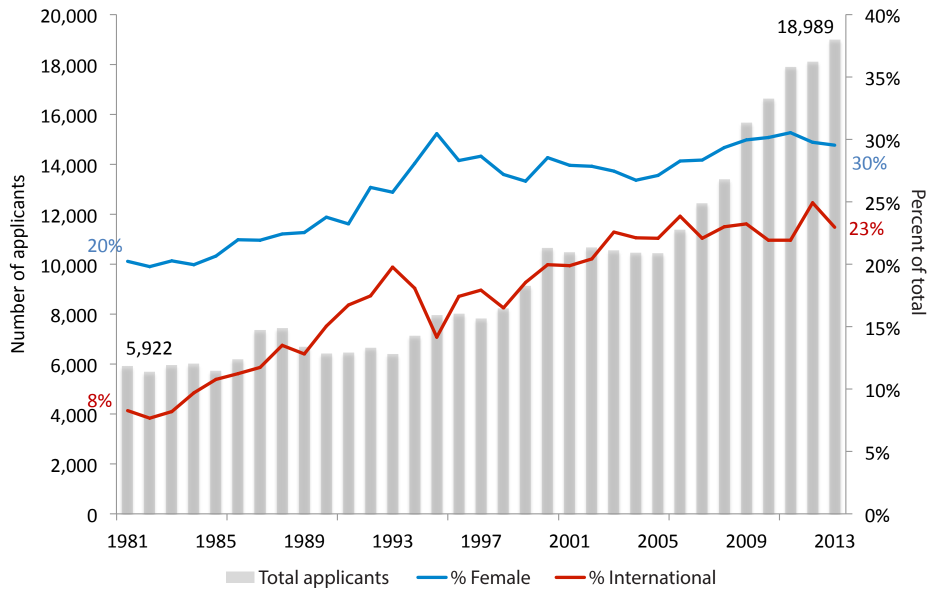
Undergraduate applications have tripled since the early 1990s to 19,000, while admissions have been relatively flat at 1,800–2,000 students (Figure 11). Admitted students have chosen to enroll at MIT in higher proportions. In the mid-1990s, one out of every two admitted students chose to come to MIT. Today, nearly three out of four students admitted to MIT will choose to enroll. The numbers of international and female applicants have grown as well, with internationals comprising close to 25% of applicants and women comprising about 30% (Figure 12). Applicant quality has also increased. The mean Math SAT score of today's applicant pool (737) matches the mean score of students who enrolled at MIT in the mid-1990s. Today's enrolling freshmen have the highest mean Math (769) and Verbal (723) SAT scores of any previous class.

Figure 11. Undergraduate applications and admissions, AY1972–AY2013



Source: MIT Admissions

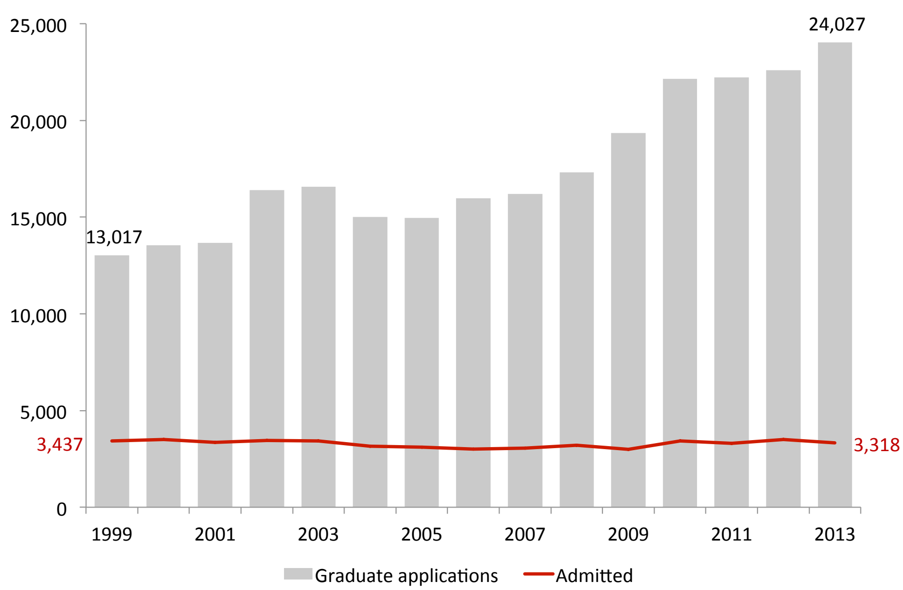
Figure 12. Undergraduate international and female applicants as a proportion of total applicants, AY1981–AY2013



Source: MIT Admissions

The pool of graduate applicants to MIT is increasingly deep as well. Graduate applications have almost doubled since the mid-1990s, to 24,000 in 2013 (Figure 13). During the same period selectivity has increased, with the percentage admitted reduced from 26% to 14% and yield increasing from 59% to 65%. There is a vast unmet need among well qualified students for access to high-quality education.

Figure 13. Graduate applications and admissions, AY1999–AY2013



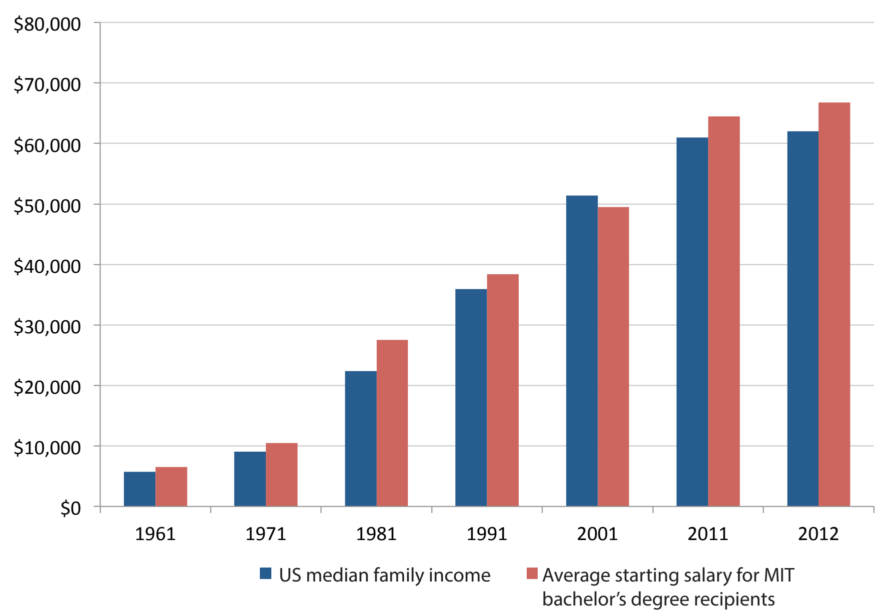
Source: MIT Institutional Research

THE GREAT VALUE OF AN MIT RESIDENTIAL EDUCATION

MIT has a significant impact on educating some of the brightest engineers, scientists, and businesspeople of our time, and graduates from MIT perform exceedingly well in their life pursuits. For instance:

- If trends continue, between 30% and 50% of graduates at all degree levels will form companies within 20 years of graduation, playing an important role in job creation.
- The average starting salary of an MIT undergraduate upon graduation ($66,800 in 2012) has been consistently higher than the U.S. median family income ($62,035 in 2012) (Figure 14).
- The undergraduate completion rate has been over 90% since 1992, with recent graduation rates of 93%.
- Doctoral student completion rates within eight years approach 80%.
- Eighty percent of MIT undergraduate alumni continue on to graduate school at some point in their lives (70% within five years of graduation).
- Twenty years after graduation, most MIT undergraduate alumni have reached a senior-level or higher position.
- Twenty years after receiving their MIT degree, most MIT alumni across all programs earn between $150,000 and $200,000 per year, excluding bonuses.
- About three-quarters of undergraduates and master's level graduates are employed by industry, while nearly half of doctoral alumni go into academia.
- MIT graduate alumni produce a significant number of patents and inventions, advancing the boundaries of science and engineering.

Figure 14. Average starting salary for MIT bachelor's degree recipients, 1961–2012



Source: MIT Global Education and Career Development

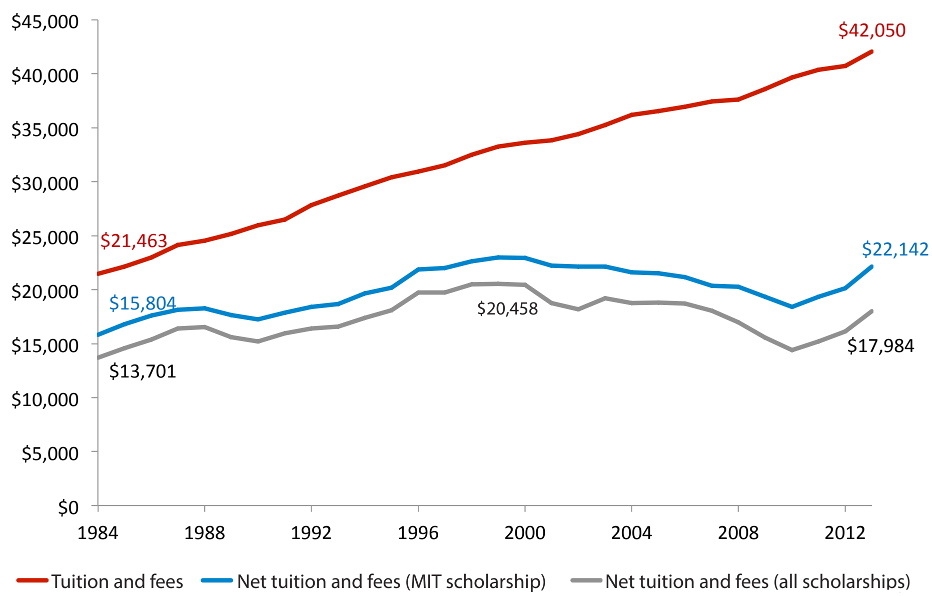
IMPROVED AFFORDABILITY OF AN MIT EDUCATION

The public conversation about escalating higher-education costs and their impact on access for students from all socioeconomic levels is ever present. Some see online learning as an opportunity to make education more affordable. While it is true that higher education is expensive, MIT remains committed to need-blind admissions and to meeting the full financial need of its undergraduates.

Nonetheless, the actual cost of educating an undergraduate student at MIT with the kinds of outcomes discussed above is twice the price of tuition charged by MIT. The Institute further discounts that sticker price through its need-based scholarship program. The average net tuition (defined as the sticker price minus MIT need-based scholarships) is a better metric of MIT's affordability, as well as a more accurate measure of MIT's financial investment in its undergraduates.

The gap between the price of the tuition and fees charged by MIT and the average net tuition and fees paid by students after receiving MIT scholarships demonstrates MIT's commitment to making an MIT education as affordable as possible for students coming from all socioeconomic backgrounds (Figure 15).

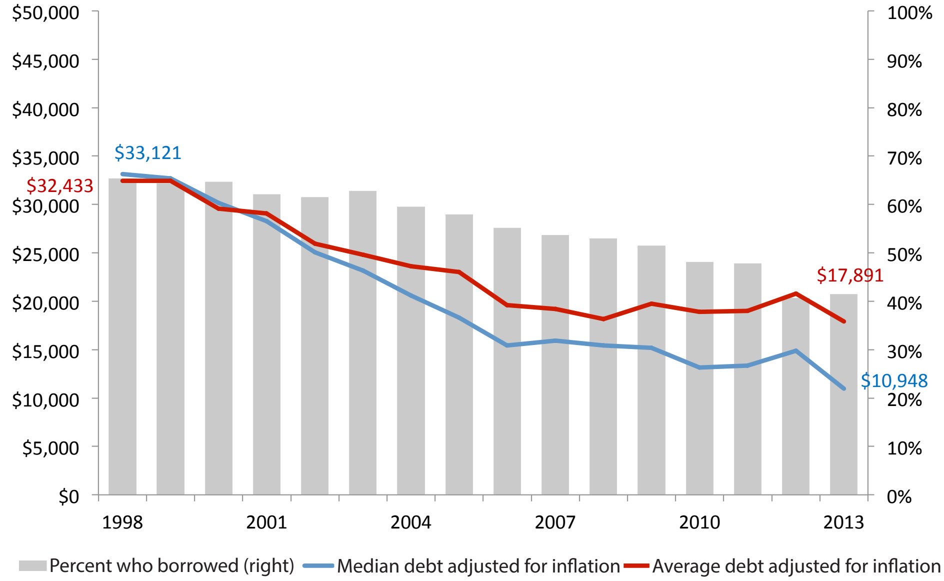
Figure 15. Net undergraduate tuition and fees, AY1984–AY2013 (inflation adjusted $2012)



Source: MIT Student Financial Services

Undergraduate debt has been dramatically reduced since the late 1990s. From 1998 to today, the percentage of undergraduates borrowing has decreased from 66% to 40%, while the mean borrowed amount has been reduced, from $33,000 to $11,000 (adjusting for inflation) (Figure 16).

Figure 16. Average undergraduate debt load at graduation, 1998 vs. 2013 (inflation adjusted $2012)

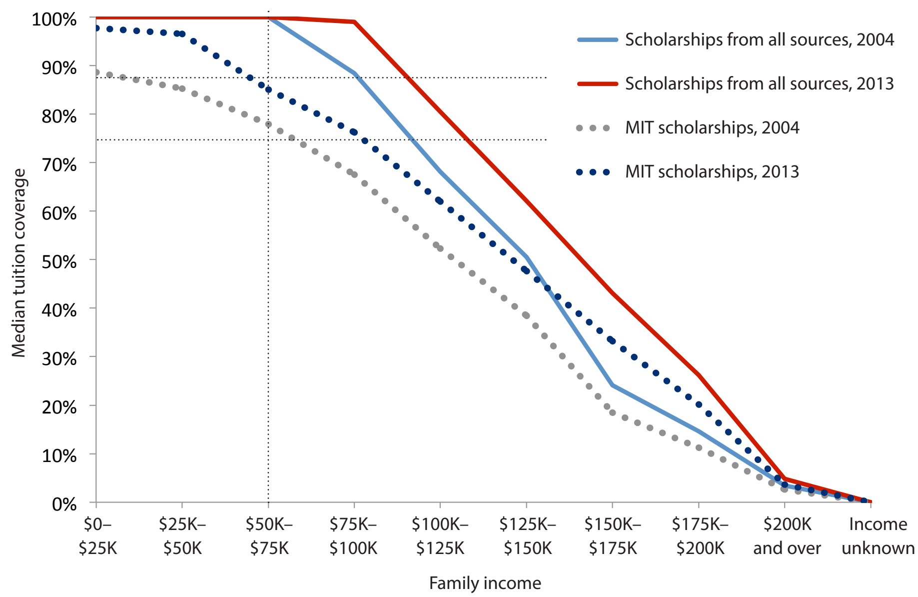


Source: MIT Student Financial Services

At MIT, the Institute is the highest provider of undergraduate financial aid, at 76% of aid. In the nation overall, the federal government provides the highest percentage. MIT provides mostly scholarships and very few loans, but nationally loans are the largest support mechanism. This allows MIT students to graduate with significantly less debt. About one-third of undergraduate students at MIT receive scholarships that cover the full cost of tuition. Families today are positioned to qualify for more aid and are incurring lower levels of debt.

Assuming that scholarships are first applied to the cost of tuition rather than room and board, the percentage of students receiving scholarships covering the full tuition price has increased over the past 10 years. During the 2003–2004 academic year, 75% of undergraduate families with incomes of less than $75,000 received scholarships covering the full tuition price. During the 2012–2013 academic year, 88% of families at this income level received scholarships covering the full tuition price (Figure 17).

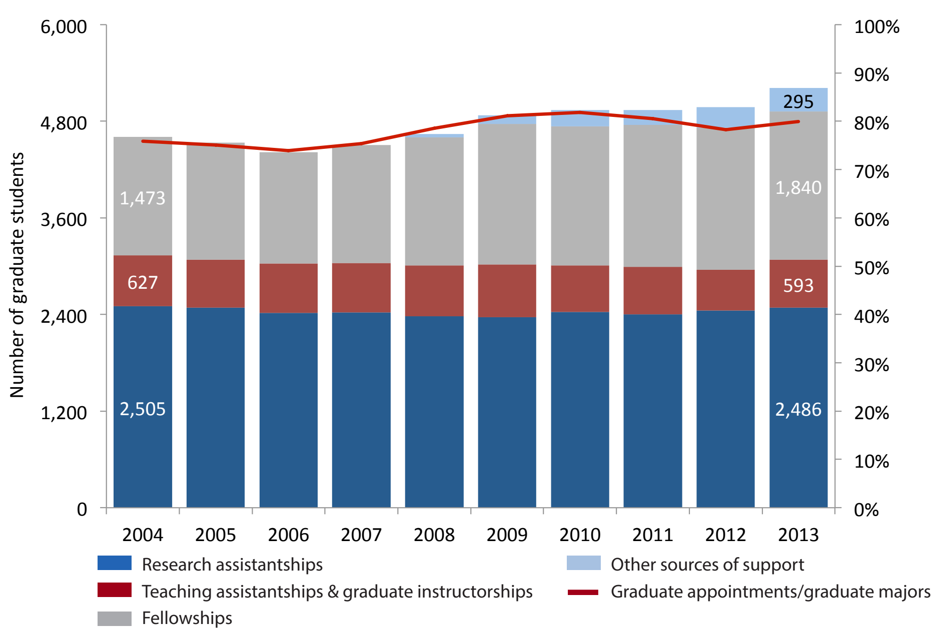
Figure 17. Median undergraduate tuition coverage by scholarships, AY2004 vs. AY2013 (inflation adjusted $2012)



Source: MIT Student Financial Services

Among graduate students, the largest source of support is from research assistantships (RAs) funded by sponsored research, MIT fellowships, and MIT teaching assistantships (TAs) and graduate instructorships (Figure 18). Forty percent of graduate students have RAs, 30% fellowships and 10% TAs or instructorships. As a result, tuition and stipend awards make up 88% of the financial aid received by graduate students. Student loans continue to play a significant role in the financing of a master's degree, especially for students attending the Sloan School of Management. In 2013, 32% of students receiving master's degrees, or 495 graduates, borrowed to finance their MIT graduate education and the average loan per borrower was $86,474. Three hundred thirty-nine of those graduates, or 68%, were Sloan students. This is in comparison to 6% of students receiving a PhD degree, or 32 graduates, borrowing an average of $24,745.

Figure 18. Sources of graduate student support, AY2004–AY2013



Source: MIT Institutional Research

To further enhance affordability for our undergraduate and graduate students, there is significant pressure on MIT to continually grow both sponsored research and endowment through market returns and philanthropy.

FUTURE SUSTAINABILITY OF MIT'S MODEL

By any measure we have studied, the MIT model is increasingly in demand, and it produces outstanding results in educating students and advancing knowledge. It is, however, a costly model that depends primarily on the ability to continue to attract philanthropic support and to generate investment returns.

The campus revenue mix has changed significantly from 1961, when research funding comprised 68% of revenue. Sixty-five percent of faculty members have active research programs today, and this percentage has remained fairly stable since 1997. Average research expenditures per faculty member have grown in constant dollars (2013) from $634,103 in 1997 to $815,596 in 2013. Median research expenditures in constant dollars have grown from $323,197 to $476,640 during this same time period. Today, while research expenditures have grown significantly, their percentage of campus revenue has dropped to 29%, with investment income growing from 3% of total in 1961 to 27% today.

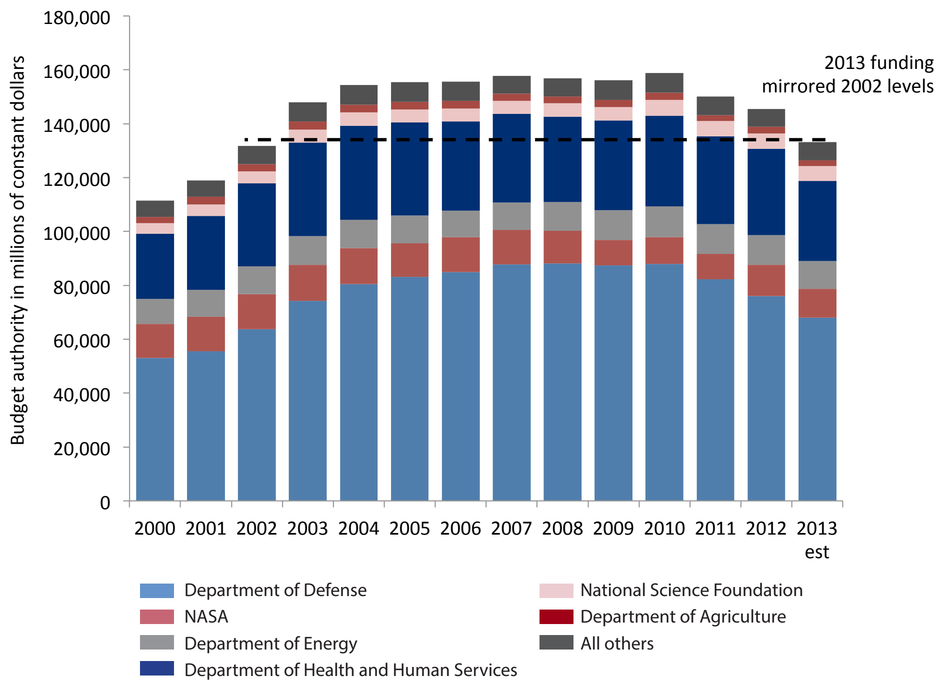
MIT has been quite fortunate in competing well for available research dollars, attracting the very best students, and growing the endowment through philanthropy and market returns. These results have allowed our vibrant research university to flourish beyond its initial conception.

At the same time, we face significant challenges.

1. Constrained federal funding has forced the Institute to grow and diversify our sponsored research portfolio to include greater portions of industrial and international support. As the overall pool of federal research funding shrinks, the mix of campus research sponsorship changes. Federal funding of campus research has reduced from almost 100% 50 years ago to 69% today (Figures 19 and 20).
2. Endowment returns and gift flows have typically followed macroeconomic trends, and we face a still-uncertain global economy and implied volatility (Figure 21). Investment support and gifts represent 38% of all campus annual revenues.
3. Academic and research space on campus has grown significantly over the past decades, to 5 million net assignable square feet, in order to accommodate the expansion of research and educational activities (Figure 22). We face the need to maintain and improve a great fraction of our world-class teaching and research infrastructure at considerable expense.
4. We also face the challenge of maintaining competitiveness in the recruitment of top talent without offsetting gains in productivity. This effect, known as Baumol's cost disease,[52] is caused by the need to compete for skilled workers in industries experiencing productivity gains.

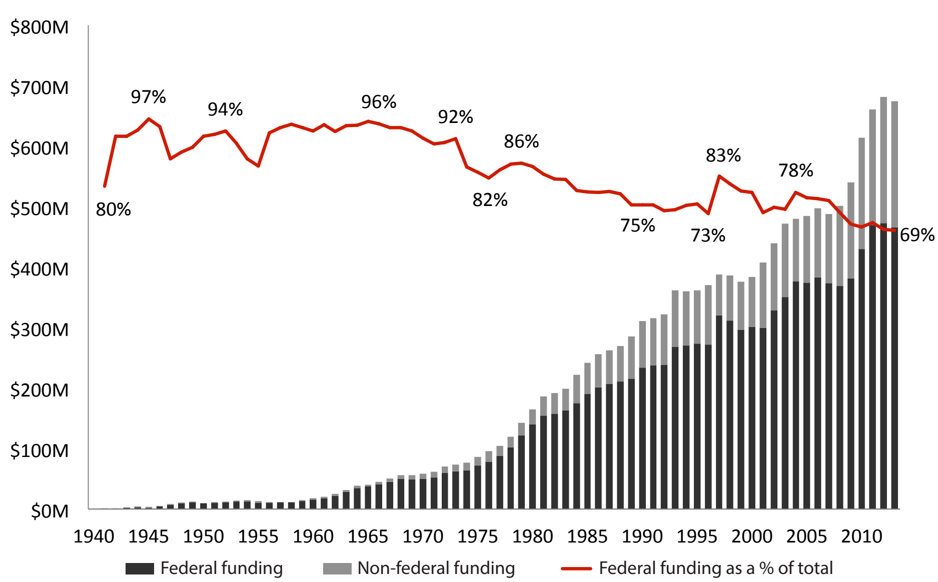
52. Baumol, William J. and William G. Bowen. *Performing Arts: The Economic Dilemma*. New York: The Twentieth-Century Fund; 1966.

Figure 19. Campus research and development budget authority, by agency, FY2000–FY2013



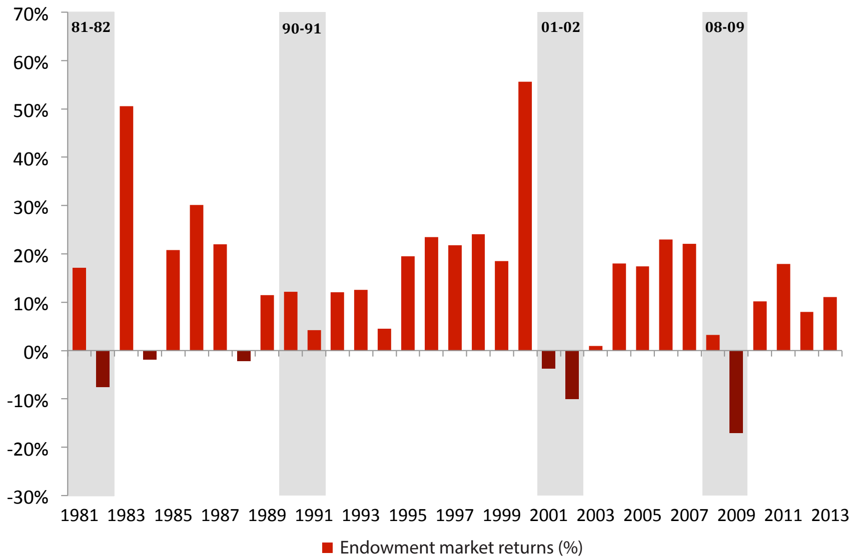
Source: American Association for the Advancement of Science R&D report series, based on Office of Management and Budget and agency R&D budget data

Figure 20. Campus federal funding as a proportion of total research funding, FY1940–FY2013



Source: MIT Institutional Research

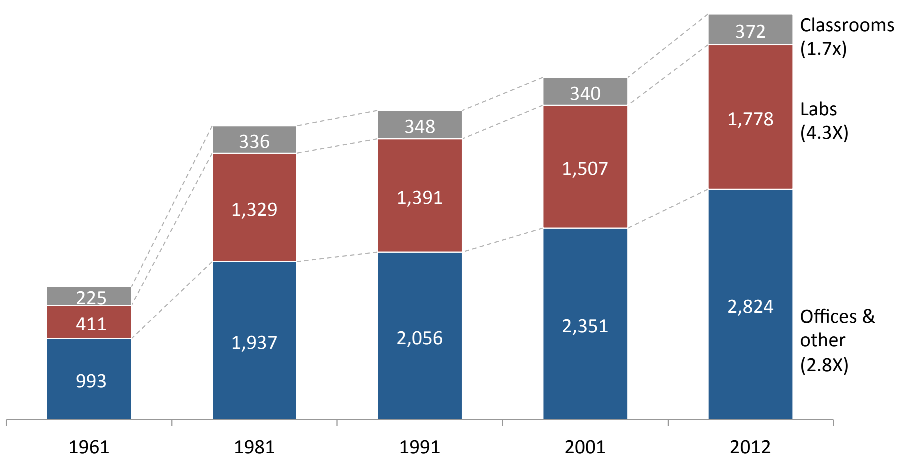
Figure 21. Market returns on MIT's endowment, FY1981–FY2013



Note: Endowment returns have typically followed macroeconomic trends.

Source: MIT Vice President for Finance

Figure 22. Growth in net assignable square feet of academic and research space on MIT campus, FY1961–FY2012



Source: MIT Space Accounting

The importance of increasing the resiliency of MIT's financial model is paramount. We will need to broaden our revenue base to balance volatility. We will need to increase the efficiency of the MIT educational model without disrupting the outcomes and exceptional quality that characterize an MIT education. We will need to maintain physical laboratories and spaces to high standards so that we continue to attract the best faculty and students to keep advancing scientific discoveries, knowledge, and innovation. And we will need to address the challenges of affordability and access, while adopting a financial model that can withstand the impacts of shifts in research funding or significant endowment volatility.

Providing the facilities required for our exceptional faculty, students, and researchers to advance research discovery and innovation is inherently expensive. With constrained research funding and a growing need to renew the campus, we need a mechanism that will allow us to meet the needs of research programs not yet imagined and continue our momentum as a premier research university. These challenges exist regardless of our involvement in online and global education. We will need to go beyond merely managing these resources and formulate a way to maximize use of existing space.

Our solution will need to be multi-pronged. We may need to slow the growth of new space, reduce our dependence on leased space, accelerate campus renewal, and develop flexible spaces that will enhance the residential experience. We will need to think creatively about incentives for increasing the density of occupants in new space, while taking old and low-quality space offline. New spaces will need to support the increasingly interdisciplinary and collaborative nature of our research and educational programs.

An improved understanding of how we use our space might inform how we can accommodate people to enhance collaborative activities, and expanded access to comprehensive space data might increase our collective awareness of the value of our facilities. The availability of this type of data could help guide us in strategic planning and allow us to quickly respond to potential changes in our student population, research endeavors, and financial position.

THE EVOLUTION OF MIT'S FINANCIAL MODEL

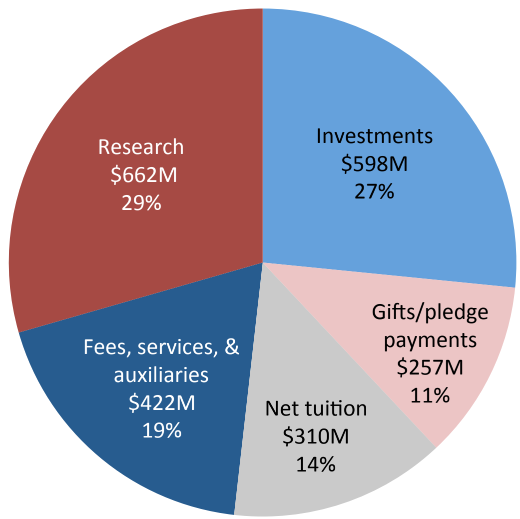
MIT today is an over $3 billion operation, including $891 million of research at Lincoln Laboratory. Excluding Lincoln, MIT's campus operations are funded through five major categories of operating revenue (Figure 23).

Research revenue ($662 million) includes reimbursements for direct research expenses (recognized when the expenses are incurred) as well as indirect research revenue earned to support centrally incurred expenses for administration, space (utilities, depreciation, interest) and other indirect costs as facilities and administrative (F&A) revenue.

Revenue support from investments ($598 million) consists primarily of distributions from MIT's endowment ($499 million) and income from all other investments, including non-endowed investments invested alongside the endowment in Pool A. (Assets and funds are pooled for investment purposes.)

Gifts and pledge payments ($257 million) include current expendable gifts received by the Institute along with payments on pledges made in prior years. Pledges received in the current year are not recognized as operating revenue, and are only recognized in the years the payments on the pledges are received.

Figure 23. Campus revenues, FY2013: $2.2B



Source: MIT Report of the Treasurer, year ending June 30, 2013

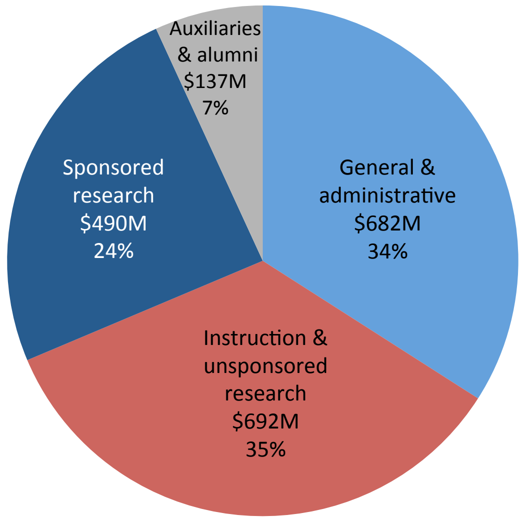
Net tuition ($310 million) is all tuition received by MIT, including tuition for executive and professional education, minus MIT-supported financial aid, which is treated as a "contra-revenue" instead of an expense according to accounting rules. Financial aid includes scholarships, fellowships, summer tuition remission, RA subsidies, and other tuition support provided by the Institute.

Fees, services, and auxiliaries revenues ($422 million) result from various other activities across the Institute. Auxiliaries ($114 million) include Housing, Dining, MIT Press, Endicott House, and Technology Review revenues. Fees and services include revenues earned through technology licensing, MIT Medical, the Department of Athletics, Physical Education and Recreation, the Industrial Liaison Program, parking, and other ancillary activities.

These sources of revenue fund MIT's faculty, research, and educational enterprise, facilities, and supporting functions.

MIT's expense structure can be segmented in many ways. The following view of functional expenses shows the campus expenses in 2013 were $2.0 billion (Figure 24). Of this total, $682 million, or 34%, was for general and administrative purposes. These expenses were for central administration, maintenance of facilities, payments on MIT's debt, and other non-instruction, non-research expenses.

Figure 24. Campus expenses, FY2013—Functional view: $2.0B



Source: MIT Report of the Treasurer, year ending June 30, 2013

Instruction and unsponsored research, $692 million or 35% of total campus expenses, includes expenses directly related to supporting instruction, such as faculty salaries, supplies to support courses, teaching assistants, and other instructional expenses. Unsponsored research is primarily internally funded research expenses not supported on any research contracts.

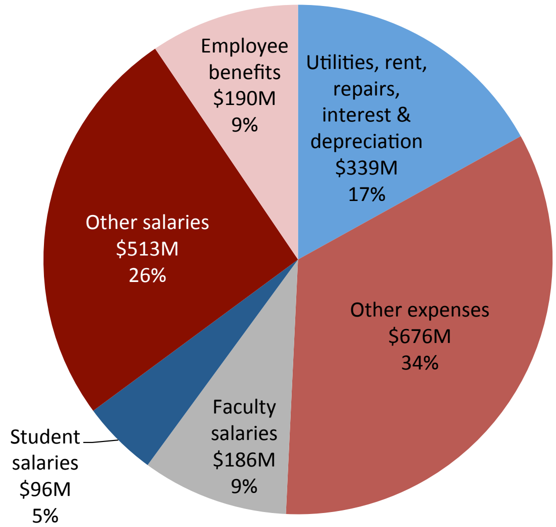
Sponsored research, $490 million or 24% of total campus expenses, is direct research expenses and does not include indirect expenses, which are covered in general and administration. This includes principal investigator salaries, research assistant costs that can be charged directly to grants, and any other expenses that can be charged directly to research contracts.

Auxiliaries and Alumni are expenses associated with operating Housing, Dining, MIT Press, Technology Review, Endicott House, and the Alumni Association.

Figure 25 shows a different way of slicing the same campus expenses, by what the money actually paid for. Salaries, wages, and employee benefits (SWEB) make up nearly 50% of all campus expenses, $985 million out of $2.0 billion. Campus salaries and wages can be broken out by faculty, student salaries (including RA and TA stipends), and other salaries. It does not include costs for temporary employees, consultants, and other contractors, which are included in other expenses. Employee benefits costs include those associated with medical, dental, parking, pension, postretirement medical, and other benefit programs offered to employees through MIT.

Utilities, rent, repair, interest, and depreciation costs ($339 million or 17% of total campus costs) include those costs associated with space on campus. These include costs to operate the central utility plant and to buy utilities from outside MIT; interest expenses on MIT's borrowings; depreciation on buildings, equipment, and other capitalized property; lease costs; and costs associated with maintaining MIT's physical infrastructure. It does not include capital investments in infrastructure and other capital assets, which are reflected on our balance sheet and show up as periodic depreciation expenses over the lives of the assets.

Figure 25. Campus expenses, FY2013—Natural view: $2.0B

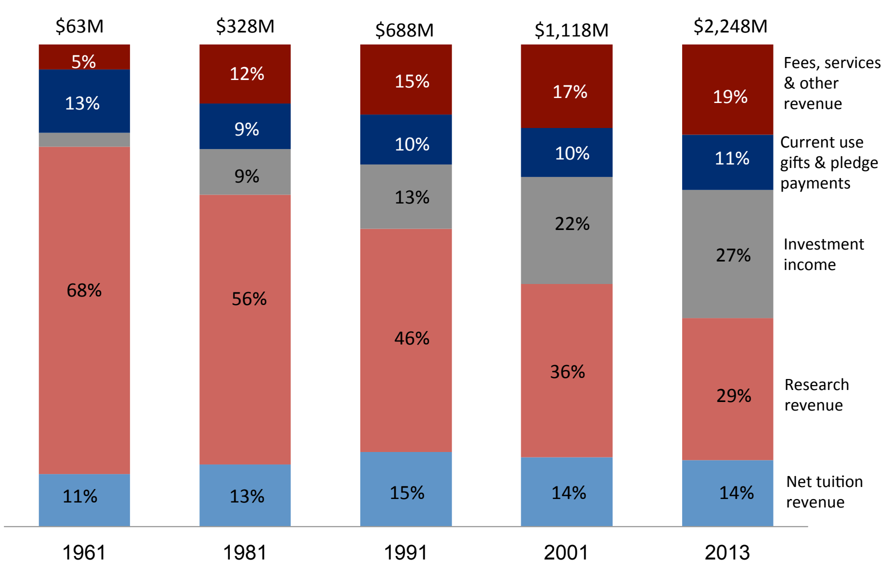


Source: MIT Report of the Treasurer, year ending June 30, 2013

Other operating expenses ($676 million or 34% of total campus costs) capture all remaining expenses at MIT. These items run the gamut from non-capital equipment to supplies and services, contractors, travel, and anything else MIT pays for that is not related to compensation or space.

It is clear from reviewing the historical figures that MIT's financial model evolved to adapt to the mission of MIT over many decades.

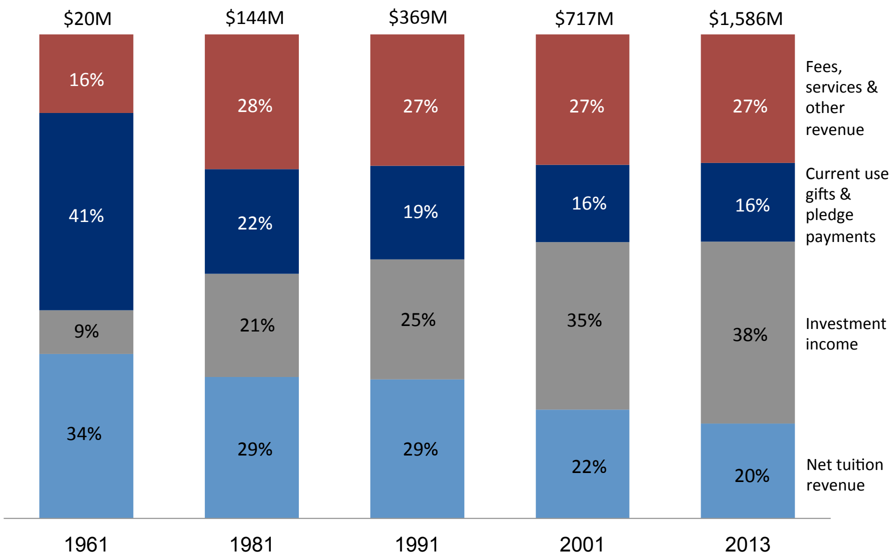
Figure 26. Evolution of campus revenue mix, FY1961–FY2013



Note: Excludes the Broad Institute, Lincoln Laboratory, and the Singapore-MIT Alliance for Research and Technology.

Source: MIT Vice President for Finance

Figure 27. Evolution of campus non-research revenue mix, FY1961–FY2013



Note: Excludes the Broad Institute, Lincoln Laboratory, and the Singapore-MIT Alliance for Research and Technology.

Source: MIT Vice President for Finance

Figures 26 and 27 illustrate how MIT's revenue mix has evolved over time, from being research-centric in the 1960s to being more reliant on investment income in recent years. In the throes of the space race and Cold War, MIT's research enterprise was its primary source of campus revenue, making up 68% in 1961.

However, as the model evolved, MIT diversified its revenue sources. As MIT's endowment grew and its investment returns improved substantially in the 1990s and 2000s, the revenue mix shifted toward heavier reliance upon investment income, which in turn provided the funding needed to expand MIT's research and education mission into new priorities such as life sciences. Of course, as noted before, this heavy reliance on investment income comes with the added risk of exposure to economic volatility, as MIT experienced during the financial crisis of 2008–2009, which resulted in our needing to reduce endowment payout rates by 18% in 2011 and adjust spending accordingly.

Another item of note is that net tuition has not been a major source of revenue, never comprising more than 16% of the campus total. We have also become somewhat more reliant upon fees and services, driven in part by technology licensing activities. Though MIT has experienced great success in fundraising over the years, as a proportion of total revenue it has remained relatively flat.

FRAMEWORK FOR MODELING FUTURE OPPORTUNITIES

The Working Group has been developing possible approaches to test scenarios emerging from Task Force discussions and evaluate financial impacts. It has also been considering opportunities to generate alternative revenue streams within the current model to provide increased flexibility in the future. In addition, we have been looking at ways to better support residential and global experiments that may be identified by the Task Force.

Revenue Opportunities

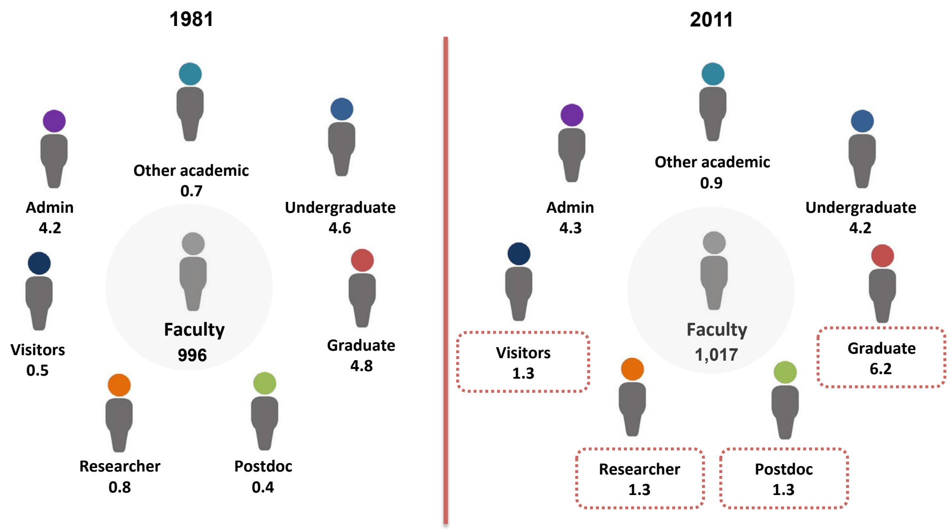
Preserving and enhancing the extraordinary research and educational environment at MIT is likely to require both a strengthening of existing income sources and consideration of new revenue opportunities. Two current sources of institutional support—government research funding and tuition—are likely to be under pressure, the former from ongoing federal budget pressures and the latter from growing interest among policy-makers and the public in slowing the growth of gross tuition prices and raising financial aid. It may be possible to increase the revenues generated from other existing sources of funds by raising the level of development activity to support increases in charitable gifts, and by expanding the scope of institutional and corporate partnerships.

Other strategies for enhancing revenues involve getting more resources from existing revenue streams, for example by hosting an expanded menu of summer programs and broadening the array of executive education activities by involving more faculty in both on-campus and off-campus initiatives. One potential new source of revenue to be explored is the use of digital learning technologies to leverage on-campus course instruction, coupled with some form of paid certification. One of the most difficult potential revenue streams to assess is the one associated with edX and related online learning initiatives. The experience of a number of programs at other universities may provide some guidance on the revenue possibilities in this sphere. Another possible new revenue source may involve more creative ways to engage the private sector in technology licensing. However, such an initiative is fraught with potential conflicts of interest with respect to MIT's educational mission, and this risk must be carefully weighed against any benefits from entrepreneurship.

MIT Operating Model—A Visual View

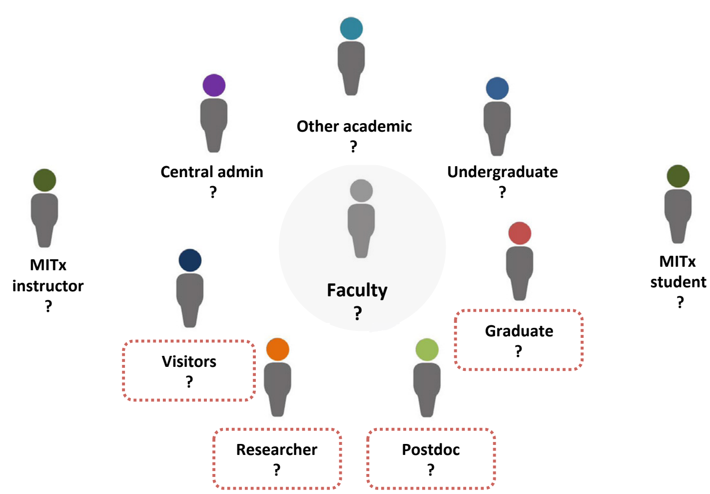
The number of MIT faculty has remained relatively constant over the past 30 years, with 996 faculty members in 1981 and 1,017 in 2011 (Figure 28). Similarly, the number of undergraduate students has remained constant, with 4.6 undergraduates per faculty member in 1981 and 4.2 undergraduates per faculty member in 2011. The numbers of graduate students, research staff, postdoctoral trainees, and visitors to MIT have all grown significantly as a result of the substantial growth in research funding over this same time period. The numbers of faculty and undergraduates have been strategically controlled, while the numbers of graduate students admitted and research staff hired have been determined at the departmental level. These changes in population on campus have evolved based on individual unit decisions with little opportunity for strategic integration. It is important to consider the faculty-undergraduate relationship as we work to reach more people and improve funding opportunities over the long term.

Figure 28. How we have evolved: Headcount 1981 vs. 2011



We now have the opportunity to influence the evolving campus population as we move into the future. Strategically increasing the undergraduate student-to-faculty ratio could have positive financial impact, but if pursued, this must occur without damaging the quality of the residential experience. Online experiences present new opportunities for envisioning educational roles for the future. For example, the roles of *MITx* instructor and *MITx* student may exist in 2020. As Task Force discussions continue, this model can be used to project how potential experiments might impact the campus population (Figure 29).

Figure 29. Looking forward: What will we look like in 2020?



MIT Operating Model—Operating Component View

The operating component view of the MIT operating model considers distinct categories of costs: Revenue-generating operations, academic and research expenditures, academic and research support services, student and residential services, administrative enabling services, and plant and capital costs.

Incremental Cost Framework

The incremental cost framework looks at operating costs—compensation, space-related expenses, supplies and services, and expense offsets (tuition, fees, room and board)—in relation to faculty with specific attributes or students enrolled in particular programs, in order to estimate the incremental financial impact of adding faculty and students under specified scenarios.

The incremental analysis framework is designed to support different combinations of faculty and student increases, with consideration of specific disciplines and associated needs. Recognizing the impact of housing on the cost of adding students, the framework supports various housing options—lower or average cost on-campus housing and off-campus housing. Using a scenario builder, we can study a variety of scenarios and resulting financial impacts.

CONTINUING OUR WORK

The questions we are trying to answer are complex and nuanced, and the public conversation about affordability and access is growing. The MIT model produces outstanding students and advances knowledge in extraordinary ways, yet we face significant challenges. We need to adopt a financial model that can weather the challenges of constrained federal funding, an uncertain global economy, and the need for campus renewal without disrupting the outcomes and exceptional quality that characterize an MIT education. It is a daunting task, but we are confident that the best approaches for enabling MIT for generations to come will emerge as we continue the Task Force work.

APPENDICES

Appendix 1. Presidential Charge to the Institute-wide Task Force on the Future of MIT Education

In a letter to the MIT Community on February 6, 2013, President Rafael Reif described the formation of an Institute-wide Task Force.

To the members of the MIT community:

With great optimism and excitement, I write to share the news that I am creating an Institute-Wide Task Force on the Future of MIT Education.

Reinventing what we do and how we do it

At my inauguration, I made the case that, thanks to the pressures of cost and the potential of new online teaching technologies, higher education is at a crossroads. As a result, we have a truly historic opportunity to better serve society by reinventing what we do and how we do it. I proposed that MIT should continue to use *MITx* and edX to create the best online education possible, in ways affordable and accessible for students far beyond our campus. And I challenged us all, in the great MIT spirit of learning by doing, to use our own campus community to invent the residential research university of the future.

Listening to our community and the wider world

Since then, in my listening tour across MIT, people have told me over and over how glad they are that MIT is helping to lead this educational revolution—and how important it is that we "get it right." Conversations with leaders in Washington and at the World Economic Forum have confirmed my view that we are rapidly reaching an inflection point in the history of higher education and that the outcome will be critically important for MIT, for colleges and universities in general, and for generations of students around the world.

Leadership of the Task Force

To help MIT assess and rise to the demands of this complex challenge, I am following a path many MIT presidents have followed successfully before me: I am creating an institute-wide task force that will draw on and focus this community's legendary capacity for rigorous analysis, technical know-how, creative problem-solving and thinking big.

To lead this effort, I have chosen two co-chairs: Professor Sanjay Sarma, who already serves as our Director of Digital Learning, and Executive Vice President and Treasurer Israel Ruiz SM '01. A member of the edX board, Israel also brings to the task a deep understanding of MIT's physical and financial resources and previous experience in leading such a complex "volunteer" effort, since he co-chaired the 2009–2011 Institute-Wide Planning Task Force that helped MIT find a creative path forward during the global financial downturn.

I am asking Sanjay and Israel to assemble the remaining members of the Task Force, including faculty, students, alumni and staff who can represent the broad interests of the MIT community. I expect that they will announce the list of members within a few weeks.

* * *

I encourage everyone to read my official charge to the Task Force, which describes its scope and purpose. We face big questions, with big consequences. To arrive at the best solutions, we will need to draw on the collective experience and wisdom of individuals and groups from across the MIT community. If we share our best thinking, informed by our highest aspirations for MIT, I have no doubt that we will come to answers that will serve our community and advance the larger conversation.

Sincerely,

L. Rafael Reif

Charge to the Institute-wide Task Force on the Future of MIT Education

Higher education is striving to respond to the forces of disruptive change. While many US students struggle to cover the cost of higher education, colleges and universities are straining to cover the cost of providing that education. Yet at the same moment, advances in online teaching technologies are opening up extraordinary new possibilities, suddenly making it possible to offer highly effective but comparatively low-cost advanced instruction to students on campus and to millions of learners around the world.

The positive implications for society are immense and impossible to fully foresee. And I am convinced that these forces offer us the historic opportunity to reinvent the residential campus model and perhaps redefine education altogether. Our society can only benefit if we improve what the residential research university does better than any other institution: Incubate brilliant young talent, and create the new knowledge and innovation that enrich our society and drive economic growth.

For MIT—an institution passionately committed to the kind of hands-on, team-focused, apprenticeship education that depends on community and human contact—the challenge and the opportunity are particularly urgent and direct. In short, to stay true to our educational values, we must seize the opportunity to reimagine what we do and how we do it. I raised this challenge at my inauguration. In the four months since, the stunning pace of change has proved that we are in the midst of an educational revolution.

MIT has already chosen to help lead one aspect of this revolution through edX and *MITx*, our ongoing experiments in online learning. But I believe we can and should take the lead in helping to invent the future of education more broadly—both on our campus and beyond. Defining this path and leading us toward a financially sustainable solution will be the charge of this Task Force.

Building on a legacy of educational innovation

MIT has helped lead the world to new educational frontiers before. In its very founding, with its bold insistence on learning by doing, MIT helped invent the educational model that turned the United States into an industrial success. In the 1950s, MIT rebuilt its engineering curriculum on a foundation of basic science. In the 1970s, MIT dared to make frontline research a routine part of the undergraduate learning experience through its now widely copied Undergraduate Research Opportunities Program (UROP). In the 1980s, with Project Athena MIT created a crucial prototype of the connected campus. In 2002, MIT launched the unprecedented experiment in free online sharing known as MIT OpenCourseWare. And in late 2011, we took the next step in online learning with the creation of *MITx*, followed shortly by edX, a partnership with Harvard University to launch a non-profit learning platform open to students and institutions around the world.

Today, I ask that this Task Force be bold—just as bold—in experimenting with ideas that would both enhance the education of our own students on our own campus and that would allow us to offer some version of our educational experience to learners around the world. Your explorations may lead you to answers that will have implications and applications far beyond MIT, and I encourage you to capture and consider those ideas as well.

This challenge is non-trivial, but you will be able to draw on a growing resource never available before: the rapidly evolving research on learning science, including the remarkable flow of data emerging from our own online learning efforts. Use this information to inspire your thinking. The future of education may include many possible models and scenarios. Experiments will be necessary, and as we learn more along this journey, we will need flexible thinking, reliable feedback and an "ecosystem" that helps us adapt. Help us imagine how to make that ecosystem work.

Leadership

Sanjay Sarma, Professor of Mechanical Engineering and Director of Digital Learning, and Israel Ruiz, EVP and Treasurer, will lead the Task Force as Co-Chairs.

Leveraging the wisdom of our community

In the best tradition of MIT, it is vital that we use this Task Force to expand discussion of these complex, critical issues to include all members of our community. I therefore ask that the Task Force move immediately to create a mechanism, such as an Idea Bank, that will allow people throughout the MIT community to contribute their experiences and recommendations. And although I propose below some preliminary questions to focus your discussions, I encourage you to solicit ideas and concerns from the MIT community, leverage existing research on education and identify additional areas of importance.

A commitment to transparency and communication

Because the Task Force will consider topics that go to the marrow of MIT, we owe the community a commitment to transparency and to regular communications about the progress of its work. I encourage you to suggest the most effective tools and approaches we can use to meet these commitments.

The Charge

So that you may advise me and MIT's administration, I charge the Task Force to:

- Propose an "ecosystem" for ongoing research, learning and innovation about the future of education.
- Recommend a range of possible experiments and pilot projects that will allow us to explore the future of MIT education:
    - *On our own campus*, in ways that incorporate online learning tools to the fullest extent while maximizing the value of face-to-face learning for both faculty and students.
    - *Beyond our campus*, through which learners around the world could benefit from important aspects of MIT's educational content, vision and values
- Evaluate the future strength and sustainability of MIT's current financial model in this evolving context and propose alternative or complementary approaches.
- Develop a roadmap that will describe the work streams and the phases of work necessary to enable this ecosystem and implement these experiments.

Proposed questions to be addressed:

1. What can we learn from the many examples of "blended models" of education, which seek to magnify the effectiveness of online instructional tools with in-person teaching?
2. MIT has traditionally used a four-year, two-semester system. More modular models are also being tested. What other approaches could emerge by 2020?
3. Online technologies have already proven very effective at *instruction*—the conveying of content. But as our graduates can attest, an MIT *education* clearly includes many learning experiences that can only occur in person. Today, the MIT learning experience involves several modes of interaction: lectures, recitations, labs, projects, internships, study groups, individual study and so on. It also features signature educational approaches such as UROP and MISTI (MIT International Science and Technology Internship program), and intensive project-based hands-on learning in many fields. What learning experiences will constitute an MIT education in 2020? Which elements would be enhanced by online technologies, and which truly demand interaction in person? What new experiences could courses incorporate?
4. How can MIT improve accessibility and affordability?
5. What are the implications for MIT's financial model and pricing structures?
6. What are the implications for MIT's physical spaces, including classrooms, research laboratories, residential spaces and common spaces?
7. What are the pathways and barriers, advantages and disadvantages, to extending important aspects of the MIT educational experience to vastly more learners than we could ever bring to our campus?

Working Groups

- Working Group on MIT Education and Facilities for the Future
- Working Group on the Future Global Implications of edX and the Opportunities It Creates
- Working Group on a New Financial Model for Education

Timeline and Results

I ask that you complete a preliminary report in approximately six months, for the start of the 2013–14 academic year. This initial report should include your initial findings on all the elements of the charge. I expect that your final report could be complete a year from now.

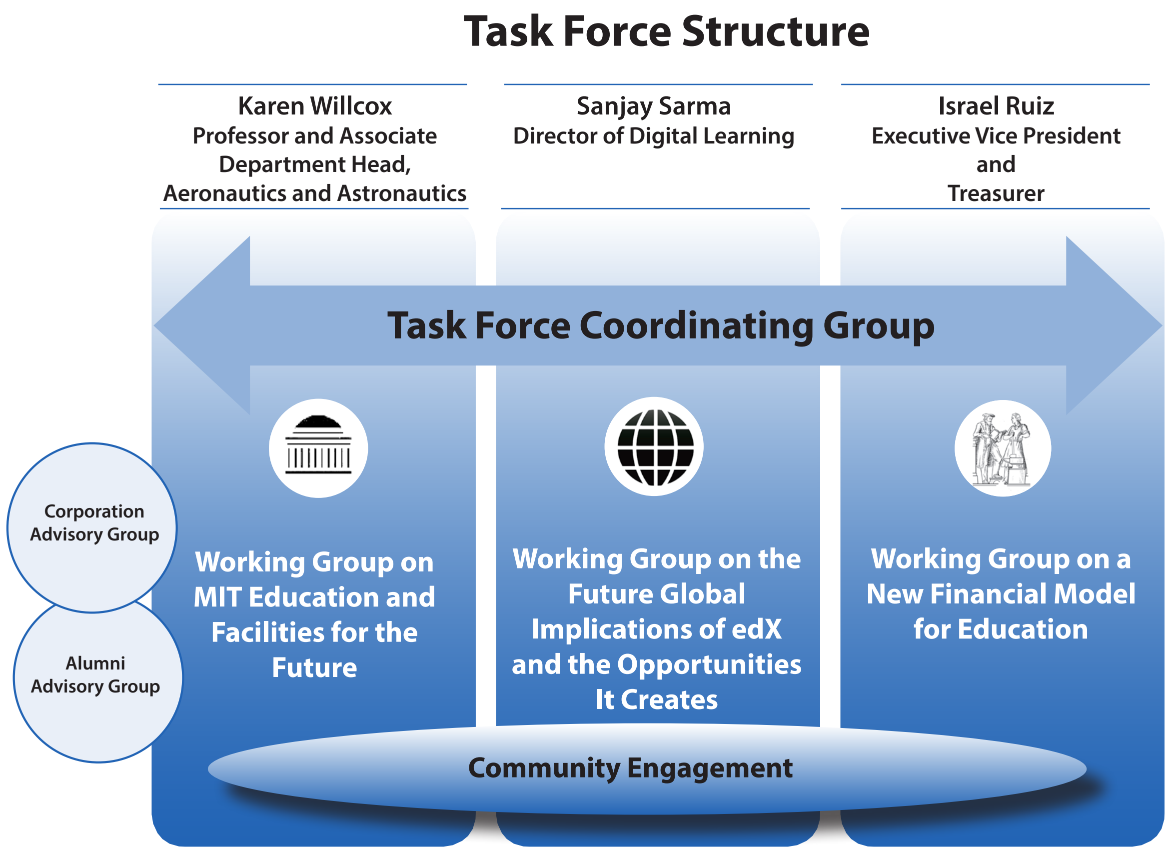
The task before you is serious and pressing. I hope it will also be fascinating, and I urge you to bring to it all of your creativity and your highest aspirations for MIT. MIT has long stood for openness, accessibility and educational innovation, and through your efforts, we can lead the way to a new realization of these ideals.

I am deeply grateful for your willingness to serve the Institute through this Task Force, and I believe your work will also serve the world.

Sincerely,

L. Rafael Reif

Appendix 2. Task Force Structure and Membership



Three Working Groups of Faculty, Students, and Staff

Working Group Membership includes faculty representing all five schools, staff and both undergraduate and graduate students, with approximately 50 individuals participating as members. The Task Force Coordinating Group is comprised of faculty, students, and staff representing the three working groups, and is designed to provide connectivity across the groups. Corporation and Alumni Task Force Advisory Groups were formed to provide insights and recommendations as the Task Force performs its work.

Task Force Membership

Task Force Co-Chairs

Israel Ruiz, Executive Vice President and Treasurer
Sanjay Sarma, Director of Digital Learning
Karen Willcox, Professor and Associate Department Head, Department of Aeronautics and Astronautics

Working Group on MIT Education and Facilities for the Future

Chair

Karen Willcox, Department of Aeronautics and Astronautics

Faculty

Samuel Allen, Department of Materials Science and Engineering
Deepto Chakrabarty, Department of Physics
Isaac Chuang, Department of Electrical Engineering and Computer Science
Catherine Drennan, Department of Chemistry
Dennis Freeman, Dean for Undergraduate Education
Daniel Hastings, Engineering Systems Division and Aeronautics and Astronautics
Daniel Jackson, Department of Electrical Engineering and Computer Science
SP Kothari, Sloan School of Management
Anne McCants, Department of History
Augustín Rayo, Department of Linguistics and Philosophy
Mitchel Resnick, Program in Media Arts and Sciences
Laura Schulz, Department of Brain and Cognitive Sciences
Nader Tehrani, Department of Architecture
Karen Willcox, Department of Aeronautics and Astronautics

Staff

Peter Bedrosian, Registrar's Office
Lori Breslow, Office of the Dean of Undergraduate Education

Students

Devin Cornish, Undergraduate, Department of Mechanical Engineering
Kuang Xu, Graduate, Department of Electrical Engineering and Computer Science

Working Group on the Future Global Implications of edX and the Opportunities It Creates

Chair

Sanjay Sarma, Director of Digital Learning

Faculty

Martin Culpepper, Department of Mechanical Engineering
Michael Cusumano, Sloan School of Management
Rick Danheiser, Department of Chemistry
Steven Eppinger, Sloan School of Management
Eugene Fitzgerald, Department of Materials Science and Engineering
Steven Hall, Chair of the Faculty
Sep Kamvar, Program in Media Arts and Sciences
Philip Khoury, Associate Provost
Eric Klopfer, Department of Urban Studies and Planning
Thomas Malone, Sloan School of Management
Christine Ortiz, Dean of Graduate Education
Sanjay Sarma, Director of Digital Learning
Hanna Rose Shell, Program in Science, Technology and Society
Hazel Sive, Department of Biology
Jacob White, Department of Electrical Engineering and Computer Science

Staff

Vijay Kumar, Office of Digital Learning, Office of Educational Innovation and Technology
Bhaskar Pant, MIT Professional Education

Students

Anubhav Sinha, Undergraduate, Department of Electrical Engineering and Computer Science
Ellan Spero, Graduate, Program in Science, Technology and Society

Working Group on a New Financial Model for Education

Chair

Israel Ruiz, Executive Vice President and Treasurer

Faculty

John Belcher, Department of Physics
Claude Canizares, Vice President
Andrew Lo, Sloan School of Management
James Poterba, Department of Economics
Craig Wilder, Department of History

Staff

Elizabeth Hicks, Office of Student Financial Services
Michael Howard, Vice President for Finance
Karl Koster, Corporate Relations
Israel Ruiz, Executive Vice President and Treasurer
Anthony Sharon, Office of the Executive Vice President and Treasurer

Rochelle Weichman, Sloan School of Management
Heather Williams, School of Science
David Woodruff, Office of the Vice President of Resource Development

Students

Patrick Hulin, Undergraduate, Department of Mathematics
George Chen, Graduate, Department of Electrical Engineering and Computer Science

Task Force Coordinating Group

Co-Chairs

Israel Ruiz, Executive Vice President and Treasurer
Sanjay Sarma, Director of Digital Learning
Karen Willcox, Department of Aeronautics and Astronautics

Faculty

Claude Canizares, Vice President
Michael Cusumano, Sloan School of Management
Daniel Jackson, Department of Electrical Engineering and Computer Science
Eric Klopfer, Department of Urban Studies and Planning
SP Kothari, Sloan School of Management
Anne McCants, Department of History
Hazel Sive, Department of Biology
Jacob White, Department of Electrical Engineering and Computer Science

Staff

Anthony Sharon, Office of the Executive Vice President and Treasurer
Heather Williams, School of Science

Students

Patrick Hulin, Undergraduate, Department of Mathematics
Ellan Spero, Graduate, Program in Science, Technology and Society

Task Force Corporation Advisory Group

Chair

Diana C. Walsh, President Emerita, Wellesley College

Members

Raja H.R. Bobbili, Student, JD/MBA Program, Harvard University
Vanu Bose, CEO, Vanu, Inc.
R. Erich Cauffield, New Orleans Federal Lead for White House Strong Cities, Strong Communities (SC2) Initiative
Diane B. Greene, Member, Board of Directors, Google Inc., Intuit and MIT
Brian G. R. Hughes, Chairman and Product Engineer, HBN Shoe, LLC

Robert B. Millard, Managing Partner, Realm Partners, LLC
Megan J. Smith, Vice President, Google X, Google, Inc.
Kenneth Wang, President, US Summit Company

Task Force Alumni Advisory Group

Chair

John W. Jarve ’78, President of the Association of Alumni and Alumnae of MIT, 2013–14

Members

Katy Brown ’93, SM ’96
Dan W. Butin ’90, Founding Dean of the School of Education at Merrimack College
John Gavenonis ’98, Global Technology Manager, Renewable/Sustainable Materials, E. I. Du Pont de Nemours, DuPont Performance Polymers
Bhavya Lal ’89, SM ’90, SM ’92, Core Staff Member at the Science and Technology Policy Institute
Thomas H. Massie ’93, SM ’96, U.S. Representative from Kentucky
Andrew N. Sutherland, Founder, Quizlet
Priyamvada Natarajan ’90, ’91, SM ’11 Professor of Astronomy and Physics, Yale University

Financial Data and Analysis Team

Liaison from Task Force Working Groups to Data Team

Michael Howard, Vice President for Finance

Staff

Christine Albertelli, Office of the Vice President for Finance
Deborah Leitch, Office of the Vice President for Finance
Allen Marcum, Office of the Vice President for Finance
Lydia Snover, Office of the Provost
Basil Stewart, Office of the Vice President for Finance

Appendix 3: Community Engagement

Community Engagement

In the best tradition of MIT, the Task Force is a collaborative and inclusive process where input from all parts of the community is sought, welcomed and valued. With the guidance of the Advisory Groups and input from the broader MIT community through the Idea Bank and group discussions, this work reflects the experiences and knowledge of the faculty, students, staff, members of the Corporation and alumni who contributed their expertise to these conversations.

Advisory Groups

Recognizing the magnitude and tremendous importance of this effort, two Advisory Groups were formed. The Corporation Advisory Group, chaired by Corporation and Executive Committee member Diana Chapman Walsh, provides insight and expertise and engages Corporation members more broadly in these discussions. The Alumni Advisory Group, chaired by President of the Association of Alumni and Alumnae of MIT John Jarve, will engage MIT's alumni in these discussions and provide opportunities to contribute to this work.

Idea Bank

An Idea Bank was created for the MIT community to contribute experiences and recommendations. The Idea Bank website, future.mit.edu, received visitors from 102 countries and saw 180 ideas submitted. Social networks joined the conversation, with more than 500 followers on Twitter and more than 100 followers on the Future of MIT Education Yammer group.

Engagement Meetings

A number of face-to face meetings have been held and are still ongoing to gather input and encourage engagement. This includes discussions at 22 academic department faculty meetings across the five schools, outreach sessions hosted by the Graduate Student Council and Undergraduate Association, table discussions at the spring 2013 Administrative Council meeting, and table discussions at the October Corporation dinner.

Surveys

A survey was conducted of the faculty and instructional staff designed to understand present and anticipated educational resource needs and how interactions between students and their instructors are changing. A student survey designed to better understand how students learn and interact with faculty, and what educational technologies students use was also carried out. Fifty-two percent of the faculty, 35% of the instructional staff, 35% of graduate students, and 39% of undergraduates responded to the two surveys.

List of Community Engagement Sessions

Meeting with Housemasters, April 17, 2013
Discussion with Task Force Co-chairs Sanjay Sarma and Israel Ruiz

Administrative Council Meeting, April 30, 2013
Table discussions captured and submitted to Idea Bank

Undergraduate Association Council meeting, May 7, 2013
Discussion with Task Force Co-chair Sanjay Sarma

Graduate Student Council–sponsored coffee hour at Sidney-Pacific graduate residence, June 12, 2013
Moderated discussion with approximately 50 participants

Academic Council, September 24, 2013
Discussion with Task Force Co-chairs Sanjay Sarma and Israel Ruiz

Research Council, October 10, 2013
Discussion with Task Force Co-chairs Sanjay Sarma and Israel Ruiz

Committee on the Undergraduate Program, October 23

Department Faculty Meeting Conversations with Task Force Working Group Chairs

School of Architecture and Planning

Media Arts and Sciences, September 16, 2013

Urban Studies and Planning, October 3, 2013

Architecture, October 9, 2013

School of Engineering

Chemical Engineering, September 9, 2013

Aeronautics and Astronautics, September 11, 2013

Mechanical Engineering, September 20, 2013

Engineering Systems, October 1, 2013

Materials Science and Engineering, October 3, 2013

Civil and Environmental Engineering, October 4, 2013

Nuclear Engineering, October 4, 2013

Electrical Engineering and Computer Science, October 21, 2013

Biological Engineering, November 18, 2013

School of Humanities, Arts and Social Sciences

Economics, October 30, 2013

Anthropology; Comparative Media Studies/Writing; Foreign Languages and Literatures; History; Linguistics and Philosophy; Literature; Music and Theatre Arts; Science, Technology and Society, November 4, 2013

Political Science, November 7, 2013

School of Science

Earth, Atmospheric and Planetary Sciences, September 26, 2013

Brain and Cognitive Sciences, September 27, 2013

Biology, October 21, 2013

Mathematics, October 24, 2013

Physics, October 24, 2013

Chemistry, November 5, 2013

Sloan School of Management, September 24, 2013

Idea Bank: Summary of Data and Themes

Idea Bank demographics and visitor information, April–July 2013

Type of participant*	Count
Alumnus/a	211
Current student	69
MIT faculty or instructor	20
MIT staff	89
Unknown/Other	40
Total	**429**

Page visits by country of origin	Count
United States	7,468
China	126
Canada	115
France	97
India	94
Australia	92
United Kingdom	66
Germany	51
Brazil	47
Spain	44
Remaining 92 countries	774
Total	**8,974**

Page visits by type of device	Count
Desktop	7,883
Mobile	667
Tablet	424
Total	**8,974**

*Includes all accounts created, most of which did not contribute to the discussion

Idea Bank: Ideas by Category

Number of ideas	Idea summary	New programs or paths	New courses or focuses	Integration of industry	The online platform	MIT in the world	The residential experience	Finances	Considerations/Concerns	Miscellaneous
23	Use online lectures to supplement, not replace, future residential classes				X		X			
16	Uncategorized									
9	Promote greater faculty–student interaction on campus to offset online education						X			
8	Reduce tuition, control costs							X		
6	Offer a cheaper three-year degree with stripped-down GIRs[a]	X			X		X	X		
6	Focus content to be more applied and connected to the real world			X						
6	Balance online and classroom education				X		X			
5	Offer different versions of the same course to fit different learning styles		X							
4	Integrate industry partners into classes across all departments			X				X		
4	Give credit for online education				X					
4	Create online courses for high school seniors to prepare them for college				X					
4	Reduce or adjust MIT's physical footprint to reflect a more online experience						X			
4	Actively promote group project and pset[b] work via expansion of group spaces						X			
3	Greater integration of internships for credit	X								
3	Focus on issues of sustainability on campus		X							

Idea Bank: Ideas by Category, continued

Number of ideas	Idea summary	New programs or paths	New courses or focuses	Integration of industry	The online platform	MIT in the world	The residential experience	Finances	Considerations/Concerns	Miscellaneous
3	Integrate one-on-one experience into online format				X					
3	Integrate new pedagogical advances made possible by web techologies				X					
3	Integrate living spaces with learning spaces, learn/work in small groups						X			
3	Focus on making online content accessible to all, including those with disabilities								X	
2	Break classes down into atomistic/bite-sized elements/goals that are linked across the entire Institute	X	X							
2	Add an alternative track to tenure for exceptional teachers/reward exceptional teachers	X								
2	Focus more on research methods, bring research experience online		X		X					
2	Include ethics module in online education		X							
2	Develop certification tests so students can prove their online education improved their skills				X		X			
2	Explore more options for real-time feedback in classes and online				X		X			
2	Involve MIT in projects aiming to improve education both locally and globally					X				
2	Use MIT's influence to promote conversation on science and technology worldwide					X				
2	Drop lectures in favor of more recitations						X			

Idea Bank: Ideas by Category, continued

Number of ideas	Idea summary	New programs or paths	New courses or focuses	Integration of industry	The online platform	MIT in the world	The residential experience	Finances	Considerations/Concerns	Miscellaneous
2	More tapings/live streams of classes for those who are sick/can't get to class						X			
2	Allow students to pay for tuition with a percentage of their future salary							X		
2	Improve transparency in financial aid							X		
2	Leave MIT the same								X	
2	Consider impact of online education on FSILGs[c], consider their importance in education								X	
2	Use metrics and a data-driven approach to determine the best course of action									X
1	Make all classes pass/fail	X	X							
1	Give students credit for creating content that helps other students learn	X								
1	Set up a formal teacher training program	X								
1	Teach smaller, shorter classes for subjects that don't need a full semester	X								
1	Move beyond course-focused education to concept-focused education	X								
1	Add a class in Course 6 which focuses on interdisciplinary collaboration, similar to 2.009		X							
1	Reintroduce classes focused on engineering a smarter power grid		X							
1	Increase focus on "grit"/self-efficacy		X							
1	Offer class on genocide history and prevention		X							

Idea Bank: Ideas by Category, continued

Number of ideas	Idea summary	New programs or paths	New courses or focuses	Integration of industry	The online platform	MIT in the world	The residential experience	Finances	Considerations/Concerns	Miscellaneous
1	Make HASS[d] classes more applied toward specific disciplines		X							
1	Host guest entrepreneurs in exchange for voluntary percentage of future wealth			X				X		
1	Increase focus on training PhDs for industrial leadership			X						
1	Create edX "satellite" campuses				X	X				
1	Traveling professors to teach supplementary material to edX courses				X	X				
1	Force online collaboration in MOOCs[e] by teams in different countries				X	X				
1	Allow online students to compete for "externships" with MIT through online course challenges				X					
1	Create physical spaces around the world for local edX recitation groups				X					
1	Use online platform for prerequisites				X					
1	License online platform to companies for their own internal learning				X					
1	Explore technologies to automate the video capture process for online classes				X					
1	Use edX to provide career education				X					
1	Create a MOOC[e] version of IAP[f]				X					
1	Cold-calling in online classrooms				X					

Idea Bank: Ideas by Category, continued

Number of ideas	Idea summary	New programs or paths	New courses or focuses	Integration of industry	The online platform	MIT in the world	The residential experience	Finances	Considerations/Concerns	Miscellaneous
1	Allow students to take online classes to get a taste of MIT before they choose to attend				X					
1	Allow the best online students to fill spots vacated by dropouts				X					
1	Allow students to submit media to fulfill course requirements in humanities MOOCs[e]				X					
1	Use influence to drive down journal prices to make them more affordable					X				
1	Encourage more students to live off campus						X			
1	Remove the "cap" on tuition—make it a flat percentage of income							X		
1	Utilize retired people as teachers, helpers									X
1	Improve functionality and depth of MIT directory									X
1	Make course evaluations due after exam period, hold grades if necessary									X
1	Make all intellectual property developed by anyone at MIT property of the inventor(s)									X
180										

[a]General Institute Requirements
[b]Problem sets
[c]Fraternities, sororities and independent living groups
[d]Humanities, Arts and Social Sciences
[e]Massive online open courses
[f]Independent Activities Period

Idea Bank: Notable Quotes, by Working Group

MIT Education and Facilities for the Future

My fraternity experience was positive and a major influence after graduation. Please remember student life as you work through the MIT of the future.	Alumnus/a
What about creating interdisciplinary academic programs focused on specific goals for improving the world?	Faculty/Staff
I do not want to see widespread changes in teaching techniques unless there is some quantitative evidence that they will actually lead to improvement for at least a set of students.	Current student
I find it very frustrating that course evaluations are due DURING exam period… Why can't we have evaluations due a week later?	Current student
Break MIT subjects into atomistic concepts that are linked across the entire institute… Students learn what they want to learn, and they can see how each concept builds upon others.	Alumnus/a
It would be nice to have a long project-type class (similar to 2.009) where Course 6 students could work with Course 2 students (or any other combinations of majors).	Current student
Set up a formal teacher training program, where part of a professor's bid for tenure is dependent on student evaluations.	Alumnus/a
I feel that there is a need for all MIT students to have the chance/opportunity to work as an intern in a company in their field of endeavor during a few semesters.	Faculty/Staff
Most [MIT PhD students] will work in private industry… PhD students [should] be prepared to become industry leaders when they leave their labs.	Alumnus/a
The bias of writing "simple" tests that simply require you to state information needs to be done away with. Instead, tests should focus on asking conceptual questions.	Current student
MIT [should] make research methods more of a focus: that classes focus as much on defining problems and identifying what topics need to be learned in order to solve them as they do on actually teaching those topics.	Current student

Idea Bank: Notable Quotes, by Working Group, continued

Global Implications of EdX & the Opportunities It Creates

Online learning enhances our modes of learning but cannot exist on its own. Instead of thinking of 'blended learning'—let's think of 'balanced learning'.	Faculty/Staff
Education is about more than just collecting facts—there is a critical social component as well. I think that no matter how technically deep one could go in an on-line course, it would still be 'MIT-lite.'	Alumnus/a
Whatever we do with online education, we need to be the world leader in making it as accessible and inclusive to the widest possible audience.	Faculty/Staff
A friend tells me of her dyslexic son, who's having a terrible time in college because his required courses are on line. He needs in-person classes to accommodate his disability, but his college isn't providing them.	Friend of MIT
Enhance the class experience by generating interaction among different kinds of groups. For example in a course, create a problem set that has to be solved by teams in different countries.	Faculty/Staff
Can we imagine an MIT where we don't have alumni, but life-long students who could 'come back' (for an additional fee) and get MIT (not MITx) credential for career advancement.	Faculty/Staff
Lectures can be recorded and put online. Then instead of lecturing, professors can have more sessions where they can answer questions, solve problems, and hold discussions.	Alumnus/a
What a campus and residential education should offer that the web basically cannot is a person to person connection—one generation training the next generation in how to think, to structure ideas, to solve problems.	Alumnus/a
I encourage the new direction to emphasize personal face-to-face interaction… The ILG system in the early '90s did this exceptionally well. If you just want knowledge, then online delivery is fine.	Alumnus/a
It is hard for me to imagine that non-residency could ever become a dominant mode at MIT. What about Labs—which even today are still a crucial part of most technical courses? What about team projects…?	Alumnus/a

Idea Bank: Notable Quotes, by Working Group, continued

A New Financial Model for Education

An option—rather drastic considering the logistics, but hugely beneficial financially to the student's family—is to offer a 3-year BS degree with minimal "liberal education" requirements.	Alumnus/a
I think students from every major could be tackling industry's problems to help fund their education, the same way we currently do with research as graduate students.	Alumnus/a
MIT would accept applications from entrepreneurs who wish to come to MIT to create new companies… They would have access to use of MIT resources and collaboration with MIT faculty, staff, and students.	Alumnus/a
I propose an option for undergraduates to pay for their education out of their salaries after they graduate. [How about] 5% of their income every year until the sum of the percentage points paid totals 100.	Current student
Significant dollars can be redirected back to universities from commercial publishers by the advocacy of publishing at reasonable prices. MIT is well positioned to lead in this transformation.	Faculty/Staff