

IT-Based Transformation in Higher Education

Possibilities and Prospects

Gregory A. Jackson, March 2012†

Which way to Millinocket? "Well, you can go west to the next intersection..." the drawling Mainer replies in the classic Dodge and Bryan parody¹ of Down East navigation,

"... get onto the turnpike, go north through the toll gate at Augusta, 'til you come to that intersection ... well, no. You keep right on this tar road; it changes to dirt now and again. Just keep the river on your left. You'll come to a crossroads and ... let me see. Then again, you can take that scenic coastal route that the tourists use. And after you get to Bucksport ... well, let me see now. Millinocket. Come to think of it, you can't get there from here!"

Skeptics have argued that transforming higher education, especially to attenuate its cost, is like getting to Millinocket: We know where we want to be, but we can't get there from here.

Might information technology help? To answer this, we need to explore how information technology might advance higher education, and its prospects for success. To that end, I begin with some key attributes of higher education (Section 1), then turn to information technology (2), and finally sketch and assess some potential roles of information technology in transforming higher education (3–6).

1 HIGHER EDUCATION

In 2009, over 20-million students attended almost 4,500 degree-granting postsecondary institutions in the United States.² That this continue successfully and efficiently is central to the nation's progress. Before exploring information technology and its potential roles in higher education, a statistical overview of the enterprise and some of its current challenges is helpful.

Most of us know some key demographic facts about higher education—for example, that the largest group of students is in 2-year colleges, followed closely by research universities. We also know that an awful lot of commentary and influence in higher education comes from people in or connected with research universities, and that therefore many of us unintentionally but inevitably have trouble thinking intuitively about other kinds of institutions, let alone new extra-institutional approaches.

¹ <http://www.islandportpress.com/BIwhichway.html>

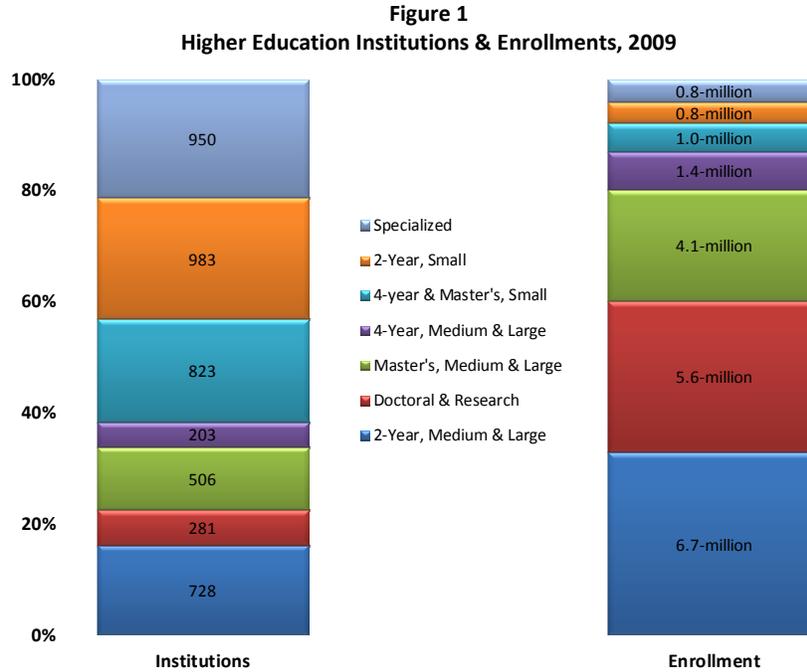
² National Center for Education Statistics, *Digest of Education Statistics* (Washington, DC: 2010) <http://nces.ed.gov/programs/digest/d10/>, table 244

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The Center for American Progress <http://americanprogress.org> and EDUCAUSE <http://educause.edu> share an interest in the advancement of higher education for the greater social good. We agree that innovation in higher education is necessary for future progress. Therefore, we bring together our organizational strengths to better understand the issues and opportunities at the intersection of public policy, information technology, and potential new models for education delivery. We promote public policy innovation by collaboratively convening thought leaders to create interdisciplinary dialogue on innovation in higher education, producing white papers to set the stage for policy action, and producing issue briefs that promote policies conducive to innovation in higher education.

1.1 Students and Institutions

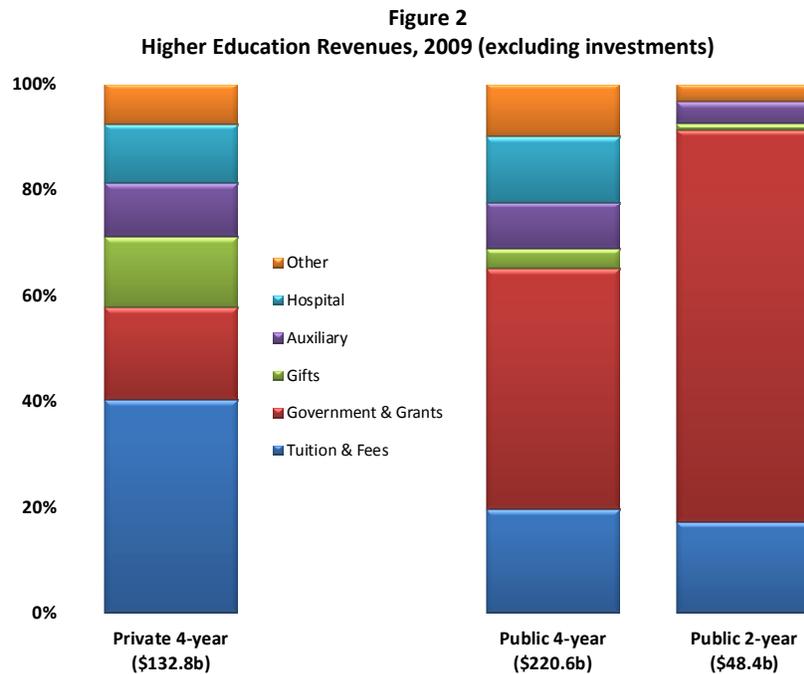
Institutions and students distribute differently across the various types of colleges and universities. Figure 1 gives a summary ("small" means enrollment under 2,500 and "large" means over 20,000). Here are some things we tend to forget:



- Research and doctoral universities account for fewer than 10% of institutions even though they enroll over 25% of all students.
- There are lots of big community colleges that enroll lots of students, but not all 2-year colleges are big community colleges; more than half are small, and most of those are private.
- Most small 4-year and master's institutions are also private, and although they comprise almost 20% of all institutions, they enroll only 5% of all students.
- There are a lot of specialized business, health, medical, engineering, technical, design, theological, and other similar institutions, but they don't enroll very many students.
- Enrollment isn't quite a Pareto distribution (the classic 20-80 rule), but it is pretty close: 33% of institutions enroll 80% of the students.

1.2 Finances

On the financial side, Figure 2 summarizes data on 2009 revenues for private 4-year colleges and universities and for public 4- and 2-year institutions:³



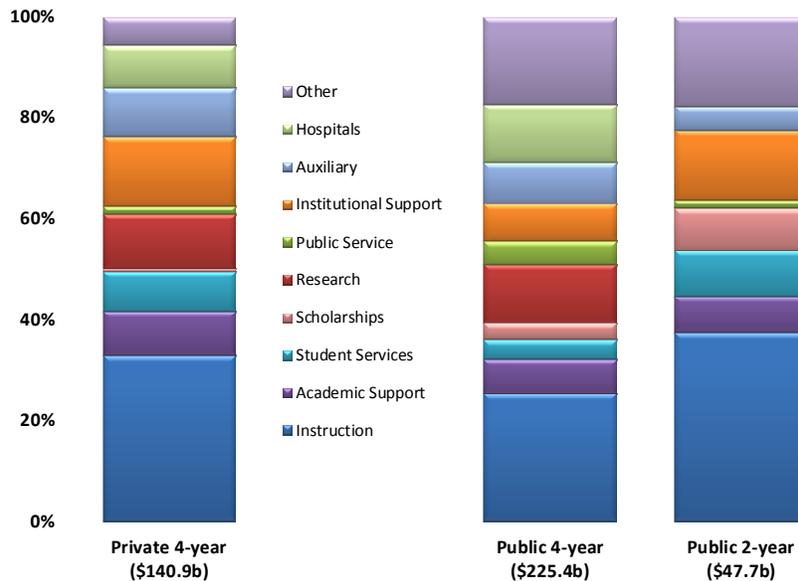
Private institutions derive about twice as much of their revenue from tuition, proportionally, as public ones do. Conversely, private institutions derive only a small fraction of their revenues from government appropriations, whereas for public institutions this is the largest source. Public 4-year institutions depend more on hospital, auxiliary, and other sources than public 2-year institutions.

Private 4-year colleges and universities, which enrolled 3.7-million students in 2009, spent about \$22,514 per student on instruction (including faculty salaries), academic support, and student services⁴ (the bottom three categories in Figure 3). Public 4-year institutions spent \$12,812 on their 7.7-million students, and public 2-year institutions spent \$5,981 on their 7.1-million students. It is variances like these within the "industry," summarized in Figure 3, that drive structural challenges to higher education's future.

³ Digest <http://nces.ed.gov/programs/digest/d10/>, tables 201, 275, 362, 367, 373, 376

⁴ Based on the widespread convention that three part-time students are equivalent to one full-time student.

Figure 3
Higher Education Expenditures, 2009



1.3 Costs and Productivity

"Education costs, and student debt, are rising at what seem like unsustainable rates," James Surowiecki observed in a recent article⁵ in *The New Yorker*. A recent speech by Secretary of Education Arne Duncan⁶ made the same point, as did a White House⁷ discussion among several college and university leaders and President Obama. As Duncan said,

*I want to ask you, and the entire higher education community, to look ahead and start thinking more creatively—and with much greater urgency—about how to contain the spiraling costs of college and reduce the burden of student debt on our nation's students.*⁸

It is no secret that higher education costs and debt are problems, that addressing them will require fundamental change, and that information technology will probably play an important role in that change. As the 2011 *National Education Technology Plan* put it,

*... Technology-based learning and assessment systems will be pivotal in improving student learning and generating data that can be used to continuously improve the education system at all levels. Technology will help us execute collaborative teaching strategies combined with professional learning that better prepare and enhance educators' competencies and expertise over the course of their careers.*⁹

In part, Surowiecki goes on to say, cost problems in higher education are an instance of "Baumol's cost disease," first diagnosed in the 1960s:¹⁰

⁵ http://www.newyorker.com/talk/financial/2011/11/21/111121ta_talk_surowiecki

⁶ <http://www.ed.gov/news/speeches/well-rounded-curriculum-age-accountability>

⁷ <http://www.whitehouse.gov/the-press-office/2011/12/05/readout-presidents-meeting-college-presidents>

⁸ <http://www.ed.gov/news/speeches/beyond-iron-triangle-containing-cost-college-and-student-debt>

⁹ <http://www.ed.gov/technology/netp-2010>

¹⁰ William J. Baumol and William G. Bowen, *Performing Arts - The Economic Dilemma* (Cambridge MA: MIT Press, 1968) <http://mitpress.mit.edu/catalog/item/default.asp?tid=7099&ttype=2>

... [S]ome sectors of the economy, like manufacturing, have rising productivity ... which leads to higher wages and rising living standards. But other sectors, like education, have a harder time increasing productivity ... the average student-teacher ratio in college is sixteen to one, just about what it was thirty years ago. In other words, teachers today aren't any more productive than they were in 1980 ... colleges can't pay 1980 salaries, and the only way they can pay 2011 salaries is by raising prices.

Surowiecki's productivity observation, however simple and appealing, is incomplete. It neglects rising expectations, nontraditional educational models, and the subtle effects analysts' personal experiences—which, like Surowiecki's and mine, have been mostly in elite institutions—have on their perspectives.

1.4 **Expectations and Models**

Society expects more and more of higher education each year. This stems partly from the continuing expansion of knowledge, and therefore of what must be included in courses and curricula, and partly from growing cognitive challenges and diversity.

My introductory electrical engineering course in 1966 barely mentioned solid-state electronics; the equivalent today reaches all the way to complex integrated-circuit design. What sufficed as a survey of modern Western literature back then encompassed only a fraction of what today's counterpart covers—and whereas Western literature was deemed sufficient back then, today a well-educated American student must have some familiarity with Eastern, Islamic, and other literatures.

But content is only part of growing expectations for higher education. There has been comparable growth in the reasoning and critical-thinking skills expected of graduates today—for example, the ability to make judgments about news, data, arguments, and analysis, now that so much of it arrives unfiltered by editors, commentators, librarians, or other moderators.

Moreover, a vastly more diverse student population—itself a major achievement of higher education, with important and positive consequences for our society—is by its very nature more difficult and expensive to educate, since its learning styles and requirements are also diverse.

Baumol cost disease accurately describes traditional campus-based higher education built on the German and British models. Although much of higher education remains traditional, many examples exist of educational models less dependent on traditional classrooms and faculty. These are better capable of exploiting technology and perhaps overcoming Baumol disease.

Nontraditional models include well-established public institutions like Empire State College, newer public institutions like California State University at Monterey Bay, for-profit institutions like the University of Phoenix, multi-state collaborations like Western Governors University, and many community colleges. These institutions came into existence precisely because they recognized (if perhaps did not name) the Baumol dilemma. In many cases, they were early examples of what G. Lynn Shostack¹¹ called "service blueprinting," the formal disaggregation and reconstitution of processes to refine existing services or implement new ones.

1.5 **Prospects**

How does higher education escape from this vicious cycle? Certainly there are opportunities to streamline administration, to reduce duplication and waste, and to consolidate departments, colleges, and even institutions. But these don't address the Baumol problem. To get higher education out of its

¹¹ G. Lynn Shostack, "Designing Services that Deliver," *Harvard Business Review* 62 (Jan/Feb 1984) 133–139
<http://www.semanticfoundry.com/docs/servicesThatDeliver.pdf>

current morass, it will be important to seek fundamental changes in its core activities, in its organizational structures, and especially in how colleges, universities, and other postsecondary institutions teach and their students learn.

One way to achieve such change, as the authors of the *National Education Technology Plan* argued, is by making information technology far more central to the teaching and learning process. The argument is not new. PLATO (Programmed Logic for Automated Teaching Operations) and its programmed-instruction kin, for example, were supposed to transform higher education. So were the Apple II, and then the personal computer (PC or Mac), and then the "3M" workstation (megapixel display, megabyte memory, megaflop speed) for which MIT's Project Athena, Carnegie-Mellon's Andrew Project, and Brown's Scholar's Workstation were designed (those were three of the so-called "Star Wars" initiatives of the mid-1980s, the fourth being Dartmouth's requirement that its undergraduates own Macs). Simulated laboratories, BITNET and then the Internet, MUDs, Internet2, artificial intelligence, supercomputing—all were at some point seen as auguries of change.

Each of these initiatives and innovations helped higher education grow, evolve, and gain efficiency and flexibility. Even simple technologies—e-mail, for example, and texting—changed higher education in ways hard to imagine before personal computers and the Internet came on the scene. But at its core, as Surowiecki and many others observe, much of higher education remains very much unchanged.

What about today's technological changes and initiatives—social media, streaming video, multiuser virtual environments, mobile devices, the cloud? Are they to be evolutionary, or transformational? If higher education needs the latter, can we get there from here?

2 **INFORMATION TECHNOLOGY**

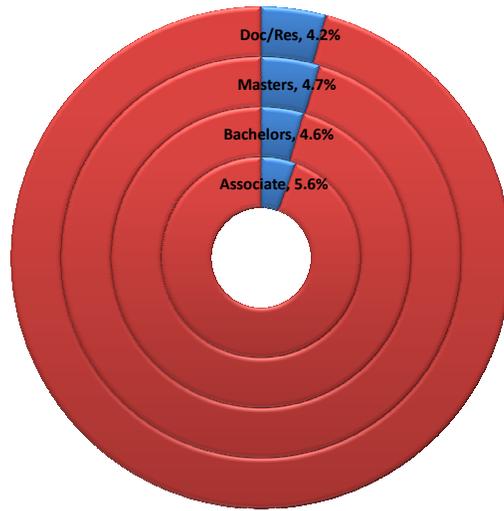
For the most part, "information technology" means a tripartite array of hardware and software: *end-user devices*, which today range from large desktop workstations to small mobile phones; *servers*, which comprise not just racks of processors, storage, and other hardware, but rather are aggregations of hardware, software, applications, and data that provide services to multiple users (when the aggregation is elsewhere, it is called "the cloud"); and *networks*, wireless or wired, which interlink local servers, remote server clouds, and end-user devices.

Based on responses to EDUCAUSE's Core Data Survey¹² (CDS), colleges and universities devote about 5% of their overall expenditures to information technology, with the variation across institutional types shown in Figure 4. In all, US colleges and universities (other than specialized single-discipline ones) probably spend about \$21-billion on information technology.¹³

¹² <http://www.educause.edu/coredata>

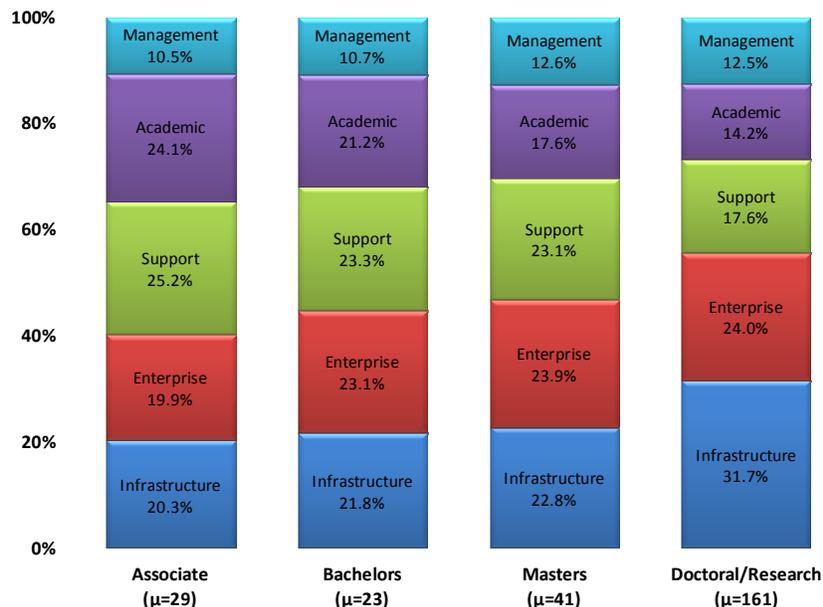
¹³ CDS data extrapolated using IPEDS national totals from *Digest* <http://nces.ed.gov/programs/digest/d10/>, tables 275, 373, 375, 377

Figure 4
IT as a Fraction of Campus Educational & General Expense, 2010
 (US Non-Specialized Campuses, EDUCAUSE Core Data Survey & IPEDS)



Of that, as Figure 5 shows, the lion's share goes to core organizational systems and services—data centers, administrative systems, communications, general user support, and so forth. Using central IT staffing as a metric, the next largest fraction of spending goes to teaching and learning technology: almost 25% in community colleges and 12% in research universities.

Figure 5
Average Central IT Non-Student Staffing Levels, 2010
 (US Non-Specialized Campuses, EDUCAUSE Core Data Survey)



As technology evolves, its role in higher education will depend on how institutions set and focus their IT spending. If IT spending goes primarily to enhancing the traditional model, then the transformational role of IT will be limited. However, if it is used to supplement, change, and even replace the traditional model, it may help institutions escape Baumol disease.

2.1 Progress

Information technology tends to progress rapidly but unevenly. Progress or shortcomings in one domain drive or retard progress in others. Today, for example, the rapidly growing capability of small smartphones has taxed previously underused cellular networks. Earlier, excess capability in the wired Internet prompted innovation in major services like Google and YouTube. The success of Google, Facebook, and Amazon forced innovation in the design, management, and physical location of servers.

Perhaps the most striking aspects of technological progress have been its convergence, integration, and migration. One could reasonably think separately some years back about servers, networks, and end-user devices, and do so explicitly because organizations bought and ran their own IT. Today the three are not only tightly interconnected and interdependent, but increasingly their components are indistinguishable, as well as provided and operated by organizations other than one's own. Network switches are essentially servers, servers often comprise vast arrays of the same processors that drive end-user devices plus internal networks, and end-user devices readily tackle tasks—voice recognition, for example—that once required massive servers. And all of it is outsourced to some degree.

Information technology permeates daily life. End-user devices are small and light enough to be carried everywhere, wireless networks are pervasive enough for those devices to be connected at all times, and clouds of servers host an astonishing diversity of services, resources, and information. This has enabled social change to occur more rapidly and extensively than it might have otherwise, and has made connectivity at least as important as location socially, economically, and even politically.

2.2 Looking Ahead

How will technology evolve over the next few years? Specific predictions mostly fail, but generalities do better. For example, these were IBM's "5 in 5" predictions in 2006 for 2011:¹⁴

- We will be able to access healthcare remotely, from just about anywhere in the world.
- Real-time speech translation—once a vision only in science fiction—will become the norm.
- There will be a 3-D Internet.
- Technologies the size of a few atoms will address areas of environmental importance.
- Our mobile phones will start to read our minds.

Today we have nearly real-time translation through services like Google Translate, there is some 3-D Internet, and healthcare information and advice, if not complete healthcare, are accessible remotely. On the other hand, nanotechnology continues to promise rather than deliver, and although Siri sometimes appears prescient, she is not quite reading minds yet. Still, 2½ out of 5 ain't bad.

Here are IBM's 2011 predictions for 2016:¹⁵

- **Energy:** People power will come to life. Imagine being able to use every motion around you—your movements, the water rushing through the plumbing—to harness energy to power anything from your house to your city.
- **Security:** You will never need a password again... The use of your retinal scan or your voice as a passport to verification will replace multiple passwords for access.
- **Mind reading:** no longer science fiction... See a cube on your computer screen and think about moving it to the left, and it will.

¹⁴ http://www.ibm.com/smarterplanet/us/en/ibm_predictions_for_future/examples/index.html

¹⁵ http://www.ibm.com/smarterplanet/us/en/ibm_predictions_for_future/ideas/index.html

- **Mobile:** The digital divide will cease to exist... In five years, the gap will be imperceptible as growing communities use mobile technology to provide access to essential information.
- **Analytics:** Junk mail will become priority mail. Imagine technology that replaces the unwanted messaging in your life with the next best thing to a personal assistant.

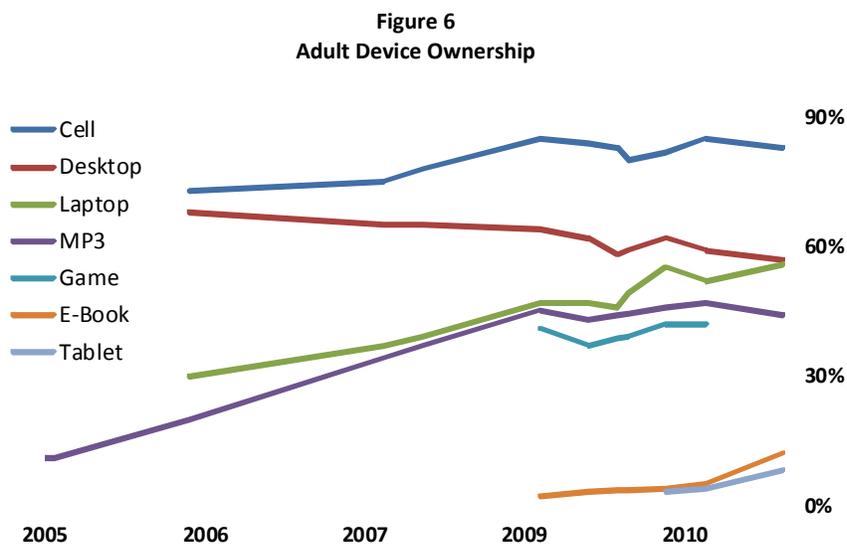
These predictions sketch a world where the locus of technology has shifted dramatically from the institution—be it home, workplace, school, or campus—to the mobile individual. The locus of control and responsibility will have shifted accordingly: connectivity, content, services, even identification will come from providers external to one's immediate location or affiliation—the "cloud"—which is a sharp departure from past practice.

3 INFORMATION TECHNOLOGY IN HIGHER EDUCATION

Progress, convergence, and integration in information technology have driven fundamental change in the information technologies faculty, students, colleges, and universities have or might be expected to acquire. As IBM and others suggest, this will continue. But progress may be uneven.

3.1 Access

The Pew *Internet and American Life* project has gathered illustrative data for some years, asking samples of adults and teens about the devices they own, their Internet access, and their use of both. For example, Figure 6 shows trends in the gadgets adults own:¹⁶



3.1.1 *Individuals*

For years there has been concern about a "digital divide" between those who have ready access to information technology—especially the broadband Internet—and those who do not.

The concern, as with other social and economic resources, has been that those already ill served by society would have less access to technology, and therefore would be left behind as technology became more important. A 2007 *Washington Post* article described

¹⁶ <http://www.pewinternet.org/Static-Pages/Trend-Data/Device-Ownership.aspx>

... the two Americas online: one that's connected to high-speed Internet—socializing, paying bills, uploading debate questions to presidential candidates on YouTube—and one that's not. This is the digital divide, now more than a decade old, a rarely discussed schism in which the unconnected are second-class citizens. In some parts of this so-called Internet ghetto, the screech of a telephone modem dialing up to get online is not uncommon. And with dial-up, YouTube is impossible to use.¹⁷

Concerns remain today, but in much subtler form. As a recent commentator on *sfgate.com* observed,

... when the Internet began to change life as we know it, [Latinos and African Americans] had less access to the Web and slower online connections placing them on the wrong side of the "digital divide." Today, as mobile technology puts computers in our pockets, Latinos and African Americans are more likely than the general population to access the Web by cellular phones, and they use their phones more often to do more things. But ... It's tough to fill out a job application on a cell phone, for example. Researchers have noticed signs of segregation online that perpetuate divisions in the physical world. And African Americans and Latinos may be using their increased Web access more for entertainment than empowerment.¹⁸

Keeping this important nuance in mind, we can nevertheless make assumptions about individual access to information technology today, especially as it relates to students:

- Teenagers¹⁹ and most adults²⁰ have some kind of mobile phone, and that phone usually has the capability to handle routine Internet tasks like viewing Web pages and reading e-mail.
- Households have some level of broadband access²¹ to the Internet, and at least one computer capable of using that broadband access to view and interact with multimedia material.
- Everyone—or at least everyone between the ages of, say, 12 and 65—has at least one authenticated online identity, including e-mail²² and other online services; Facebook, Twitter, Google, or other social-media²³; online banking, financial, or credit-card access; and/or network credentials from a school, college or university, or employer.
- Everyone knows how to search on the Internet using Google, Bing, or other search engines.
- Most people have a digital camera, perhaps integrated into their phone and capable of both still photos and videos, and they know how to offload and share their photos and videos.

3.1.2 Institutions

With similar caveats about the digital divide among institutional types and locales, we can reasonably make assumptions today about information technology in higher education, for both campus-based and other institutions:

- College and university faculty and administrators are comfortable with institutional information technology, such as student records or learning management systems.
- Electronic interaction within campus communities is commonplace and effective, whether by e-mail, instant message, social media, chat rooms, or other media.²⁴

¹⁷ <http://www.washingtonpost.com/wp-dyn/content/article/2007/07/22/AR2007072201278.html>

¹⁸ http://articles.sfgate.com/2011-02-13/business/28532467_1_latinos-web-access-broadband-access

¹⁹ <http://www.pewinternet.org/Static-Pages/Trend-Data-for-Teens/Teen-Gadget-Ownership.aspx>

²⁰ <http://www.pewinternet.org/Static-Pages/Trend-Data/Device-Ownership.aspx>

²¹ http://www.ntia.doc.gov/reports/2011/NTIA_Internet_Use_Report_February_2011.pdf

²² <http://www.pewinternet.org/Static-Pages/Trend-Data/Online-Activites-Total.aspx>

²³ <http://pewinternet.org/Reports/2011/Social-Networking-Sites.aspx>

²⁴ <http://www.educause.edu/ers0902>

- Classrooms are equipped with appropriate technology, although this varies with institution and classroom type.²⁵
- Most college and university course materials are in electronic form, and so is most library and reference material used by the typical student.
- Most colleges and universities have facilities for creating video from lectures and similarly didactic events, whether in classrooms or elsewhere, and for making video available online.²⁶
- Colleges and universities have campus networks²⁷ operating at broadband speeds of at least 10Mb/sec, and most have wireless networks operating at 802.11b (11Mbps) or greater speed.
- Computers, servers, and other hardware have become quite inexpensive,²⁸ so that the primary costs of information technology now are dominated by software licensing and technical staffing.
- "Cloud" providers have figured out how to gain and then sell economy of scale, and thus server capacity rarely constrains activities or initiatives.²⁹

3.1.3 Looking Ahead

It is striking how many of these assumptions were invalid even five years ago. Most were invalid a decade before that (the "3M" workstation was a lofty goal as recently as 1980, for example, and cost nearly \$10,000 in the mid-1980s, yet today's iPhone³⁰ almost exceeds the 3M spec).

Looking a bit into the future, here are some further assumptions that probably will be safe:

- Almost everyone will have the devices and accounts necessary for ubiquitous mobile connectivity sufficient to communicate with anybody else and to use online service.
- Typical home networking and computers will have improved to the point they can handle streamed video and simple two-way video interactions.
- Most people will know how to communicate with individuals or small groups online through synchronous social media or messaging environments, in many cases involving video.
- Authentication and monitoring technologies will exist to enable colleges and universities to ensure that student assessment, including testing and grading, is protected from fraud.
- Locally operated production servers will become far less important as data centers give way to cloud-hosted technology and locally managed services give way to cloud-based services.
- Colleges and universities will collaborate on key IT applications such as learning management systems, student systems, library systems, fundraising systems, and the like.

3.2 Roles

The fundamental educational purpose of higher education (in contrast to its research and local community service roles) is to advance society, polity, and the economy by increasing the social, political, and economic skills and knowledge of students—what economists call "human capital." At the postsecondary level, education potentially augments students' human capital four ways:

- *Enrollment*, which is to say choices by students or institutions (or both) symbolizing that a student has chosen (or been chosen) to seek education beyond high school that will make him or her more qualified or adaptable than others.

²⁵ <http://net.educause.edu/ir/library/pdf/PUB8007c.pdf>

²⁶ <http://net.educause.edu/ir/library/pdf/PUB8007c.pdf>

²⁷ <http://net.educause.edu/ir/library/pdf/PUB8007d.pdf>

²⁸ http://data.bls.gov/pdq/SurveyOutputServlet;jsessionid=668FD1112DA1E8FE02465A1A459965D1.tc_instance4

²⁹ <http://www.technologyreview.com/business/38710/>

³⁰ <http://www.apple.com/iphone/specs.html>

- *Instruction*, including core and disciplinary curricula, the essentially unidirectional transmission of concrete knowledge through lectures, readings, and the like, and also the explication and amplification of that through classroom, tutorial, and extracurricular guidance and discussion (this is what we often mean by the narrow term "teaching").
- *Certification*, specifically the measurement and documentation of knowledge and skill through testing and other forms of assessment.
- *Socialization*, specifically learning how to become an effective member of society independently of one's origin family, through interaction with faculty and especially with other students.

Higher education needs to fulfill its purposes with greater efficiency and within narrowing resource constraints. How might information technology help higher education pursue this goal across its enrollment, instruction, certification, and socialization processes? Specifically, what applications will actually translate IT infrastructure into educational productivity?

It is important to distinguish two different but overlapping roles information technology might play:

- Those that *enable evolutionary change* in longstanding mechanisms and processes, and
- Those that *transform or replace* those mechanisms and processes.

In the first category are four overlapping educational functions of information technology that go further down current paths. It can

- Streamline administration (Section 4.1),
- Amplify and extend traditional pedagogies, mechanisms, and resources (4.2),
- Make educational events and materials available outside the original context (4.3), and/or
- Enable experience-based learning (4.4).

In the second category are two functions that require us to blaze new trails. Information technology can

- Renew and redefine the social environment (5.1) and/or
- Replace the didactic classroom experience (5.2).

4 **GOING FURTHER**

Information technology can promote progress by enabling administrative processes to become more efficient and/or by creating diverse, flexible pathways for communication and collaboration within and across different entities. Making administrative processes more efficient in this way is *organizational* technology. Although organizational technology is very important, it affects higher education much the way it affects other organizations of comparable size. Somewhat more distinctively, information technology can function as *learning* technology and thereby become an integral part of the teaching and learning process.

The basic infrastructure already exists to enable colleges and universities to reach, teach, and assess students and to streamline administration. Infrastructure includes not only core hardware, software, and services but also key organizational processes—such as identity management and security—without which information technology cannot function. Through what applications might information technology infrastructure help higher education evolve?

4.1 **Streamline Administration**

Higher education involves the administration of human resources, scheduling, financial transactions, and physical plant. But administration in higher education also conveys academic resources to faculty and

students, and it collects, describes, and indexes data that document student experience. Information technology reduces redundancy, eliminates roadblocks, and maximizes access.

Paper-based registration, scheduling, and student-record systems managed separately have given way to highly integrated online student systems based on relational databases, enabling registrar offices to do more work with fewer staff. Decentralized and inconsistent distribution and access mechanisms for instructional and research materials—everything from reserve collections in the library to "course packs" at the local Kinko's to stacks of syllabi outside faculty offices—have given way to sophisticated library and learning management systems. The fundamental effect of this and similar progress has been to greatly reduce transactional costs.

Sadly, though, in many cases the reduction in transactional costs has been offset by an increase in the volume of transactions processed and stored. Sometimes this has been triggered by regulatory requirements or liability worries, and sometimes by analytic demands.

Separately, colleges and universities have made significant progress in cost control, if not actual efficiency, by obtaining economies of scale. Some of this has involved collaborative activity, such as uPortal³¹ and Sakai.³² A rapidly growing fraction involves adapting institutional processes to external standards and so gaining access to highly efficient cloud services.

The recent "Course Signals" initiative at Purdue³³ demonstrates another way technology can make academic administration more effective. Analytic and data-mining tools made it possible for Purdue to analyze data on student progress and learn that reduced use of the learning management system (LMS) was an early indicator of academic trouble ahead. Purdue then used LMS log-in data to focus its academic support resources on students whose LMS log-in frequency was declining, enabling early intervention. Early intervention greatly increased student success. Without data mining, which is possible with modern information technology and data collection, Purdue's counseling resources would have been less focused and hence less efficient.

Bringing analytics and big data to bear in this way can greatly improve administration. At the same time, big data entails complex policy challenges involving privacy and can trigger fears of "big brother." Moreover, not all institutions have the analytic capability and expertise to exploit even the data they already collect.

4.2 Amplify and Extend Traditional Pedagogies, Mechanisms, and Resources

Storing and distributing materials electronically, enabling lectures and other events to be streamed or recorded, and providing a medium for one-to-one or collective interactions among faculty and students potentially expedite and extend traditional roles and transactions. Similarly, search engines and network-accessible library and reference materials vastly increase faculty and student access.

These effects of information technology, although profound, nevertheless fall short of transformational. Even though chairs outside faculty doors give way Blackboard,³⁴ Sakai, or Moodle³⁵ LMSs, and wearing one's PJs to 8 a.m. lectures gives way to watching lectures from one's room over breakfast, the enterprise remains recognizable.

³¹ <http://www.jasig.org/uportal>

³² <http://sakaiproject.org/>

³³ <http://www.itap.purdue.edu/learning/tools/signals/>

³⁴ <http://www.blackboard.com/Platforms/Learn/Overview.aspx>

³⁵ <http://moodle.org/>

Going further, information technology can enable true distance education, whereby students never set foot on campus. In 2008, 3.7% of students took all their coursework through distance education, and 20.4% took at least one class that way.³⁶ In traditional institutions, the resulting curricula often remain recognizable even at a distance; indeed, they are often simply extensions of campus programs. Conversely, in for-profit 4-year institutions, which in many cases are designed around distance education, 19% of students took all their coursework online, and it is often markedly different from classroom instruction.

In fact, we can imagine a future where students readily satisfy one institution's degree requirements with coursework from many other institutions. Several institutions were early pioneers in this direction, organizing around competency-based degrees based on self-paced learning and life experience, including Empire State College, for example, and more recently Western Governors University. Further down this road, we can imagine a transformed future in which some institutions admit students, prescribe curriculum, certify progress, and grant degrees—but have no instructional faculty and do not offer courses. This, in turn, might spawn purely instructional institutions, and even purely instructional institutions that operate entirely online—institutions that would have every incentive to use technology in novel, effective, efficient, non-Baumol ways.

As the Sloan-sponsored report *Going the Distance: Online Education in the United States 2011*³⁷ observes, these trends trigger rethinking of the role and effectiveness of online distance education and its implications for challenges like faculty training. But rethinking meets resistance: only about a third of the 2011 Sloan survey respondents agreed that "Faculty at my school accept the value and legitimacy of online education," not many more than had agreed with the sentiment nine years earlier.

As traditional campus-based mechanisms give way to network-based ones, it becomes possible to imagine truly global campuses. But extending traditional pedagogy across the network leaves unsolved how to extend traditional pedagogy across linguistic, cultural, and stylistic boundaries. Similarly, although network-based technologies enable materials to be available simultaneously in diverse arrangements and formats, thereby enabling adaptation to diverse learning styles and speeds, achieving this diversity can increase rather than reduce "teaching" effort.

Rendering material electronically requires technical specifications, protocols, and associated software applications. So far these have proven frustratingly transient, not just for images and video but even for text. I wrote my 1977 Harvard dissertation,³⁸ for example, entirely on the university's mainframe computer, using a variant of the Runoff text-processing program developed in the mid-1960s at MIT. Harvard refused to accept the computer file as my dissertation, or, for that matter, the smudge-prone output from the computer line printer. After considerable negotiation, the university accepted copies of the computer printout Xeroxed onto archival paper. Today the paper copies survive and are eminently readable (as is the microform copy at ProQuest³⁹); the computer version vanished long ago.

As pedagogical materials evolve into born-digital form, the risk of impermanence grows. The risk is not simply that data will become inaccessible. In simulation-based environments, educational material is in effect existential and irreproducible, something traditional records management cannot handle. Similarly, as information technology enables the personalization of educational experience, every

³⁶ <http://nces.ed.gov/programs/coe/tables/table-dhe-1.asp>

³⁷ http://sloanconsortium.org/publications/survey/going_distance_2011?date=121011

³⁸ <http://hollis.harvard.edu/?itemid=|library/m/aleph|000859002>

³⁹ https://order.proquest.com/OA_HTML/pqdtibeCCTpltmDspRte.jsp

student's education becomes different. How that experience is measured and recorded becomes a new problem accompanying a new opportunity. (I'm reminded that Hampshire College's pioneering, highly individualized curriculum and assessment mechanisms in the 1970s yielded 30-page transcripts comprising extensive descriptions of the student's performance in every class—transcripts so unmanageable and difficult to evaluate that they came to impede grad-school admissions.)

4.3 **Make Educational Events and Materials Available Outside the Original Context**

As materials become electronic, barriers to broader distribution shrink. As barriers shrink, it becomes possible for materials to find new uses beyond their original intent. That educational materials should be reusable outside their original context is a core tenet of the Open Educational Resources⁴⁰ (OER) movement, which seeks to move from a production model based on copyright and licensing to one based on shared investment and benefit.

For example, the Open CourseWare initiative⁴¹ (OCW) started as publicly accessible repository of lecture notes, problem sets, and other material from MIT classes. It since has grown to include similar material from scores of other institutions worldwide, and most recently spawned the MITx initiative,⁴² which provides not only material but also mechanisms for demonstrating and certifying mastery of the material. Although some of this material is used in traditional classes, albeit in institutions other than those creating it, much of it is simply used by individuals who want to learn independently.

Similarly, the newer Khan Academy⁴³ has collected a broad array of instructional videos on diverse topics, some from classes and some prepared especially for Khan, and made those available for anyone interested in learning the material. The Open Learning Initiative⁴⁴ (OLI) at Carnegie Mellon is different in that its courses are specifically designed from scratch to provide the full enactment of instruction for the course online. They allow novice learners to master the material using only the OLI course.

Like course materials, research and publication by faculty have evolved beyond the traditional, discipline-managed, peer-reviewed books and journals to encompass a broad array of media and mechanisms. This gradual dissolution of campus scholarship boundaries has raised fundamental questions about how faculty are hired, evaluated, retained, and promoted, especially in research universities and other institutions that deal similarly with faculty.

As Kathleen Fitzpatrick observed in an interview with *Inside Higher Education* about her recent book,⁴⁵ which argues that traditional evaluation based on peer review of individual work must give way to collaborative evaluation based on how much faculty have influenced progress in their field,

*... [S]hifting our focus from the individual to the collaborative will require us to get past some fairly entrenched assumptions. We in the humanities will need to think differently about "credit," so that collaborative work will count in hiring, tenure, and promotion processes ... we need to change our mindset: we need to understand ourselves as working toward collective goals; we need to value work done on behalf of a community as much as we do work that serves ourselves.*⁴⁶

⁴⁰ <http://www.oercommons.org/>

⁴¹ <http://ocw.mit.edu/index.htm>

⁴² <http://web.mit.edu/newsoffice/2011/mitx-education-initiative-1219.html>

⁴³ <http://www.khanacademy.org/>

⁴⁴ <http://oli.web.cmu.edu/openlearning/initiative>

⁴⁵ Kathleen Fitzpatrick, *Planned Obsolescence: Publishing, Technology, and the Future of the Academy* (New York: NYU Press, 2011) <http://nyupress.org/books/book-details.aspx?bookId=5008>

⁴⁶ <http://gregj.us/rr3Xmi>

Information technology can have a profound effect on how higher education defines and respects boundaries, be they physical or disciplinary or status-based. This may refine how its goals are framed and its achievements measured.

4.4 **Enable Experience-Based Learning**

The principal information technology for experience-based learning is simulation. Simulated chemistry laboratories or factories were an early example—students could learn to synthesize acetylene by trial and error without blowing up the laboratory, or fine-tune just-in-time production processes without bankrupting real manufacturers. Today simulations go well beyond such single-user, predefined applications.

As computers have become more powerful, so have simulations—which include many computer-based games—become more complex and realistic. As they have moved to cloud-based servers, multiuser virtual environments have emerged. These go beyond simulation to replicate complex environments—indeed, sometimes they simply *are* complex environments. Somewhat less purposively, as social media like instant messaging, Facebook, LinkedIn, Second Life, and Twitter have enabled geographically scattered communities to grow and flourish, so have faculty and student experience-based learning jumped beyond campus boundaries.

Communal experiences like these were impossible before the advent of powerful, inexpensive server clouds, ubiquitous networking, and graphically capable end-user devices. That they are possible now potentially transforms the notion of "campus" in very important ways. At the very least, these applications shift traditional notions of authority. For example, crowdsourcing among widely distributed peers already vies for respect among students with faculty expertise based on traditional credentials or documented scholarship recorded in refereed books and journals and collected in libraries.

As information technology makes experiential learning more feasible across a broad array of disciplines historically dependent on professors instructing students, the 19th-century German university model may lose ground to very different models based on direct, albeit often simulated, experience. This, in turn, entails faculty advising and guiding inquiry rather than (or, more likely, in addition to) providing direct instruction. Students, in turn, must learn to tell the difference between valid and invalid experiences, reliable and unreliable sources, and accurate and inaccurate simulation.

5 **BLAZING NEW TRAILS**

When playing the three instructional roles above, learning technology functions primarily as a delivery mechanism, much as direct instruction does in traditional classrooms. In these cases learning technology enhances and expands traditional pedagogies and learning environments.

But in some cases—the most promising, from a transformational perspective—technology *creates new social environments* in lieu of traditional campuses, or becomes the *basis* of education rather than its *conduit*.

5.1 **Renew and Redefine the Social Environment**

The socialization potential of information technology in higher education is less controversial than its didactic role, but its transformational potential is comparable.

One channel for socialization in higher education is academic: spending time in the scholarly community and learning how to evaluate information and argue positions under its formal and informal rules. A second channel is cultural: being exposed to diversity in all its dimensions, be they involvement with different kinds of people, different rules of informal rhetoric and evidence, different social expectations,

different kinds of food, different perspectives on life. Some cultural socialization occurs within the academic milieu, but some—albeit a diminishing fraction—is extracurricular:

... Even at colleges where most students live off campus, they are still often deeply immersed in the social life of the institution ... We tend to think of "higher education" as being about learning, but a lot of it is about ... getting a job through all of the contacts that you make.⁴⁷

Disaggregating the certification function of higher education from the instructional function, which in turn means less emphasis on campuses, means that both kinds of socialization might decline even more than they already have. Indeed, most students already live off campus—in 2007–08, only 14% of undergraduates lived in college-owned housing⁴⁸—and so are less intensively involved in extracurricular activities. Higher education today has limited socialization effects, except for the minority of students who live or spend significant time on traditional campuses.

Whether information technology will exacerbate or reverse diminishing socialization effects is a major opportunity and challenge for the future. Reversal requires restoring socialization to a prominent role in higher education. This, given that students are unlikely to flock back to residential campuses, requires online mechanisms for students who are scattered across the nation or the world to commune with faculty and fellow students.

Technology should make it possible to expand rather than shrink the socialization effect of higher education. Today's students are as comfortable communicating and exchanging views electronically, especially through social media such as Facebook and Twitter, as they are interacting in person—perhaps even more so, in some cases. However, in many cases students handle their social-media environment orthogonally to their academic environment, resisting efforts to combine the two.

Whether social media communication promotes or detracts from effective socialization remains controversial, although the controversy stems largely from generational perspectives. Nevertheless, as the fraction of students enrolled at a distance increases, the importance of social media to socialization will increase. The University of Phoenix, Athabasca, Empire State College, and other innovative institutions have sought to achieve this through both commercial and ad hoc mechanisms. Socialization remains a domain whose importance is matched by uncertainty about mechanisms and effectiveness.

5.2 **Replace the Didactic Classroom Experience**

This brings us to the most controversial application of learning technology, exemplified by questions like "Why do we need faculty to teach calculus on thousands of different campuses when it can be taught online by a computer?" This is the role that drives most discussion of how technology might transform higher education, especially for disciplines and topics where instructors convey what they know to students through classroom lectures, readings, and tutorials. Daphne Koller, a Stanford faculty member, recently commented in a *New York Times* essay that although

... some argue that online education can't teach creative problem-solving and critical-thinking skills ... to practice problem-solving, a student must first master certain concepts. By providing a cost-effective solution for this first step, we can focus precious classroom time on more interactive problem-solving activities that achieve deeper understanding—and foster creativity⁴⁹

⁴⁷ Serge Goldstein, personal communication, 7 December 2011

⁴⁸ http://nces.ed.gov/programs/digest/d10/tables/dt10_349.asp

⁴⁹ http://www.nytimes.com/2011/12/06/science/daphne-koller-technology-as-a-passport-to-personalized-education.html?_r=1&ref=science

PLATO, now a commercial education provider,⁵⁰ emerged from the University of Illinois in the 1960s as the first major example of computers replacing teachers. It has been followed by myriad attempts, some more successful than others, to create technology-based teaching mechanisms that automatically tailor their instruction to how quickly students master material. When the US Marines contract today with civilians to undertake projects at their bases abroad, for example, they require those individuals to complete an online "Survival, Evasion, Resistance, and Escape" (SERE) course. That course used to involve classroom instruction; today it is entirely online, self-paced, and self-certifying.

More typically, the classroom experience is not so much replaced as reengineered, by bringing information technology to bear on peri-classroom activities such as student support (transfer credits, counseling, and so on). The combination of these often goes beyond the amplification mechanisms from Section 4.2 above. The University of Texas's Core Transformation Program⁵¹ (CTP), for example, "... is designed to improve student success in large, lower division gateway courses by ... the identification, development, and adoption of appropriate evidence-based approaches to teaching and learning," especially in large, "gateway" courses such as introductory calculus. Carnegie Mellon's OLI goes a step further, in that its courses are designed explicitly to replace classroom experience, but like CTP it remains firmly grounded in a traditional institution.

Replacing the traditional face-to-face experience with technology, even in the CTP or OLI sense, is controversial. Some opposition stems from legitimate concerns that technology cannot replace certain kinds of interaction, or is inappropriate for certain subject matter. But some opposition stems from a more basic antipathy to replacing labor with capital, thereby eliminating jobs.

In most cases the issue is more complicated. For example, most colleges and universities offer an introductory calculus course even though there are many longstanding examples of calculus being taught effectively online by institutions as traditional as the University of Illinois⁵² or as innovative as StraighterLine.⁵³ It is clearly more expensive and less efficient to pay a faculty member to teach calculus than to exploit an existing online course developed elsewhere and hosted in the cloud. So why does the classroom-teacher model persist?

The simple answer is that for most colleges and universities it is important to have a mathematics faculty to teach more advanced classes and to collaborate with other faculty, especially in the sciences, and teaching introductory calculus enables math faculty to generate the teaching credits necessary to justify their department's staffing level. More generally, the point is that colleges and universities organize teaching not in isolation, but as part of their larger organizational choices. One cannot change teaching without considering its larger context.

6 **GETTING TO MILLINOCKET**

Information technology can help higher education evolve and transform itself to better tackle the pedagogical, sociological, economic, and financial challenges of the future in many ways. There are many specific obstacles to be overcome for this to happen. These obstacles require colleges and universities to contemplate difficult, fundamental changes in how they organize and educate.

⁵⁰ <http://www.plato.com/>

⁵¹ <http://www.utexas.edu/academic/ctp/about-ctp/>

⁵² <http://www.online.uillinois.edu/catalog/ProgramDetail.asp?ProgramID=286>

⁵³ <http://www.straighterline.com/college-courses/general-calculus-i.cfm>

The need for such changes has been apparent for some time, yet progress addressing them has been uneven. In part, a colleague points out, progress is limited because some of the necessary changes "...are dangerous to discuss." For example,

... libraries still add miles of books every year that are never used [and... i]nstitutions still teach introductory courses in large classrooms where there is very little faculty-student engagement. Students would learn as much by watching a video lecture, or better still, a video lecture from a faculty star at some other University ... Soon, I believe, massive amounts of capital will be invested in producing automated teaching factories.⁵⁴

It is that image of "automated teaching factories" that triggers much instinctive reluctance to consider transformational information technologies in higher education.

If information technologies are to transform higher education, we must exploit opportunities and address problems. At the same time, transformed higher education cannot neglect important dimensions of human capital. In that respect, our goal should be not only to make higher education more efficient than it is today, which is where *organizational* technologies are likely to play a central role, but also better, which is the principal goal for *learning* technologies.

Achieving both greater efficiency and better outcomes through information technology requires a commitment to fundamental, unfettered thinking about the future both within and outside current institutions—the kind of process many institutions, such as Virginia Tech,⁵⁵ are beginning to undertake.

Drivers headed for Millinocket rarely pull over any more to ask directions from drawling downeasters. Instead, they rely on the geographic location and information systems built into their cars, phones, or computers, which in turn rely on network connectivity to keep maps and traffic reports up to date. Tourists get to Millinocket, but their reliance on GPS and GIS tends to insulate them from interaction with the diversity they pass along the road, much as interstate highways have standardized cross-country travel. The gain from geographic information technology is not without cost.

The same is true for administrative and learning technology in higher education, be it focused on organizational efficiency or learning outcomes: we will both gain and lose. Effective progress can result only if we explore and understand the technologies and their applications, decide how these relate to the structure and goals of higher education, identify obstacles and remedies, choose our tradeoffs, and figure out how to get there from here.

gj 3/13/12j

⁵⁴ Ken King, personal communication, 7 December 2011

⁵⁵ <http://blogs.is.vt.edu/inventthefuture2020>