

The Future of Higher Education: Beyond the Campus

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Abstract

Higher education's purpose is to equip students for success in life—in the workplace, in communities, and in their personal lives. While this purpose may have remained constant for centuries, the world around colleges and universities is undergoing significant change. Higher education is under pressure to meet greater expectations, whether for student numbers, educational preparation, workforce needs, or economic development. Meanwhile, the resources available are likely to decline. New models, an intense focus on the student experience, and a drive for innovation and entrepreneurship will ensure that higher education continues to meet society's needs. Information technology supports virtually every aspect of higher education, including finances, learning, research, security, and sustainability, and IT professionals need to understand the range of problems their institutions face so they apply IT where it brings greatest value. Creating this future will require collaboration across organizational and national boundaries, bringing together the collective intelligence of people from backgrounds including education, corporations, and government.

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1. Higher education's purpose is to equip students for success in life—in the workplace, in communities, and in their personal lives. While this purpose may have remained constant for centuries, the world around colleges and universities undergoes constant change. With colleges and universities so well known for their traditions, emerging changes might escape notice. The campus, the library, the refereed journal article, the classroom, and the traditional-age student may be common features of higher education yet might not adequately describe higher education's future. Consider a few changes already evident:¹
 - ◆ Formal, traditional boundaries are becoming more permeable and porous. There has been a rise in interdisciplinary fields (e.g., nanotechnology, bioethics). Leading faculty are recruited worldwide. The physical constraints on when and where students participate in education are being removed through open and online education, as well as competency- or experience-based credentialing.
 - ◆ The classroom is no longer limited to a three-dimensional space for the dissemination of knowledge. Students have virtually limitless access to information, faculty, tutors, and each other. Digital libraries and repositories make materials instantly accessible. And, learning is increasingly facilitated by exploration, interaction, and problem solving. Thanks to large data sets and collections, students at small or remote campuses have access to large-scale resources.
 - ◆ The library is not defined as a building for books. Many disciplines rely almost exclusively on online resources, whether books, journals, data, or artifacts. Students may consider the library more a social place than a site for the reference desk or physical books. And size of collections becomes less critical in an era when Google and other large-scale digitization projects make it possible for any institution to have access to millions of books.
 - ◆ The digital environment is a “place” for social interaction and community exchange. Although the value of the campus as a physical place continues, an increasing number of interactions are online, including the emergence of virtual, multinational research organizations.
 - ◆ Scholarship and research are becoming more “conversational.” There is less reliance on communication through formal publications; an increasing number of exchanges occur through e-mail, preprints, and monitored blogs. The journal article may continue to serve as a means of credentialing authors for the purposes of promotion and tenure, whereas the scholars' contributions to a field are posted elsewhere.
 - ◆ Digital technology and the unprecedented scale of data, as well as the nearly limitless ability to reconstitute it, have altered the conduct of traditional research and scholarship. Theory and experimentation have been

augmented with computation, involving modeling, simulations, visualization, and so on.

- ◆ The more traditional model of a university or college providing most of its services physically on (or near) a campus is changing. More and more services and programs originate off-site, sometimes shared, distributed, or aggregated by other colleges and universities or outsourced agencies.
- 2. Higher education's evolution is evident in the way the library is defined, information technology (IT) services are delivered, and the college or university is conceptualized. Higher education represents a complex, adaptive system that is influenced by larger societal trends and information technology. If higher education is adaptive, what will its future be?
- 3. The Council of Australian University Directors of Information Technology (CAUDIT), EDUCAUSE (the association for information technology in higher education, based in North America), the United Kingdom's Joint Information Systems Committee (JISC), and the Netherlands' SURFfoundation undertook a collaborative visioning of the future of higher education to explore issues common to our countries and memberships. Our hope is that this view of the future, and the questions it raises, will catalyze discussion in higher education, helping us take actions that best serve society. Just as there may be overlapping trends in higher education and information and communication technologies (ICT), there is the potential for shared solutions as well.
- 4. The focus of this paper is on higher education, not just IT, because information technology's value is in the activities it supports, which span virtually every college and university system—for managing finances, learning, research, security, sustainability, and more. IT professionals need to understand the problems their institutions face so they apply IT where it brings greatest value.

Drivers of Change

- 5. Higher education's fundamental mission and structure has been constant for centuries. However, the environment in which that mission is exercised has changed dramatically. For example, the current higher education system in the Netherlands was designed in the 1950s for a participation rate of about 5%; now 47% of the age group participates in higher education.² Although each of our countries is different, a similar set of forces is driving change in higher education.

Expanding Global Market for Postsecondary Education

- 6. The number of students pursuing tertiary education has skyrocketed worldwide over the past 37 years, growing from 28.6 million in 1970 to 152.5 million in 2007.³ Demand for postsecondary education continues to rise due to government policies, a growing population, and/or increasing affluence.⁴ For example, across

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the United Kingdom, undergraduate enrollments in higher education institutions have increased by 25% overall in the 10-year period from 1998–99 to 2007–08. In the same period, non–European Union (EU) international student enrollments have increased by 25% (with China being the largest provider).⁵ Perhaps most importantly, the demand for postsecondary education will grow because more jobs and careers will require it. For example, in the United Kingdom, the number of skilled jobs still outnumbers the supply of students with higher education qualifications, so the government is committed to increasing participation.⁶ Rapid changes in jobs, fields, and companies will result in more career transitions during a person's lifetime, necessitating additional education, as well.⁷ Some national goals illustrate the demand for postsecondary education:

- ◆ By 2025, 40% of Australians will have degree qualification. By 2020, 20% of the student cohort will be from low socioeconomic status group.⁸
- ◆ By 2025, 60% of the American population should hold high-quality college degrees or credentials.⁹
- ◆ By 2020, 50% of the Dutch labor force between the age 25 and 44 should hold a higher education degree.¹⁰
- ◆ The U.K. Government has set a 2010 deadline for 50% of all 18- to 30-year-olds to participate in higher education.¹¹

Financial Support for Higher Education

7. A global economic downturn began in late 2008; most educators and economists do not expect funds for higher education to return to previous levels. Although economies may improve, competing demands for funds from health care and retirement will continue to squeeze higher education funding.

Cost of Education

8. In most countries, the cost of higher education has risen due to infrastructure, labor, and service costs. When those costs are passed to students and their families through tuition and fees, affordability can become a challenge. Although free tuition may not lead to increased student success, costs (tuition, fees, books, housing) can put education beyond the reach of qualified students.

Efficiency and Productivity

9. Institutions are looking for ways of reducing costs and increasing efficiency, particularly in non-differentiating areas such as finance, human resources, and IT.¹² Although “homegrown” was associated with uniqueness in the earlier days of IT, the emergence of viable commercial services is leading colleges and universities to determine which core services must be resourced on campus and which are more efficiently supplied through contractual relationships¹³ (whether with corporations or other institutions).

10. *Higher education must become more productive so that it can increase capacity and serve more students.*¹⁴

Sustainability

11. Sustainability is an increasing focus of higher education—for research, education, and operations. IT can contribute to environmental challenges (e.g., generating greenhouse gases, disposal of electronic equipment and the hazardous materials it contains) and offer opportunities to solve them (e.g., redesigned data centers, server virtualization, or cloud computing). IT may enable other approaches to carbon reduction through telecommuting, virtual meetings, or “smart” grids that reduce electricity usage.

Alliances

12. Many colleges and universities are establishing alliances to gain access to expertise, degrees, and international experiences. For example, in the United States, community colleges and state universities have established articulation agreements, ensuring students can transfer from one institution to another.
13. In the United Kingdom, government-funded Lifelong Learning Networks aim to improve the coherence, clarity, and certainty of progression opportunities for vocational learners into and through higher education. Universities and colleges have formal partnerships with indirect funding arrangements to facilitate “higher education in further education” with a focus on employer engagement, skills, and the needs of local and regional communities. Managing Information Across Partners (MIAP) is a U.K.-wide program of services that will enable data sharing across the entire education sector.¹⁵
14. Multi-institutional systems share infrastructure or leverage scale for greater procurement power. Alliances are increasingly common between higher education institutions and corporations, as well. The goal is to spread out higher education’s fixed costs for research, education, infrastructure, and services¹⁶ as well as to reduce friction in inter-institutional exchanges. And, multinational agreements, such as the Bologna Accord, establish even larger alliances intended to facilitate the exchange of students and scholars.

Student Engagement and Achievement

15. Decades of educational research support the importance of student engagement to educational achievement. For example, although Dutch students are sufficiently motivated when they enroll (4.2 on a scale of 1–5), their motivation drops (to 3.8) due to a number of disappointing factors, such as lack of good administrative support, insufficiently challenging education, and uninspiring teaching staff. Twenty percent of the students in Dutch higher education indicate that they do not find their education challenging enough.¹⁷

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16. Student engagement goes well beyond content (which is in almost unlimited supply) to interaction, problem solving, and reflection. Not only are students demanding greater engagement, but “educational productivity” hinges on improved use of student, faculty, and institutional resources. Predictive tools, such as analytics (see appendix), help students and faculty identify at-risk students in time to improve their performance.

Greater Diversity of Postsecondary Education Suppliers

17. For-profit colleges, community colleges, open universities, corporate universities, and “new institutions” contribute to a growing number of international suppliers for educational episodes, classes, courses, certificates, and degrees. Although time required, delivery mechanism, pedagogy, and cost vary greatly, “customers” have the opportunity to make informed trade-offs as buyers of educational experiences.¹⁸ In the United Kingdom, for example, a significant review of higher education by the government may prompt a greater diversity of educational provision. Consumer choice will be further enhanced by the open educational resources movement, which will offer learners more opportunities for seeing the quality of course material before deciding on which university to attend.¹⁹

Accountability

18. Cost, productivity, and competing demands for funds have increased calls for higher education accountability. As education and degree completion become more critical to economic vitality, calls for measurable outcomes and return on investment become more common. Data on costs as well as student preparation and performance are being scrutinized.

Enablers of the Future

19. These drivers are catalyzing changes such as those mentioned at the beginning of this paper. Although no one can predict the future, patterns are emerging—many made possible by information technology. In fact, IT could be considered a “game changer,” providing options never before possible. Now that virtually everything and everyone are connected, the “network” underlies emerging models rather than place, whether a classroom, a building, or a campus. The network provides an architecture for participation and collaboration—irrespective of time, place, age, or position. And, because material is digital, use does not “consume” the asset—it can be available over and over again. Access becomes more important than ownership. Technology has provided platforms for knowledge creation—often involving millions of contributors. Wikipedia, Facebook, and other tools enable collective intelligence where the cumulative contributions of individuals create value for society.
20. Of course, the attitudes and experiences of college and university students and faculty enable the future in ways that are both powerful and subtle. The majority

of today's traditional-age college students have grown up with technology, using it as a natural extender of their activities, whether for communication, entertainment, friendship, learning, or work. Integrating technology into our lives is not just a practice of youth. Amazon, Google, eBay, Facebook, and Wikipedia are global, ageless environments that have become part of our society. Hundreds of IT systems are integrated across our campuses and our lives.

21. The combination of economic and social forces, enabled by new IT tools and capabilities, is providing higher education with a unique set of options for addressing its future challenges. As organizations anticipate the future, we believe three essential areas of focus should be:

- ◆ The emergence of new structures and new business models
- ◆ Expanded options for the educational experience
- ◆ Innovation and economic vitality

New Structures, New Business Models

22. The future shape of higher education will be influenced by new structures and new business models.²⁰ These models are enabled by information technology, but many are driven by cost, access, or novel approaches. Information technology can disintermediate—or break apart—traditional structures. For example, a course can be offered by an entity other than the university. Or, releasing a textbook can be done without the involvement of a traditional publisher.
23. “Above campus” is an emerging model that uses a metaphor that can be applied to sourcing, services, expertise, or even students and scholars. Increasingly, technology and its associated services are provisioned “above the campus.” A common example is the student use of Gmail rather than a campus based e-mail system—what many call “cloud computing” (see appendix).
24. Openness and transparency are emerging as key features of developing structures and sustainability models. The fundamental value higher education places in sharing, added to the Internet's ability to make information almost universally available, has led to the growth of opportunities for meaningful local, regional, and international collaboration around the creation of a variety of resources. Open access publication, open educational resources (see appendix), and open-source software are all examples of this. Such resources are freely available for improvement, modification, or localization. It is important to note that sharing and openness are approaches, not necessarily sustainability or business models. A number of organizations generate revenue based on services supporting open-source software, for example.

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25. Although the Internet makes the exchange of services and information more open, it is not necessarily trustworthy. Tools such as identity and access management are designed to ensure that those who access resources (data centers, databases, remote instruments, learning resources, etc.) are “trusted.” The ability to share resources beyond the limitations of the physical campus hinges on trust, identity, and access management (see appendix).
26. New educational models are emerging, as well. Western Governors University is based on a competence model rather than credits. The Open University, the first U.K. university to offer distance learning to entrants with no prior qualifications, is the country’s largest university with more than 200,000 students; it routinely tops the country’s national student satisfaction survey. For-profit institutions (University of Phoenix, Capella, etc.) are growing. Non-traditional institutions are emerging, such as Peer 2 Peer University, which describes itself as “an online community of open study groups for short university-level courses,” and University of the People, “the world’s first tuition-free, online academic institution dedicated to the global advancement and democratization of higher education.” Common characteristics of these models include an emphasis on openness, the use of digital resources, a distributed student and faculty base, and global reach. Information technology is a critical infrastructure for such institutions.

Educational Experience

27. The educational experience is increasingly connected, experiential, flexible—and driven by individual preferences and needs. With information changing rapidly, the complexity of problems increasing, and the need for skill renewal a constant, education’s focus is shifting from instruction to discovery.²¹ Students must develop the skills to discover what they need to know, where to find it, how to validate the quality of the information, and how to assemble the resources necessary to solve problems.
28. Students search for information—from wherever they are, on any device they choose, at any time, with near-instantaneous results, in their preferred medium (audio, animation, video, text). With an increasing amount of the world’s literature and archives available online, student access to information is not limited by location or library collections. Search tools are increasingly sophisticated (e.g., semantic searches), but even more powerful is the students’ network of peers, mentors, and experts that leads them to information and insight.
29. Networks enable connections and collaboration, whether social, scientific, or civic. Social networking tools enable personal and professional connections. Emerging reputation and recommendation systems allow networks to go beyond being lists to assigning value.
30. Mobile devices (see appendix) allow groups to stay in touch, no matter where they are. With a billion new mobile devices manufactured each year, mobiles are

becoming the world's affordable and ubiquitous computing platform. Mobile applications are exploding, and the difference in computing power between PCs and mobiles shrinking, with high-end mobile phones approaching the processing power of low-end PCs.²² Geolocation and geotagging augment texting, talking, and surfing.

31. Collaboration is facilitated by IT. Collaboration tools are freely available on the web (Google Docs, Zoho Wiki, etc.). A host of communication options are available, as well (e.g., Skype, Facebook, Twitter). And videoconferencing is morphing into telepresence, where people in different locations feel as though they are in the same room thanks to life-sized displays and high-definition signals.
32. Beyond access to global resources, communication, and collaboration tools, IT provides learners access to highly interactive and immersive experiences that enable students to move from "learning about" to role playing, scenario building, and assuming different roles. Virtual worlds are used to allow students to "experience" weather, mathematical models, civic participation, or prepare for interviews. Massively multiplayer online gaming environments allow students to compete, cooperate, and solve problems as teams. Visualizations and simulations allow students to experience unique locations and scale (nano to galactic).
33. Data is becoming essential to learning environments. It not only forms the basis of important collections that learners can explore, but data about students themselves serves as a resource in understanding which educational models are most effective, which students might be at risk (see appendix for analytics), and documenting a learner's educational record (see e-portfolios in appendix). Governments and educators are increasingly interested in aggregating data about students so that it can be mined for trends and predictions, allowing individuals and institutions to improve outcomes.
34. As students become more diverse and as learners' needs expand across a lifetime, more flexible models for education are emerging. Many students' education must fit alongside work and family responsibilities. Online learning and accelerated programs provide greater flexibility than traditional campus programs. Transferability of credits from one institution to another becomes more important as time-to-degree increases and lifelong learning grows. And, if lifelong learning credits become a reality, learners will be provided with opportunities to refresh their education throughout their career. The expectation that a single institution will provide all of an individual's learning throughout life may not be realistic.

Innovation and Economic Vitality

35. Innovation, which may be defined as the successful development and fulfillment of new ideas, is now essential to success for individuals and economies. Universities are "sources of new knowledge and innovative thinking."²³ Over 50% of basic research is conducted at universities, which creates the foundation for

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new industries and technologies. Rather than being “owned” by any single institution or country, innovation is spread across tens of thousands of researchers from developed and emerging economies that are linked (by technology) in a global science and innovation system.²⁴

36. Research and innovation are increasingly interdisciplinary, inter-institutional, and international, generating vast amounts of data. Particularly in scientific fields that rely on highly specialized, expensive instrumentation, research involves a distributed network of researchers, instruments, and data sets. Knowledge generation is increasingly a collaborative, iterative process. Scholarly communities now pursue their research and learning goals in real time and without regard to geography. The technology (information, grid, and networking technologies with contemporary communications) and individuals with common interests are establishing virtual organizations (VOs) that are revolutionizing the conduct of science and engineering research and education.²⁵
37. VOs pose complex technical and social challenges. The technological framework may include applications, tools, middleware, remote access to experimental facilities, instruments and sensors, as well as monitoring and analytical capabilities. Socially, the stakeholders must develop mechanisms for trust, rapport, working styles, and interaction.²⁶
38. For innovation to fuel economic vitality and social progress, it must go beyond good ideas to fulfilling the promise of those ideas in practical terms, for example by creating new jobs, companies, or industries, or solving pressing social or environmental challenges. As a result, innovation is increasingly tied to entrepreneurship, or turning new ideas into viable business models in the public as well as private sectors. Higher education has a history of collaborating with government, business, industry, and nongovernmental organizations in problem definition, technology transfer, process improvement, and entrepreneurship. These cooperative endeavors ensure local, national, and international communities benefit from innovation. College and university innovations are diffused through patents, start-ups companies, and consulting, as well.²⁷

Emerging Themes

39. As we have looked at the future, several recurring themes emerge. One is that many solutions will be found “above the campus.” While faculty, students, and staff are affiliated with a specific institution, the resources they access, the colleagues they interact with, and their frame of reference go well-beyond the campus. Accessing a book may be more easily done online than physically. And, the worldwide collections of resources (books, artifacts) far exceed what is available on any single campus. Computing cycles, storage, and specific applications are instantly accessible and scalable “above campus.” Faculty, study groups, and mentors are available above the campus, as well. Computing cycles

and storage may not be come from one's own campus; they may be a shared resource aggregated above the campus.

40. Information technology, ubiquitous networks, and new models mean that institutions need to focus less on ownership than access. Books may be accessed online without needing to own a physical copy. Applications, such as e-mail, can be accessed "in the cloud" without needing to own the software or a computer. Educational resources may be from a freely accessible repository whose material is owned by no one—yet by everyone.
41. Although much of education has been focused on the individual, we are learning that collaboration is a powerful force for knowledge generation, problem solving, and innovation. Tools such as Wikipedia illustrate the power of collective intelligence where anyone has the opportunity to add to a body of knowledge. Small contributions by millions of people add up. Worldwide networks of volunteers, students, and scholars are contributing to knowledge and solutions that address society's most challenging problems.
42. However, as our world increasingly mirrors "the network" and "the collaborative," a host of traditional policies must be reexamined. One example is intellectual property rights. In the networked digital age, traditional protection mechanisms are increasingly meaningless. New tensions emerge between privacy and access over issues such as security, data handling, and identity. While institutions might make better decisions by centralizing and mining student, staff, patient, and financial data, how do they guard against misuse or inappropriate disclosure? And, as data, finances, research instruments, and purchasing cross institutional boundaries, how should institutions ensure that identity, institutional affiliation, and role are validated and trustworthy?²⁸
43. Governance may shift in response to the needs of the future, as well. Because technology now supports the entire institution, IT directors have broad responsibility and unprecedented flexibility.²⁹ As IT has become a more powerful "game changer," senior IT staff roles change—rather than managing IT as a utility, technology is combined with business strategy, communication, and integration, as well as financial and risk management. Senior IT staff (vice presidents or chief information officers) participate in decision making with the most senior executives of the institution, joining academics and administrators in institutional leadership.
44. Information technology, and its ability to link people, ideas, and resources, is making new ideas and new models, such as above-campus sourcing, possible. Information technology may bring unique value to the future of higher education through its ability to enable redesign while increasing scale and personalization. IT enables communication with more people and can promote participation and collaboration. Although the purpose of higher education has not changed in centuries, the options for achieving that purpose have grown.

Conclusion

45. There is broad agreement on the value of higher education; it benefits individuals and society:
46. *Higher education is a great national asset. Its contribution to the economic and social well being of the nation is of vital importance. Its research pushes back the frontiers of human knowledge and is the foundation of human progress. Its teaching educates and skills the nation for a knowledge-dominated age. It gives graduates both personal and intellectual fulfillment. Working with business, it powers the economy, and its graduates are crucial to the public services. And wide access to higher education makes for a more enlightened and socially just society.*³⁰
47. Even so, higher education is under pressure to meet greater expectations, whether student numbers, educational preparation, workforce needs, or economic development. Meanwhile the resources available are likely to decline rather than grow with the need. New models, an intense focus on the student experience, and a drive for innovation and entrepreneurship will ensure that higher education continues to meet society's needs. Creating this future will require collaboration across organizational and national boundaries, bringing together the collective intelligence of people from backgrounds including education, corporate, and government.
48. We hope you will join us in this exploration of the future of higher education. Your questions, discussions, and suggestions will shape our future.

Appendix 1: Underlying Technologies

Cloud Computing

49. As higher education faces budget restrictions and sustainability challenges, one approach to addressing these pressures is cloud computing. Although definitions of “cloud computing” abound, the concept fundamentally involves delivering technology resources to users over the Internet.
50. Colleges and universities have traditionally built robust infrastructures to provide services that are often developed and maintained at the campus level. E-mail, for example, was long considered a staple of an institution’s IT offerings. As e-mail services have become highly commercialized—and as expectations, particularly among students, have changed—a growing number of campuses have shed the operation of e-mail and contracted with outside suppliers. For most institutions, e-mail does not represent a core competency and can be outsourced for lower cost. In this same manner, organizations are beginning to consider moving other services to the “cloud,” where, through an Internet connection, a wide range of applications and services are available on an on-demand basis, including storage, software, processing power, and IT infrastructure itself.
51. In a traditional model, an institution estimates current and future capacity needs, invests time and money in building an infrastructure and associated systems to meet those needs, and uses operational resources to maintain those systems. With cloud computing, the operation of services moves “above the campus,” and an institution saves the upfront costs of building technology systems and instead pays only for the services that are used. As capacity needs rise and fall, and as new applications and services become available, institutions can meet the needs of their constituents quickly and cost-effectively. In some cases, a large university might become a provider of cloud services. More often, individual campuses will obtain services from the cloud. The trend toward greater use of mobile devices also supports cloud computing because it provides access to applications, storage, and other resources to users from nearly any device.
52. Cloud computing carries certain risks, including the loss of privacy and security of information, and the model depends on a high degree of trust. Adoption rates for cloud services in higher education are relatively low, owing to a wide range of factors such as its newness, regulatory uncertainties, and a tradition focused on ownership rather than access. Still, as these issues are addressed, higher education stands to benefit in several important ways from adopting cloud computing.
53. Aside from costs savings, another key benefit is the increased flexibility that comes from the cloud model. An institution can quickly respond to requests for new services because they simply need to be located and purchased from the cloud, without having to build in-house systems and operate them. Similarly,

cloud computing is highly scalable. Institutions can often increase the reliability of IT services, or provide similar reliability for less money, using the cloud. Cloud computing also compels IT organizations and providers to increase standardization of protocols and processes so that the many pieces of the cloud computing model can interoperate properly and efficiently. As resources—including money and talent—become increasingly scarce, cloud computing provides a means to stretch those resources and make them more useful, to more people, more of the time.

Open Educational Resources

54. As higher education works to increase educational opportunities and student success, even as budgets shrink, an increasingly common approach is open education—the notion that education serves a communal, public good and should be freely and easily available to anyone seeking it. A central component of open education are the resources that underpin learning, and these open educational resources (OER) provide benefits both for those who provide them as well as those who use them. In the words of the Cape Town Open Education Declaration,³¹ open education and the people who develop OER create “a world where each and every person on earth can access and contribute to the sum of all human knowledge.”
55. Open educational resources include textbooks, lesson plans, journal articles, audio and video files, exams, digital images, entire courses, and any other content that supports learning and is available to the public for free or has been released under an intellectual property license, such as Creative Commons, that allows use for teaching or research. With some open resources, users are allowed to modify the content or the medium and redistribute those new materials for public use. This movement toward open educational resources is motivated by a desire to allow anyone in the world to create, share, and use valuable educational materials in the pursuit of expanded knowledge.
56. In the United States, several high-profile initiatives have brought considerable exposure to the open educational resources effort, including MIT's OpenCourseWare project, Rice University's Connexions program, and other efforts from institutions including Tufts University, Carnegie Mellon University, and Johns Hopkins University.
57. The United Kingdom has benefitted from the Open University's publicly funded, long experience in providing effectively supported distance learning, their unique capability to quickly meet large-scale demand, and the success of its popular OpenLearn portal. “With nearly two million unique visitors and 60,000 registered users in the first 18 months of operation of the website, OpenLearn is being used by more and more people for study, either individually or in groups.”³² Building on this success, the government has funded a £5M pilot program to support the open release of learning resources. An Online Learning Taskforce will identify

opportunities for investment leading to further innovation within and between universities and colleges in the development of online learning.

58. European SchoolNet, another example, is a “partnership of 31 European ministries of education developing learning for schools, teachers, and pupils across Europe.”³³ Sites such as the OER Commons work to collect, organize, and facilitate searching of and access to the range of open educational resources from numerous sources.
59. Despite widespread support, the move toward open educational resources must overcome some hurdles. Because the sources and oversight of such resources vary considerably, the quality can be uneven, and materials might not conform to local accessibility requirements for users with disabilities. Most open educational resources are available online, so users must have the necessary technology infrastructure to access them.
60. Still, open educational resources have the potential to change the way higher education is delivered. Freed from the costs of developing educational content, institutions can focus on programs and activities that directly improve learning and student success. Individuals and institutions that provide open educational resources not only earn the respect and goodwill of the community of users but also receive feedback and support that improve their own educational efforts. Open educational resources expand access to the tools of learning, supporting an environment of self-directed and lifelong learning and contributing to a “participatory culture of learning, creating, sharing, and cooperation.”³⁴

Identity Management

61. Information technology affords far greater access to content, tools, and other resources than ever before. This increased access will be a defining characteristic of higher education as it responds to global trends to provide more opportunities to greater numbers of learners and to do so with a strong focus on the students themselves. As students see their education as a lifelong pursuit, spanning multiple institutions, careers, and phases of life, they will expect and need greater access to appropriate resources, and identity management becomes a vital component of educational systems.
62. *Identity management* refers to the procedures and tools that establish user identities and enforce rules about access those users have to digital resources in a networked environment. As a means to streamline the availability of digital resources and to protect intellectual property, identity management serves both as a facilitator of access and a primary tool for security, both of digital resources and of user privacy. *Federated* identity management endeavors to create independent authorities that multiple organizations can use to verify user identities based on common protocols and attributes.

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63. An institution that requires students to have separate passwords for access to e-mail, registration and the course management system, library databases, and scientific instruments or tools is not only a headache for the students but also presents multiple points of weakness for security policies. Tying security to individual applications is unsustainable as applications move online and as users change roles—from undergraduate to graduate student, to alumni, or even to faculty. Identity management authenticates users through any of several means and allows or forbids access—and, in many cases, certain *kinds* of access—based on different roles.
64. A highly developed identity management system provides users with a single point of authentication to all of the resources to which they are entitled. End users benefit from a streamlined means to access resources from disparate sources, and this increase in efficiency also allows more reliable access from a wider range of sources. As students move from one institution to another, or as they graduate and assume new relationships to colleges and universities, identity management systems can follow these changes and provide appropriate access for all stages of a person's education. Increased access and efficiency also promote greater collaboration and innovative uses of digital resources.
65. From the institutional perspective, identity management systems centralize the task of managing access to many systems, which lessens the risk of unauthorized exposure of information assets. As security for resources is improved, so is protection of the identities of users and of their personal information. Identity management also allows institutions to more easily add new applications to an existing suite because the security and access structure is already in place, and such systems make it easier for colleges and universities to comply with institutional and governmental requirements.
66. Federated identity management systems go a step further by allowing many institutions to share information about the identities and authentication requirements needed to access resources on multiple campuses. Without a federated identity arrangement, institutions that want to extend access to one another must work out individual agreements, which quickly becomes extremely complicated, in terms of technology and policy.

Analytics

67. *Analytics* (referred to as “business intelligence” by some) is a tool that higher education can use to respond to calls for increased accountability and improved outcomes. U.S. higher education has used simple analytics for admissions, building models that use data from standardized tests and transcripts to predict which applicants are most likely to succeed. Applying the same principles to enrolled students, institutions can construct data-driven models that correlate patterns of behavior with student success (e.g., course grades, college graduation) and endeavor to identify students who are at higher risk not to

complete a course or degree. Once at-risk students are identified, a wide range of proactive steps can be taken to improve their odds of success.

68. The analytics process begins with the identification and collection of data, often from disparate sources, within or outside the institution, including course management systems, student information systems, and other data sources. The data are analyzed and predictive models constructed that allow the institution to intervene with students who are likely to experience academic difficulty.
69. For example, a course management system (CMS) (or learning management system) might collect highly detailed data about student use of the resources. Correlating these data with outcomes (e.g., student grades in the course) can reveal patterns that can predict which students are more or less likely to achieve specific levels of success. Based on policies set by the institution, an analytical model can monitor student activity in the CMS and take particular actions when certain triggers are activated. If, for instance, the system determines that a student has not logged in to a course website three weeks into the academic term, it could send an e-mail to that student to confirm that he is in fact enrolled and advise that, historically, students who do not take advantage of the course website are several times less likely to earn a passing grade than those who do. Other triggers could prompt more aggressive interactions, including phone calls or personal visits from faculty or staff.
70. Analytics has the potential to take advantage of the vast amounts of data that institutions collect to provide additional support for students and improve teaching by helping faculty understand where their efforts are best applied. It also helps institutions demonstrate they are doing all they can to ensure students succeed in an era of growing accountability.

Mobile Devices

71. Mobile devices include laptops and tablet PCs, but many smaller devices increasingly rival traditional notebook computers in the applications and functionality they support. Even basic cell phones have broad capabilities, and many smartphones have moved beyond e-mail and web browsing to become legitimate surrogates for PCs in many circumstances. For example, many colleges and universities are translating existing applications and services to the iPhone or building new applications for campus constituents.
72. Mobile devices obviously depend on connectivity, which is increasingly available on phone as well as data networks. Although Wi-Fi access is growing and many campuses are fully wireless, the ability to use mobile technology greatly expands coverage for wireless devices. The implementation of GPS technology across a wide range of wireless devices also ushers in an era of location-aware applications that discern where a user is and tailor content and features to that location, resulting in richer, more efficient interactions with data and with other users.

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73. Cloud computing services and applications are delivered over the Internet and so do not require users to install and maintain software. As such, growth of cloud computing expands the usefulness and capabilities of mobile devices. At the same time, many application developers are modifying software to recognize mobile devices and reformat the user interface to accommodate the smaller screen.
74. Mobile devices present new questions about data security, given the risks not only from wireless versus wired transmissions but also from the greater potential for mobile devices to be lost or stolen. Because of the display size and limitations on input tools such as keyboards, mobile devices remain inappropriate for some applications. Still, the growing role that mobile computing plays in the lives of students, faculty, and researchers has the potential to greatly expand access to educational resources. Allowing students to engage in independent or collaborative learning activities from any place at any time invites many people to be students—or teachers—who would otherwise not be part of the education enterprise. As degrees become increasingly inter-institutional and competency-based, mobile devices will both provide access to appropriate resources and serve as tools to gather and submit evidence of proficiency in real-world activities.

Collaboration Tools

75. Higher education must adequately prepare students for real-world jobs, and in those jobs, problems are solved by the collaborative, iterative efforts of multiple people, often geographically separated from one another. The traditional educational model of an instructor transferring information to students is giving way to new conceptions of learning as an effort between and among peers, taking place in a range of contexts, including informal, asynchronous channels. In addition, the trend toward globalization heightens this imperative, as technologies overcome hurdles of time and location. At the same time, student use of collaborative tools in their personal lives paves the way for such applications in learning and research.
76. A wiki is perhaps an archetypal example of current collaboration tools. Wikis allow multiple users, in multiple locations, to work together on a common project. The elements of collaboration include communication and the ability of disparate individuals to have access to a shared work product, to make changes and see other participants' changes. Collaborative tools are often self-organizing, allowing those who want to participate to do so, at a level that they choose. Applications like Google Docs and other document-sharing tools provide similar spaces where groups of users can effectively and seamlessly work collaboratively.
77. Early collaboration tools were often seen simply as substitutes for in-person interaction. In this sense, a videoconferencing system is a collaborative tool. As the concept of collaboration matures, newer tools offer expanded capabilities,

such as role-based differentiation for access to projects or the right to make changes. Some tools track modifications and who made them, and many applications increasingly resemble or function with social networking tools. The notion of unplanned collaborations and serendipitous connections also characterizes emerging applications.

78. Collaborative tools model the kind of work that many students will encounter in their professional lives, and they allow for interdisciplinary, inter-institutional, and international projects. Such collaboration benefits learning by engaging students more deeply in the subject matter and the many different perspectives that other students and faculty have. As instructors remove themselves from the spotlight in their classrooms and invite students to engage in self-directed learning and critical thinking, collaborative tools help bring students together in a shared exercise of discovery and knowledge creation.

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