NMC

Horizon Report > 2015 Higher Education Edition

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Executive Summary

What is on the five-year horizon for higher education institutions? Which trends and technologies will drive educational change? What are the challenges that we consider as solvable or difficult to overcome, and how can we strategize effective solutions? These questions and similar inquiries regarding technology adoption and educational change steered the collaborative research and discussions of a body of 56 experts to produce the *NMC Horizon Report: 2015 Higher Education Edition*, in partnership with the EDUCAUSE Learning Initiative (ELI). The *NMC Horizon Report* series charts the five-year horizon for the impact of emerging technologies in learning communities across the globe. With more than 13 years of research and publications, it can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

The experts agreed on two long-term trends: advancing learning environments that are flexible and drive innovation, as well as increasing the collaboration that takes place between higher education institutions. These are just two of the 18 topics analyzed in the *NMC Horizon Report: 2015 Higher Education Edition*, indicating the key trends, significant challenges, and important technological developments that are very likely to impact changes in higher education across the world over the next five years.

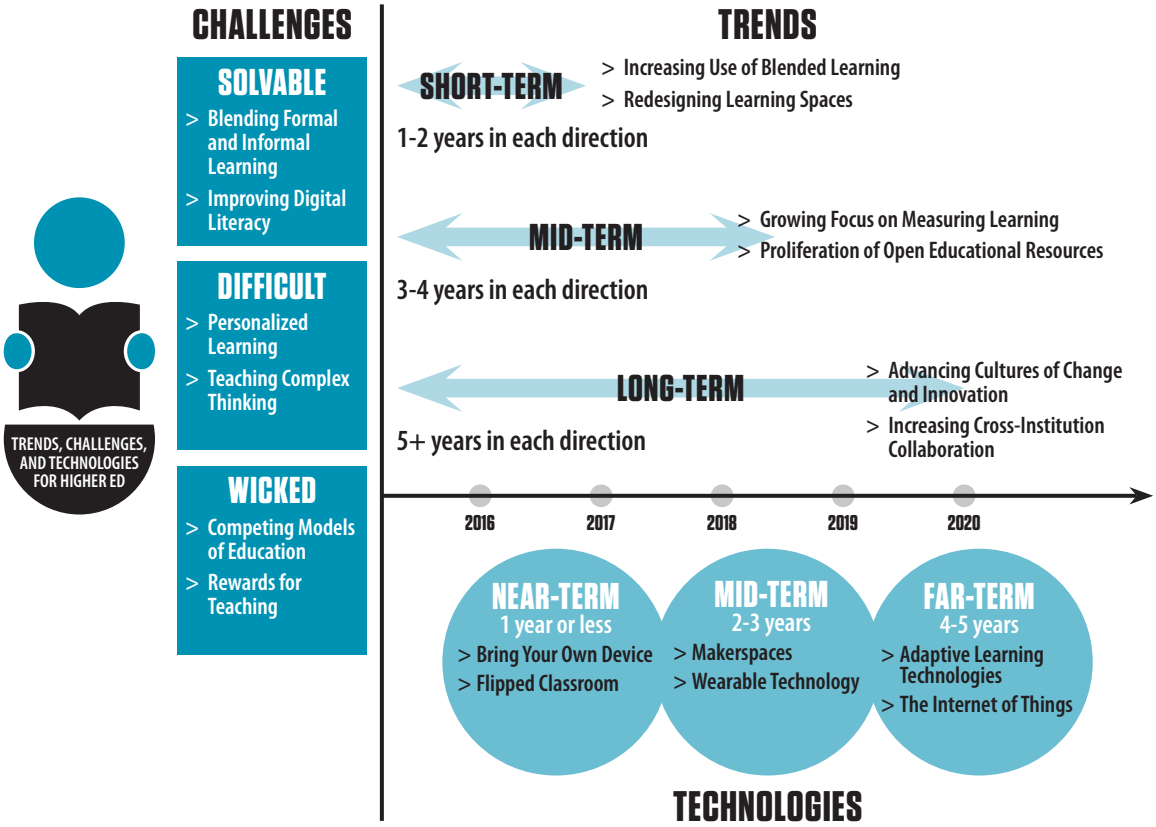
Regarding the challenges for universities and colleges, improving digital literacy is considered one of the solvable challenges. It is already being addressed by actions at individual institutions. At The Open University in the UK, they developed the "Digital and Information Framework" to standardize and implement better digital literacy training in their curriculum. Cornell University also has made available online resources for learning key technology skills. On the other hand, the experts identified rewarding teachers for innovative and effective pedagogy as a wicked challenge — one that is impossible to define, let alone solve. Many institutions provide more incentives for research over exemplary teaching.

In view of the trends and challenges observed, the panel also signalled the technological developments that could support these drivers of innovation and change. Bring Your Own Device (BYOD) and the flipped classroom are expected to be increasingly adopted by institutions in one year's time or less to make use of mobile and online learning. The time-to-adoption for makerspaces and wearable technology are estimated within two to three years, while adaptive learning technologies and the Internet of Things is expected to be mainstream in universities and colleges within four to five years.

With more than 13 years of research and publications, the NMC Horizon Project can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

The three key sections of this report constitute a reference and straightforward technology-planning guide for educators, higher education leaders, administrators, policymakers, and technologists. It is our hope that this research will help to inform the choices that institutions are making about technology to improve, support, or extend teaching, learning, and creative inquiry in higher education across the globe. Education leaders worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *NMC Horizon Report: 2015 Higher Education Edition* is presented.

Topics from the *NMC Horizon Report > 2015 Higher Education Edition*



Introduction

In the pages that follow, 18 topics carefully selected by the 2015 Horizon Project Higher Education Expert Panel related to the educational applications of technology are examined, all of them areas very likely to impact technology planning and decision-making over the next five years (2015-2019). Six key trends, six significant challenges, and six important developments in educational technology are placed directly in the context of their likely impact on the core missions of universities and colleges, and detailed in succinct, non-technical, and unbiased presentations. Each has been tied to essential questions of relevance, policy, leadership, and practice.

The *NMC Horizon Report: 2015 Higher Education Edition* was produced by the NMC in collaboration with the EDUCAUSE Learning Initiative. The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a comprehensive effort established in 2002 by the NMC that identifies and describes emerging technologies likely to have a large impact over the coming five years in education around the globe.The *NMC Horizon Report: 2015 Higher Education Edition* is the 12th in the annual higher education series of reports and is produced by the NMC in collaboration with the EDUCAUSE Learning Initiative (ELI).

Key trends, challenges, and technological developments that are detailed here will directly inform policy, leadership, and practice at all levels impacting universities and colleges. This report aims to help universities, governing boards, and education leaders to strategically approach the further evolution of teaching, learning, and creative inquiry. Each topic has been carefully researched and framed in the context of its potential impact on global higher education.

The report's first two sections focus on an analysis of trends driving technology decision-making and planning, and the challenges likely to impede the adoption of new technologies, respectively. Each includes an explicit discussion of the trend or challenge's implications for policy, leadership, and practice in universities and colleges, along with examples and relevant readings.

The third section, in which six important developments in educational technology are described, is ultimately framed by these trends and challenges. The adoption or abandonment of these technologies by higher education institutions will be very much determined by the responses taken across the globe to these drivers of and obstacles to innovation and change.

Each of the four global editions of the *NMC Horizon Report* — higher education, primary and secondary education (K-12), museum, and library — highlights six emerging technologies or practices that are likely to enter mainstream use within their focus sectors over the next five years. Key trends and challenges that will affect current practice over the same period frame these discussions. The discussions of trends and technologies have been organized into three time-related categories; challenges are discussed within a similar three-part framework related to the scope of the challenge.

Key trends, challenges, and technological developments that are detailed here will directly inform policy, leadership, and practice at all levels impacting universities and colleges.

Each topic closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report. These resources, along with a wide collection of other helpful projects and readings, can all be found in the project's open content database that is accessible via the free NMC Horizon EdTech Weekly App for iOS[1] and Android devices.[2] All the background materials for the *NMC Horizon Report: 2015 Higher Education Edition*, including the research data, the preliminary selections, the topic preview, and this publication, can be downloaded for free on iTunes U.[3]

The process used to research and create the *NMC Horizon Report: 2015 Higher Education Edition* is rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are informed by both primary and secondary research. Dozens of meaningful trends, challenges, and emerging technologies are examined for possible inclusion in the report for each edition.

Every report draws on the considerable expertise of an international expert panel that first considers a broad set of important trends, challenges, and emerging technologies, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and technologies is selected. This process takes place online, where it is captured in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window into the work of the project, one that not only provides a real-time view of the work as it happens, but also contains the entire record of the process for each of the various editions published since 2006. The wiki used for the *NMC Horizon Report: 2015 Higher Education Edition* can be found at horizon.wiki.nmc.org.

The panel was composed of 56 technology experts from 17 countries on six continents this year; their names and affiliations are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled technologies is going to have a significant impact on the practice of higher education around the globe over the next five years. The key trends driving interest in their adoption, and the significant challenges higher education institutions will need to address if they are to reach their potential, also represent their perspective.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over the now 13 years of producing the *NMC Horizon Report* series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, nationalities, and interests, yet each member brings a relevant expertise. Over the decade of the NMC Horizon Project research, more than 1,200 internationally recognized practitioners and experts have participated on the panels; in any given year, a third of panel members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the expert panel are encouraged; see go.nmc.org/horizon-nominate.

Once the panel for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic in this edition is its potential relevance to teaching, learning, and creative inquiry in higher education. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants.

Following the review of the literature, the expert panel engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the panel:

1 Which of the key technologies catalogued in the NMC Horizon Project Listing will be most important to teaching, learning, or creative inquiry within the next five years?

2 What key technologies are missing from our list? Consider these related questions:

- **What would you list among the established technologies that some higher education institutions are using today that arguably *all* institutions should be using broadly to support or enhance teaching, learning, or creative inquiry?**
- **What technologies that have a solid user base in consumer, entertainment, or other industries should higher education institutions be actively looking for ways to apply?**
- **What are the key emerging technologies you see developing to the point that higher education institutions should begin to take notice during the next four to five years?**

3 What trends do you expect to have a significant impact on the ways in which higher education institutions approach our core missions of teaching, learning, and creative inquiry?

4 What do you see as the key challenges related to teaching, learning, or creative inquiry that higher education institutions will face during the next five years?

In the first step of this approach, the responses to the research questions are systematically ranked and

placed into adoption horizons by each expert panel member using a multi-vote system that allows members to weight and categorize their selections. These are compiled into a collective ranking, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of trends, challenges, and technologies originally considered for any report, the dozen that emerge at the top of the initial ranking process in each area are further researched and expanded. Once these interim results are identified, the group explores the ways in which these topics impact teaching and learning in higher education institutions. A significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to practitioners. For every edition, when that work is done, each of these interim results topics is written up in the format of the *NMC Horizon Report*. With the benefit of the full picture of how the topic will look in the report, the topics in the interim results are then ranked yet again, this time in reverse. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2015 Higher Education Edition*.

Key Trends Accelerating Technology Adoption in Higher Education

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories — long-term trends that typically have already been impacting decision-making, and will continue to be important for more than five years; mid-term trends that will likely continue to be a factor in decision-making for the next three to five years; and short-term trends that are driving edtech adoption now, but will likely remain important for only one to two years, becoming commonplace or fading away in that time.

While long-term trends have already been the topic of many education leaders' discussions and extensive research, short-term trends often do not have an abundance of concrete evidence pointing to their effectiveness and future directions. All of the trends listed here were explored for their implications for higher education in a series of online discussions that can be viewed at horizon.wiki.nmc.org/Trends.

The NMC Horizon Project model derived three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern universities and colleges; leadership is the product of experts' visions of the future of learning, based on research and deep consideration; and practice is where new ideas and pedagogies take action, in universities and related settings.

Policy. While all of the identified trends had policy implications, two trends in particular are expected to have a strong impact on policy decisions in the next five years. The proliferation of open educational resources has emerged as a major topic of interest to national governments and universities, but requires effective policy to become mainstream in practice. The European Commission's Institute for Prospective Technological Studies (IPTS) launched the "Opening Up Education" to assist in the formulation of guidelines in OER adoption and implementation.[4]

Likewise, measuring learning through data-driven practice and assessment, currently on the rise in universities in the developed world, will reach its maximum impact in higher education in about three to five years, but many leading institutions are moving considerably faster. The Open University in the UK has created policies that support the ethical use of learning analytics,[5] and in the US, the recent Asilomar Conference convened educators, data scientists, and legal scholars to develop a framework to influence policy.[6]

These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories.

Leadership. While there are leadership implications for all the identified trends that are discussed in the following pages, two trends stand out as unique opportunities for vision and leadership. The redesign of learning spaces requires initiative to imagine how the physical set-up of classrooms can better accommodate progressive teaching, but also how to share those ideas broadly. Launched by SUNY's University at Buffalo, FLEXspace is an interactive online database that highlights best practices in design from universities all over the world.[7]

A long-term trend is the growth of collaboration between different higher education institutions. This trend reflects the notion that innovation can scale better when ideas are shared between institutions. The University of California Riverside is a notable example, co-founding the University Innovation Alliance with ten other universities to investigate emerging technologies and determine how they can best scale.[8]

Practice. Each of the six trends identified by the expert panel has numerous implications for teaching and learning practice, and current examples are easy to find. The increase of blended learning, highlighted as one of two developing short-term trends in the following pages, is bringing both technical and pedagogical enhancements to online and blended learning. Channel 9, for example, is a website that encompasses a library of training resources in computer coding and programming, with streaming videos and interactive events.[9]

All over the world, universities and colleges have been gradually rethinking how their organizations and infrastructures can be more agile. The thought is that if institutions are more flexible, they will be better able to support and promote entrepreneurial thinking — a long-term trend. At the University of Florida, the Innovation Academy acts as an incubator for students to plan and develop products and businesses, and even seek external funding.[10]

The following pages provide a discussion of each of the trends highlighted by this year's expert panel that includes an overview of the trend, its implications, and a set of curated recommendations for further reading on the topic.

Advancing Cultures of Change and Innovation

Long-Term Trend: Driving Ed Tech adoption in higher education for five or more years

Many thought leaders have long believed that universities can play a major role in the growth of national economies. Research universities are generally perceived as incubators for new discoveries and innovations that directly impact their local communities and even the global landscape.[11] In order to breed innovation and adapt to economic needs, higher education institutions must be structured in ways that allow for flexibility, and spur creativity and entrepreneurial thinking. There is a growing consensus among many higher education thought leaders that institutional leadership and curricula could benefit from agile startup models. Educators are working to develop new approaches and programs based on these models that stimulate top-down change and can be implemented across a broad range of institutional settings.[12] In the business realm, the Lean Startup movement uses technology as a catalyst for promoting a culture of innovation in a more widespread, cost-effective manner, and provides compelling models for higher education leaders to consider.[13]

Overview

This topic reflects a broader trend in society in which businesses are adapting their strategies to remain relevant to consumers. A well-known example is the publishing industry, which has transitioned their focus in the past decade from print to digital to keep pace with the rapidly changing technology landscape. Similarly, many companies that once manufactured hardware and software packages have shifted to providing cloud-based services. In the business of higher education, the consumers are the students, and there is a need to better cater to them as their expectations and behaviors evolve. In many ways, this shift is being driven by the technologies that students use in their daily lives and that extend to learning. For example, once it was clear that smartphones could play a major role in teaching and learning, institutions updated their infrastructures to accommodate BYOD programs. In this sense, it has become the responsibility of universities to foster environments that accelerate learning and creativity.[14]

The onus is on universities to create the conditions for innovation to happen. In a recent speech to the Detroit Economics Club, the outgoing University of Michigan president asserted that the institution could be paramount in promoting more entrepreneurship throughout the state.[15] She emphasized the need for universities to establish policies that spur more creativity and encourage more risk-taking, collaboration, and activities that more accurately reflect the contemporary workplace. Bringing university organizational models into the future can translate into advancing local and global economies and cultures. A university lecturer and researcher from the University of Tampere in Finland published "The Roles of Universities in the Chinese Innovation Systems," which showed a correlation between universities that emphasize technology use in improving China's economy, especially in cultivating more technologically savvy graduates.[16]

Attitude is also key in adopting more organizational flexibility and innovative practices. The SUNY System hosted a conference in late 2014 — "Higher Education Reconsidered: Executing Change to Drive Collective Impact" — to identify tactics for SUNY universities to be more agile and forward-thinking. Their goal is to develop leadership that "understands the science of change," systems that are more adaptive, and a culture that relies more on real evidence and data for decision making.[17] The US Department of Commerce published a report entitled "The Innovative and Entrepreneurial University," which depicted the ways in which universities around the country are nurturing entrepreneurship within their infrastructure. Many examples highlight partnerships between the institutions with businesses and government agencies, including Clemson University's International Center for Automotive Research.[18]

Implications for Policy, Leadership, or Practice

There is a need for policies that more aggressively support agility. The European Commission's "Modernizing Universities" agenda focuses on implementing reform in higher education by restructuring institutions to enable faculty and students to be more active participants in the global marketplace of research and innovation. The EC's goals include stimulating a more open research environment, fostering stronger partnerships with businesses, and rethinking how qualifications are recognized.[19] In the US, university consortia are

leading the charge. The Association of American Universities is dedicated to spreading innovation across campuses. They are championing a number of agendas and policies, including the Task Force on American Innovation, which advocates for greater government investments in innovative research projects in the fields of physical science and engineering.[20] They also work with universities, government agencies, and businesses to implement more policies and university competitions that stimulate innovation and economic growth.[21]

It will require visionary leadership to build higher education environments that are equipped to quickly change processes and strategies as startups do. If these organizational models are designed well, universities can experience more efficient implementation of new practices and pedagogies. Aalborg University in Denmark is designed to spur more creativity and entrepreneurship, as it is a problem-based learning (PBL) university with the central values of interdisciplinary studies and innovation.[22] UNESCO has placed its only Danish Chair at the university to oversee the continued development of the PBL model as it relates to students and faculty solving local and global issues.[23]

There are many opportunities for higher education institutions to become leaders in promoting innovation across their campuses. The University of Florida, for example, launched the Innovation Academy, a community of students from more than 30 majors who are mentored in the areas of entrepreneurship and creativity. These students are encouraged to start and grow their own small businesses.[24] Similarly, the Singapore Management University's Institute of Innovation and Entrepreneurship helps faculty and students grow their own businesses through a variety of competitions and initiatives. Thus far, they have raised $3.7 million in grant funding and $9.4 million more in follow-up funding to further invest in the 110 companies they have helped generate.[25]

For Further Reading

The following resources are recommended for those who wish to learn more about advancing cultures of change and innovation:

A New Vision for California Higher Education: A Model Public Agenda
go.nmc.org/vision
(Nancy Shulock et al., Institute for Higher Education Leadership & Policy, March 2014.) This report constructs a model public agenda for California higher education that is more dynamic than the current state. > *Policy*

Report to the European Commission on New Modes of Learning and Teaching in Higher Education
go.nmc.org/highlev
(European Commission, October 2014.) The European Commission's High-Level Group on the Modernization of Higher Education has created guidelines for governments and institutions to develop comprehensive strategies at both the national and institutional level for the adoption of new modes of learning and teaching. > *Policy*

Creating an Ever-Flexible Center for Tech Innovation
go.nmc.org/everflex
(Avi Wolfman-Arent, 10 August 2014.) A collaboration between Cornell University and the Technion-Israel Institute of Technology seeks to create an environment that allows for repurposing of materials, supports variety and accessibility, and promotes agility in technology experimentation. > *Leadership*

Looking to Future, Educators and Policymakers See Universities as Agents for Change
go.nmc.org/agents
(Daniel Day, Princeton University, 11 April 2014.) Leaders and policymakers from across the globe met this past year in Paris at the Princeton-Fung Global Forum to discuss how universities can anticipate, influence, and drive change. > *Leadership*

Universities Must Adapt to Evolution of Student Body
go.nmc.org/must
(Anthony Davis and Michael Whalen, *The Chronicle Herald*, 18 November 2014.) This article argues that universities in Nova Scotia transferring to hybrid delivery could eliminate the need for multiple small departments across each university campus in favor of significant centers of excellence at each institution. > *Leadership*

Education-as-a-Service: 5 Ways Higher Ed Must Adapt to a Changing Market
go.nmc.org/eaas
(Ryan Craig, *Venture Beat*, 11 May 2014.) This article argues that higher education will soon transition from selling expensive degree programs to "Education-as-a-Service," and explains lessons colleges and universities can learn from SaaS market leader Salesforce. > *Practice*

Online Skills Mastery - Training for Faculty
go.nmc.org/osm
(University of Colorado Denver, accessed 8 January 2015.) University of Colorado Denver created and implemented a ten-week Online Skills Mastery training program to prepare online instructors to excel in teaching and reward them for professional development through a badging program. > *Practice*

Increasing Cross-Institution Collaboration

Long-Term Trend: Driving Ed Tech adoption in higher education for five or more years

Collective action among universities is growing in importance for the future of higher education. More and more, institutions are joining consortia — associations of two or more organizations — to combine resources or to align themselves strategically with innovation in higher education. Today's global environment is allowing universities to unite across international borders and work toward common goals concerning technology, research, or shared values. Support behind technology-enabled learning in higher education classrooms has reinforced the trend toward open communities and university consortia, as educators and administrators recognize collective action as a sustainable method of supporting upgrades in technological infrastructure and IT services.

Overview

The tradition of university associations and consortia originates in the early 20th century in the US, when universities began aligning with one another to meet common goals. Although purposes for creating consortium have grown more varied over time, the oldest collegiate partnerships were based on creating a network for which every associated institution could benefit from a collective pool of resources. One of the oldest consortia, Claremont Colleges, was established in 1925 and today joins five undergraduate colleges and two graduate universities. While each institution rewards degrees independently, enrolled students have access to specialized programs and expensive facilities of the partner schools outside of their institution.

A sense of solidarity with learners is leading institutions to join together with the objective of increasing accessibility, affordability, and the quality of education on a global scale. The World University Consortium, for example, operates under these values, adopting a human-centric approach to education, developing a system that leverages online and hybrid learning strategies to reach people of all ages globally.[26] Technology also plays a key role in the creation of consortia. Universities are increasingly competitive environments, and campuses must constantly review and upgrade infrastructure to optimize their capacity. Deemed as a long-term trend, the prevalence of consortia underscores a vision of institutions as belonging to part of a larger ecosystem in which long-term survival and relevance in higher education relies on the mutually beneficial partnerships.

Emerging consortia are founded with the express purpose of helping institutions continuously adopt best practices for digital learning. Founded in 2014, Unizin is a non-profit association that aims to create a common, scalable digital infrastructure through its role as a cloud-based services operator.[27] Steered by its members, Unizin offers content, platforms, and analytics that are sourced from its community of the nation's top research institutions. Among the first commercial services offered to its members at scale is Canvas by Infrastructure, an open source LMS that aligns with Unizin's commitment to global open standards.[28] Guided by its focus on interoperability and open standards, Unizin will continue to develop services that help members to manage content their students and faculty create; to share this content across universities cost effectively; to promote interoperability among systems for teaching and learning; and to facilitate learning analytics with the aim of improving student outcomes.[29]

Implications for Policy, Leadership, or Practice

Institutional policies often dictate the nature of consortia that university leaders are seeking. Carnegie Mellon University (CMU), for example, has a strong ethos about open access and open data for scholarly communications. This approach has been called strategic by the institution's president who has underlined the importance of developing sustainable financial models for open access in order to disseminate works as broadly as possible.[30] This is underscored by CMU's membership in the Open Cloud Consortium (OCC), an open cloud computing infrastructure that facilitates community based science, in which researchers from member institutions, including the University of Chicago and Johns Hopkins University among others, can compile, analyze, and share huge data sets via the Open Science Data Cloud. Bolstered by the shared cloud computing service, researchers from CMU can work collaboratively with other scientists in a common area, increasing the efficacy and speed of research activities.

Joining a consortium is often an institution's way of

defining its position as a leader of innovation and progress in a certain area. In a recent interview with *The Chronicle of Higher Education*, the Chancellor of University of California at Riverside discussed how the institution has managed to evolve with student success as a focal point.[31] UC Riverside is a large public institution with a socio-economically diverse student population, yet it has fostered a system in which the number of underrepresented minority and low-income students graduate at the same rate as the campus average. In 2014, UC Riverside became one of 11 founding members of the University Innovation Alliance, a consortium dedicated to making high-quality degrees accessible to all students regardless of background. This specialized group of large, public research universities will be experimenting with new technologies, such as predictive analytics, in order to build on their success and bring innovation to scale.[32]

BCNET is a consortium that has a long history of helping its members upgrade and maintain their technological infrastructure and IT services. Since 1998, BCNET has been unifying British Columbia's public, post secondary sector as they explore and develop solutions to mutual IT challenges, bringing together 25 public universities and 18 research institutions in the region. In BCNET's 2014 annual report, *ROC: Return on Collaboration*, the consortium presented several examples of successful initiatives at member sites, including an account of how BCNET engineers helped Kwantlen Polytechnic University (KPU) build the IT foundation to realize its vision for 2018. In order to achieve its goals of 5% annual growth, expansion of continuing and professional studies, and improvement in learner engagement and retention, KPU turned to BCNET to support them as they planned and implemented a strategy that incorporates a high-capacity campus network and cloud video conferencing services at scale.[33]

For Further Reading

The following resources are recommended for those who wish to learn more about increasing cross-institution collaboration:

More Collaboration Needed to Fix Higher Education, Experts Say
go.nmc.org/morecoll
(Carla Rivera, *Los Angeles Times*, 23 January 2014.) A recent report by the nonprofit California Competes proposes the creation of an autonomous citizens' Higher Education Investment Board that would collect data and help inform policy decisions by the governor, legislature, and leaders of public and private institutions. > *Policy*

Competency-Based Education Network
go.nmc.org/c-ben
(Competency-Based Education Network, accessed 4 January 2015.) The Competency-Based Education Network is a group of colleges and universities working to address challenges in designing, developing, and scaling competency-based degree programs.
> *Leadership*

Global University Network for Innovation
go.nmc.org/guni
(GUNi, accessed 4 January 2015.) GUNi is an international network supported by three partner institutions — UNESCO, the United Nations University, and the Catalan Association of Public Universities — that encourages higher education institutions to redefine their role, embrace the process of transformation, and strengthen their critical stance within society. > *Leadership*

Innovative Internet Drives Collaborative EU-Central Asian Research and Education
go.nmc.org/caren
(Central Asia Research and Education Network, 1 October 2014.) The data network for research and education in Central Asia, CAREN, has connected with GÉANT, a pan-European network that will increase the capacity and efficiency of over 300 universities and research centers across Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan. > *Leadership*

The Open Education Consortium
go.nmc.org/oec
(OE Consortium, accessed 5 January 2015.) The Open Education Consortium is a worldwide community of hundreds of higher education institutions and associated organizations committed to advancing open education and its impact on global education.
> *Leadership*

University Innovation Alliance
go.nmc.org/uia
(University Innovation Alliance, accessed 12 January 2015.) The University Innovation Alliance is a group of 11 universities across the country that have organized to test and scale solutions to problems of access and graduation in higher education. > *Leadership*

7 Ways Higher Ed Institutions are Increasingly Joining Forces
go.nmc.org/seven
(Keith Button, *Education Dive*, 18 December 2014.) Collaboration between institutions is key to scaling sustainable technology efforts. Colleges and universities are sharing cloud-based supercomputing tools, data storage, and online course material and platforms.
> *Practice*

Growing Focus on Measuring Learning

Mid-Term Trend: Driving Ed Tech adoption in higher education for three to five years

There is an increasing interest in using new sources of data for personalizing the learning experience, for ongoing formative assessment of learning, and for performance measurement; this interest is spurring the development of a relatively new field — data-driven learning and assessment. A key element of this trend is learning analytics, the application of web analytics, a science used by businesses to analyze commercial activities that leverages big data to identify spending trends and predict consumer behavior. Education is embarking on a similar pursuit into data science with the aim of learner profiling, a process of gathering and analyzing large amounts of detail about individual student interactions in online learning activities.[34] The goal is to build better pedagogies, empower students to take an active part in their learning, target at-risk student populations, and assess factors affecting completion and student success. For learners, educators, and researchers, learning analytics is already starting to provide crucial insights into student progress and interaction with online texts, courseware, and learning environments used to deliver instruction. Data-driven learning and assessment will build on those early efforts.

Overview

Data are routinely collected, measured, and analyzed in the consumer sector to inform companies about nearly every aspect of customer behavior and preferences. A number of researchers and companies are working to design similar analytics that reveal patterns in learning-related data that can be used to improve learning both for individual students, and across institutions and systems. The types of student data being analyzed vary, but include institutional information such as student profile information (age, address, and ethnicity), course selections, and pace of program completion; engagement data such as number of page views, contributions by students to discussion threads, percentage of students completing assignments, and number of logins; and learning analytics such as which concepts were mastered and which concepts were particularly difficult for a student.[35] While many experiments are underway, leaders are just beginning to understand which data is useful for advancing learning, as well as the scope of privacy and ethics issues.[36]

The emerging science of learning analytics is providing the statistical and data mining tools to recognize challenges early, improve student outcomes, and personalize the learning experience. With recent developments in online learning in particular, students are generating an exponential amount of data that can offer a more comprehensive look at their learning.[37] A recent report by the National Institute for Learning Outcomes and Assessment found that student assessment is emerging as a leading priority for institutions of higher education because of pressure from accrediting and governing entities and the growing need for more and better evidence of student achievement. They reported that in 2013, nearly 84% of colleges and universities surveyed adopted stated learning outcomes for all of their undergraduates, up from 10% in 2009, and the range of tools and measures used to assess student learning has expanded greatly.[38]

While maintaining its position as a mid-term trend from last year's report, this topic is experiencing increasing activity as projects around the world launch pilots and implementations. Victoria University in Australia, for example, moved to a blended learning strategy that required a change in their LMS. They revitalized their e-learning environment by using the data analytics platform Brightspace for detailed reporting, assessment, and collaboration.[39] After a pilot of four courses confirmed the potential high value of adopting learning analytics, Nottingham Trent University (NTU) in the UK introduced the NTU student dashboard that features learning analytics software that aggregates data on library use, attendance, and grades.[40] In the US, California State University is also developing a Student Success Dashboard to help university leaders better understand problematic areas and assist in determining the effectiveness of specific interventions they have implemented.[41]

Implications for Policy, Leadership, or Practice

In online environments especially, students are generating a large amount of learning-related data that could inform important decisions in addition to the learning process, but there is more work needed to structure appropriate policies to protect student privacy. There is a growing concern that ethical and

privacy considerations are not advancing as quickly as practice.[42] The Open University in the UK produced policy on the ethical use of student data for learning analytics, grounded on eight key principles that are linked to particular facets of collecting and analyzing student data.[43] Progress is also being made in the US. In 2014, educators, scientists, and legal/ethical scholars gathered at the Asilomar Conference in California to develop a framework that will inform the ethical use of data and technology in learning research. Six principles emerged: respect for the rights of learners, beneficence, justice, openness, the humanity of learning, and continuous consideration.[44]

University leaders are demonstrating their commitment to the use of learning data through the addition of new offices and partnerships, including the University of Maryland's new Office of Analytics and their cooperation with the Predictive Analytics Reporting (PAR) Framework, Civitas Learning, and Transfer Data Repository. By sharing data on retention and progression with other institutions, universities can benchmark their progress. In the PAR project, the University of Maryland found that they had higher freshman retention rates than many of their peers, but fell behind others for students in years two and three.[45] Similarly, the Marist College and University of Amsterdam announced the Apereo Learning Analytics community in 2014 to accelerate the operationalization of learning analytics software and frameworks, support cross-institutional pilots, and avoid duplication.[46] The sharing of best practices, research, emerging tools, and proven strategies are hallmarks of this trend.[47]

Data-driven projects at universities are beginning to mature and are revealing promising results. At the University of Wisconsin, the Student Success System pilot program was initiated to identify struggling students and behavioral patterns. In addition to expanding pilot courses and institutional partners in the project's second year, there is an effort to foster a community of interest and practice, which is being accomplished by incorporating data analytics discussions into faculty professional development and inviting experts in the field of learning analytics to engage with the faculty community.[48] Dashboards, visual representations of data that are integrated in many management systems, are also currently being used by a number of universities as a way to personalize the learning experience. These sorts of tools can provide students with the means of understanding their progress.[49] Examples of new commercially available dashboards include Enterprise Analytics,[50] Campus Quad Engage,[51] and Jenzabar Analytics.[52]

For Further Reading

The following resources are recommended for those who wish to learn more about the growing focus on measuring learning:

Code of Practice for Learning Analytics
go.nmc.org/codeof
(Niall Sclater, JISC, November 2014.) The complex ethical and legal issues surrounding student data are creating barriers to the development and adoption of learning analytics. In response, this review draws from 86 publications to express the questions raised on the subject, and extract the ethical principles that can be used to advise a code of practice. > *Policy*

Lecturer Calls for Clarity in Use of Learning Analytics
go.nmc.org/clar
(Chris Parr, *Times Higher Education*, 6 November 2014.) The Open University has produced a publicly available written policy on the ethical use of student data for learning analytics and hopes the new policy will begin a debate in higher education about what level of consent is required from students before universities can use their data. > *Policy*

Carnegie Mellon Leads New NSF Project Mining Educational Data To Improve Learning
go.nmc.org/sphere
(Carnegie Mellon University, 2 October 2014.) The National Science Foundation is sponsoring Carnegie Mellon University in creating a distributed storage system that will serve as an enabling and collaborative data infrastructure that gives researchers control over which elements of their data can be accessed by outsiders. > *Leadership*

Iowa Community College Online Consortium
go.nmc.org/ean
(Next Generation Learning, accessed 4 January 2015.) The Iowa Community College Online Consortium's eAnalytics system provides instructors with the ability to identify at-risk students and provide support to improve their performance. > *Practice*

Learning Analytics Don't Just Measure Students' Progress – They Can Shape It
go.nmc.org/learnan
(Rebecca Ferguson, *The Guardian*, 26 March 2014.) This article describes how learning analytics can combine data analysis and visualization to offer ways for learners to improve while a course is in progress. > *Practice*

Proliferation of Open Educational Resources

Mid-Term Trend: Driving Ed Tech adoption in higher education for three to five years

Defined by the Hewlett Foundation in 2002, open educational resources (OER) are "teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others."[53] Momentum behind OER began early on, getting a major boost when the Massachusetts Institute of Technology founded the MIT OpenCourseWare (OCW) initiative in 2001, making MIT instruction materials for over 2,200 of its courses available online, free of charge. Soon after, prestigious universities including Carnegie Mellon University and Harvard University, among others, pushed forward their own open learning initiatives. Understanding that the term "open" is a multifaceted concept is essential to following this trend in higher education; often mistaken to simply mean "free of charge," advocates of openness have worked towards a common vision that defines it more broadly — not just free in economic terms, but also in terms of ownership and usage rights.

Overview

Altogether, OER represents a broad variety of digital content, including full courses, course materials, modules, textbooks, videos, tests, software, and any other means of conveying knowledge. OER uses Creative Commons and alternative licensing schemes to more easily distribute knowledge, media, and educational resources, which guarantees that content is freely copiable, freely remixable, and free of barriers to access, cultural sensitivities, sharing, and educational use. Open textbooks are being considered as a viable means for cutting excess costs with the goal of making education more affordable for students. According to a 2014 study by US PIRG Education Fund and the Student PIRGs, of 2,039 students surveyed, 65% said that they had not bought a textbook due to its high price. Open textbooks are open-source e-books that are freely available with nonrestrictive licenses, and have been popularized by projects such as Rice University's Open Stax College[54] and College Open Textbooks,[55] a non-profit collaborative of over 200 universities and 29 organizations.

While OER is gaining traction across campuses, its broader acceptance into higher education hinges on the issue of awareness and accessibility.[56] Babson Survey Research Group published an in-depth exploration of OER uptake in higher education throughout the US and found that among 2,144 faculty members surveyed, the majority demonstrated benevolent attitudes about using OER, unlike other technological advances in teaching.[57] Yet the survey revealed that awareness of OER and related issues was significantly scarce, with only 5.1% of respondents answering that they were "very aware" of OER and its use in the classroom.[58] More than half of the respondents said they were deterred by the lack of search tools or a comprehensive catalog of materials.[59] While understanding about OER is lacking, Babson researchers highlighted why knowledge in this area has the potential to increase greatly over the next three years; more than three-quarters of faculty members indicated that they expected to use OER or would consider using OER in the future.[60]

There are a number of existing OER repositories and search tools in place for the higher education community. Among the first, MERLOT was started in 1997 by California State University, and has since been offering its members a platform to create, share, and curate online learning materials.[61] Similarly, Jorum is a portal for university educators in the UK to collect and share OER.[62] Funded by JISC, Jorum allows users to filter materials based on community, institution, author, keyword, and license, among other search criteria.[63] Mexico's Tecnológico de Monterrey has been compiling and sharing OER through "Temoa," an online portal with over 500,000 learning materials, each subject to different conditions related to control of use, reproduction, interpretation, and material distribution established by each author. Started in 2008, "Temoa" invites users to participate as collaborators, cataloguers, and auditors, to evaluate the credibility of materials in their areas of expertise.[64]

Implications for Policy, Leadership, or Practice

Governmental policies have done much to shape OER's path through higher education environments around the world. Researchers from IPTS documented the trajectory of OER policies, attitudes, and trends in "OER: A European Policy Perspective." They highlight the creation of the "Opening Up Education" initiative in

2013 as an essential framework to develop integrated economies of access and unimpeded exchange of knowledge across borders in order for Europe to remain competitive.[65] Experts point out that although the OER has solid footing in secondary schools, policies for higher education are scarcer due to institutional autonomy. Yet top-down initiatives funded by public institutions and foundations exist to help universities pursue large-scale OER integration, such as the Support Centre for Open Resources in Education led by the Open University.

While data shows that some faculty are integrating OER on their own,[66] institutional leadership can reinforce the use of open content. Produced by the Office of the Pro Vice Chancellor, the University of South Africa (Unisa) developed an Open Education Resources Strategy for 2014-2016 to introduce a new business model and detailed plan for the assimilation of open resources into courses. The Unisa strategy acknowledges that emerging technologies, such as MOOCs and open badges, have disrupted the institution's traditional means of earning revenue, and emphasizes OER's potential for helping the university redirect its focus from content delivery to the improvement of academic and administrative services. Furthermore, Unisa highlights open licensing and sharing as a method of promoting their learning experience to prospective students, with the larger goal of becoming a major producer and distributor of high-quality instructional materials and information.[67]

Regional communities of practice have formed to provide a foundation of knowledge and tools for educators as they integrate OER into their instruction. The North-West OER Network, for example, is an online resource that encourages collaboration between 13 higher education institutions in the North-West of England.[68] The project began in Spring 2014 with a five-day open online course called "Openness in Education" as a way of on-boarding its member institutions during Open Education Week. Learners were encouraged to participate in Google Hangouts, share their thoughts in Twitter discussions, or reflect on their learning via the Facebook community page.[69] Led by the Centre for Excellence in Teaching and Learning at Manchester Metropolitan University, the project maintains a website that offers several ways for member institutions to stay informed including a dedicated Google+ community and a comprehensive list of OER search engines.[70]

For Further Reading

The following resources are recommended for those who wish to learn more about the proliferation of open educational resources:

European Open Edu Policy Project
go.nmc.org/oerpolicy
(OER Policy, accessed 5 December 2014.) Open Educational Resources Policy in Europe is a Creative Commons project that launched a coalition of international experts to strengthen the implementation of open education policies across Europe. > *Policy*

North Shore Community College Library Action Plan: 2014–2015
go.nmc.org/northshore
(North Shore Community College, accessed 4 January 2015.) The North Shore Community College Library plans to collaborate with the academic technology department to help faculty develop and promote open educational resources in an effort to ensure students across all disciplines have access to a full range of information resources and services. > *Policy*

Online Einstein Project Reveals Scientist's Magnitude and Minutiae
go.nmc.org/onein
(Peter Monaghan, *The Chronicle of Higher Education*, 5 December 2014.) The Princeton University Press has made freely available online a digital edition of The Collected Papers of Albert Einstein that permits seamless searching and comparison among Einstein's papers. > *Leadership*

Opening the Curriculum: Open Education Resources in US Higher Education, 2014
go.nmc.org/babson
(I. Elaine Allen and Jeff Seaman, Babson Survey Research Group, 2014.) Funded by The William and Flora Hewlett Foundation, this study found that the majority of faculty in higher education are not very aware of open educational resources, though they appreciate the concepts. > *Leadership*

Open Washington
go.nmc.org/opwa
(Open Washington, 3 December 2014.) "Open Washington" is an open educational resources network managed by the Washington State Board for Community and Technical Colleges and is dedicated to providing pathways for faculty to learn, find, use, and apply OER. > *Leadership*

US PIRG Report Finds Students Would Perform Better with Open Textbooks
go.nmc.org/PIRG
(Jane Park, *Creative Commons*, 30 January 2014.) A report released by the US PIRG Education Fund revealed that in the over 2,000 college students surveyed, 65% refuse to buy a college textbook if it is too expensive, and 94% said they suffered academically because of this choice. > *Practice*

Increasing Use of Blended Learning

Short-Term Trend: Driving Ed Tech adoption in higher education for the next one to two years

Over the past several years, perceptions of online learning have been shifting in its favor as more learners and educators see it as a viable alternative to some forms of face-to-face learning. Drawing from best practices in online and face-to-face methods, blended learning is on the rise at universities and colleges. The affordances blended learning offers are now well understood, and its flexibility, ease of access, and the integration of sophisticated multimedia and technologies are high among the list of appeals. Recent developments of business models for universities are upping the ante of innovation in these digital environments, which are now widely considered to be ripe for new ideas, services, and products. While growing steadily, the recent focus in many education circles on the rapid rise and burnout of massive open online courses (MOOCs) has led to the view that these sorts of offerings may be fad-like. However, progress in learning analytics; adaptive learning; and a combination of cutting-edge asynchronous and synchronous tools will continue to advance the state of online learning and keep it compelling, though many of these methods are still the subjects of experiments and research by online learning providers and higher education institutions.

Overview

Recently, the US National Center for Education Statistics reported that one in ten students were enrolled exclusively in online courses.[71] Studies conducted by the Babson Research Group reveal that 7.1 million American students are engaged in online learning in some form.[72] As online learning garners increasing interest, higher education institutions are developing more online courses to both replace and supplement existing courses. While the effectiveness varies from course to course, it has become clear that there is a demand from students for more accessible learning opportunities, and blended learning — the combination of online and face-to-face instruction — is a model currently being explored by many higher education institutions.

The University of Central Florida examined face-to-face, blended, and fully online models and found that blended approaches were most successful in "unbundling" the classroom — students felt that instructors were more accessible when learning materials and discussion forums were placed online and there was altogether more persistent communication through the use of virtual learning environments.[73] When assessing the quality of courses, researchers pinpointed clarity, authenticity, unity, suspense, economy, depth, proportion, vividness, brilliance, sensitivity, emphasis, authority, flow, and precision as the ultimate benchmarks. Institutions and instructors now have a better understanding that online learning opportunities need to encompass each of these characteristics; the task for higher education leaders for the next two years will revolve around how courses can be better designed, from conception to execution.

According to the University of Illinois, effective blended learning instructors must find ways to stimulate social activities and critical thinking within an online environment — just as they are expected to do in face-to-face experiences.[74] They also emphasize the need to support different learning preferences by enabling multiple ways for learners to engage with a concept.[75] Some students may absorb the material better through reading passages in online textbooks, while others may respond better by progressing through a playlist of video lectures and other supporting media. Furthermore, instructors are thinking more deeply about mimicking the types of interactions learners are accustomed to in brick-and-mortar settings. Cloud-based audio tools such as VoiceThread[76] and SoundCloud,[77] along with video creation tools such as iMovie[78] and Dropcam,[79] allow faculty to capture important human gestures, including voice, eye contact, and body language, which all foster an unspoken connection with learners.

Implications for Policy, Leadership, or Practice

Many higher education institutions recognize the need for concrete online learning guidelines and are taking it upon themselves to devise effective policies. The University of Glasgow, for example, released "E-Learning Strategy 2013-2020," a whitepaper that outlines best practices for the campus and increases the range and accessibility of the online learning methods that faculty can adopt.[80] Among their priorities is the use of a flexible virtual environment that incorporates interactive features to make learning more social for students. In regards to how online learning programs can be best managed and organized at an institutional and departmental level, California State University,

Sacramento has published their own policies.[81] On their campus, online course evaluation has been standardized to mirror face-to-face evaluation, and all resources that are placed online must satisfy current CSU policy to improve accessibility for students with disabilities.

Advancing the field of blended learning will require continuous visionary leadership. The European Distance and E-Learning Network (EDEN) consists of 200 member institutions and was founded to spread knowledge and best practices across the continent. EDEN is currently involved in a number of online initiatives that promote the use of emerging technologies and pedagogies for online learning, including LACE (Learning Analytics Community Exchange) and POERUP, which focuses on the integration of open educational resources in learning. The *European Journal of Open, Distance and E-Learning* is also supported by EDEN as a forum for sharing the latest research and development in online learning practices.[82] In the US, Penn State University and the Sloan Consortium are advancing a similar push for innovation in blended learning. The two organizations joined forces to launch the Institute for Engaged Leadership in Online Learning — a blended learning leadership development program that identifies key challenges and focus areas for the field.[83]

In practice, there are a number of innovative examples of online learning programs, some of which specialize in helping students acquire in-demand skill sets. Channel 9 provides users with a growing library of training resources in nearly any type of computer coding and programming, and offers streaming videos and interactive events.[84] While they remain a controversial topic laden with mixed reviews and opinions, MOOCs have enabled students to engage in learning at their own pace. Johns Hopkins University offers a MOOC through Coursera — "Getting and Cleaning Data." Video lectures and online quizzes help students learn about obtaining data through API's and databases, and includes peer-to-peer assessments to make for a more social experience.[85]

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing use of blended learning:

Trends and Policy Issues for the e-Learning Implementation in Libyan Universities
go.nmc.org/libyan
(Thuraya Kenan et al., *International Journal of Trade, Economics and Finance*, February 2014.) This paper describes trends and policy issues for e-learning implementation in Libyan universities and provides recommendations for how higher education institutions can influence governmental policies. > *Policy*

When MOOC Profs Move
go.nmc.org/profs
(Carl Straumsheim, *Inside Higher Education*, 18 March 2014.) Many universities are realizing they must create policies to clarify who has intellectual property rights to online courses. This article describes how a few major universities have addressed the issue. > *Policy*

A Catalyst For Change: Developing A Blended Training Model For The Liberal Arts Institution
go.nmc.org/Roll
(Carrie Schulz et al., *The Academic Commons*, 2013.) Rollins College created a professional development program to assist faculty in redesigning existing courses as blended learning offerings. > *Leadership*

CSU Innovation in Online Learning
go.nmc.org/uim
(Charles Sturt University News, 1 September 2014.) The "uImagine Digital Learning Innovation Laboratory" at Charles Sturt University is bringing together leading academic staff, educational designers, and students to drive innovation in digital learning by investigating new technologies and online teaching practices. > *Leadership*

Google Sponsors Carnegie Mellon Research To Improve Effectiveness of Online Education
go.nmc.org/cmu
(Byron Spice, Carnegie Mellon University, 24 June 2014.) A new Google-sponsored effort will allow Carnegie Mellon University to develop its online courses through techniques that automatically analyze and provide feedback on student work. > *Leadership*

ARTé
go.nmc.org/arte
(Texas A&M Live Lab, accessed 8 January 2015.) Art History faculty at Texas A&M University have created an online game to complement the classroom experience in Art History survey classes for undergraduate students. > *Practice*

Innovation in Online Learning (Video)
go.nmc.org/seel
(World Economic Forum, 4 March 2014.) Tina Seelig from Stanford University explains her role as instigator in her online course, presenting challenges to thousands of students as they worked together in the virtual environment to create solutions. > *Practice*

What is E-Learning?
go.nmc.org/elearning
(Nicole Legault, *E-Learning Heroes*, accessed 16 December 2014.) This overview of online learning describes how it has evolved over time and provides examples of both form-based and free-form authoring tools, methods for tracking learner results, and more. > *Practice*

Redesigning Learning Spaces

Short-Term Trend: Driving Ed Tech adoption in higher education for the next one to two years

Some thought leaders believe that new forms of teaching and learning require new spaces for teaching and learning. More universities are helping to facilitate these emerging models of education, such as the flipped classroom, by rearranging learning environments to accommodate more active learning.[86] Educational settings are increasingly designed to facilitate project-based interactions with attention to mobility, flexibility, and multiple device usage. Wireless bandwidth is being upgraded in institutions to create "smart rooms" that support web conferencing and other methods of remote, collaborative communication. Large displays and screens are being installed to enable collaboration on digital projects and informal presentations. As higher education continues to move away from traditional lecture-based programming and to more hands-on scenarios, university classrooms will start to resemble real-world work and social environments that facilitate organic interactions and cross-disciplinary problem solving.

Overview

A student-centered approach to education has taken root, prompting many higher education professionals to rethink how learning spaces should be configured.[87] The mold of the traditional classroom is being broken by several institutions to accommodate new pedagogies; instead of the traditional rows of chairs with writing surfaces facing a podium, universities are creating more dynamic classroom layouts, often with seating arrangements that foster collaborative work. These redesigned spaces support what is often referred to as flexible or active learning.[88] While active learning spaces vary, they share many common features. The typical podium is moved from the front of the classroom to the center and is surrounded by round or oval tables with movable chairs that enable students to shift between groups as needed. Each table may be technology-enabled, with interactive whiteboards or other marking surfaces. Many examples of these arrangements, such as at McGill University and Dawson College in Canada, have been in use for several years.[89]

This shift is also requiring universities to examine how informal campus environments can be modified to become theaters for learning.[90] Casual spaces in high-traffic areas such as lobbies, atriums, and hallways are being purposefully redesigned so that they can become locations where students congregate and work more productively. They often feature comfortable furniture, power outlets for charging mobile devices, and LCD monitors for connecting laptops.[91] Loughborough University in the UK has created three distinct informal learning areas where students can work collaboratively or independently. Their Learning Lounge features 16 PCs and an interactive Utouch display; the Learning Zone is outfitted with 12 PCs, two interactive whiteboards with connected PCs, two group tables, and flipcharts; and the Learning Lab contains three collaborative work zones, a group table, and vending facilities to keep students fueled during their study sessions.[92]

Academic libraries across the globe are seeing a flurry of activity as their informal learning spaces are being reimagined to take advantage of the emerging maker movement. Libraries have always been spaces to find tools for learning and some argue that in addition to books, 3D printers, laser cutters, and even sewing machines should be available to students. The physical layout of university libraries is currently being redrawn so that row upon row of stacks containing books that have not been touched in decades can be archived to make room for more productive use of floor space.[93] The DeLaMare Science and Engineering Library at the University of Nevada Reno, for example, was recently named one of the most interesting makerspaces in America by *Make* magazine. Over the summer of 2014, the ground floor of their facility was remodeled to create a more functional space for self-directed learning using new visualization hardware and software.[94]

Implications for Policy, Leadership, or Practice

While many learning space policies fall under a university's general appropriate use of information technology resources and systems principles, the evaluation of new spaces is being guided by a new Learning Spaces Rating System (LSRS) which provides a set of measurable criteria to assess the effectiveness of classroom design for promoting active learning activities. This rating system eliminates competing internal guidelines to enable benchmarking across institutions, helping universities identify lower- or higher-performing spaces within their

portfolios. The preliminary rating system currently allows the measurement of formal learning spaces, but future iterations will include informal and specialized learning spaces.[95] The LSRS is based on Leadership in Energy and Environmental Design (LEED) green building ratings systems, which promote sustainability in the planning of buildings, interiors, and schools. Policymakers can refer to this emerging system of rating and underlying research to support decisions to scale innovative classroom layouts with technology.

Campus leaders can work with instructional technologists and strategists when building technology ecosystems that are compatible, secure, and easy to update. One noteworthy resource is the Flexible Learning Environments eXchange (FLEXspace), an interactive, searchable online database containing best practices in active learning design. The site contains three main taxonomies that focus on technology integration, facilities integration, and learning and assessment.[96] The Learning Spaces Collaboratory (LSC) is another initiative that is gathering findings in contemporary research and practice to guide the creation and assessment of learning environments in undergraduate settings. This collaboration involves the perspectives of academics, architects, and other stakeholders.[97]

Before new technologies are introduced, faculty must consider how they fit into the current course structure and make necessary changes to the physical space. Australia's University of Western Sydney recently updated their curriculum to provide more options for their students. By 2016, all undergraduate courses will be offered in blended form.[98] To support this new structure, the university created collaborative learning spaces that support group activities outside of classroom settings through mobile furniture, dual projection screens, and maximized wall-writing surfaces — among other amenities. More authentic learning experiences are also driving the redesign of learning spaces in the medical field. George Washington University's Nursing Simulation Lab, for example, is an experiential learning space designed to provide a more realistic learning laboratory that mimics the actual hospital environment. Key features of the laboratory include a model emergency room suite, strategically embedded cameras and microphones to capture trainings, live streaming access to the lab, and a system capable of closed-circuit broadcast to a 100-seat lecture hall and 50-seat classroom.[99]

For Further Reading

The following resources are recommended for those who wish to learn more about redesigning learning spaces:

Blended Synchronous Learning
go.nmc.org/blendsync
(Matt Bower et al., Macquarie University, 2014.) Macquarie University's Blended Synchronous Learning project sponsored by the Australian Office for Learning and Teaching created a Blended Synchronous Learning Handbook from an analysis of seven case studies. > *Policy*

ELI Learning Space Rating System
go.nmc.org/rating
(EDUCAUSE, accessed 8 January 2015.) EDUCAUSE Learning Initiative's Learning Space Rating System project provides institutions with measurable criteria to assess how well their learning spaces encourage active learning. > *Leadership*

How Do Your Learning Spaces Measure Up?
go.nmc.org/meas
(David Raths, *Campus Technology*, 5 March 2014.) This article describes how FLEXspace, an online database of learning spaces, and Learning Space Rating System, a set of measurable criteria to assess classroom design, are helping learning institutions share and evolve best practices in classroom design. > *Leadership*

7 Design Trends in Higher Education
go.nmc.org/destrends
(Linda Pye, Academia.edu, accessed 4 January 2015.) This paper is directed at interior designers, architects, and facility managers charged with the task of creating and maintaining high-performance learning environments based on emerging trends in higher education. > *Practice*

The Evolving Classroom: Creating Experiential Learning Spaces
go.nmc.org/exper
(P.B. Garrett, EDUCAUSE, 13 October 2014.) Meshing technology with classroom elements such as furnishings, lighting, and writing surfaces is helping educators create an environment that allows near-ubiquitous use of computers and networked devices, as well as facilitating experiential learning through simulations and collaborative projects. > *Practice*

Idea Spaces
go.nmc.org/ideaspaces
(Tom Haymes, Houston Community College, accessed 8 January 2015.) In Fall 2016, the West Houston Institute will finish its massive learning space redesign that combines experiential classrooms and labs, a fully outfitted makerspace, a facilitated collaboration space, a conference space, and a connecting learning commons. > *Practice*

Significant Challenges Impeding Technology Adoption in Higher Education

The six challenges described on the following pages were selected by the project's expert panel in a series of Delphi-based cycles of discussion, refinement, and voting; the expert panel was in consensus that each is very likely to impede the adoption of one or more new technologies if unresolved. A complete record of the discussions and related materials were captured in the online work site used by the expert panel and archived at horizon.wiki.nmc.org/Challenges.

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well-understood but for which solutions remain elusive; and wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will even be possible. Once the list of challenges was identified, they were examined through three meta-expressions: their implications for policy, leadership, and practice.

Policy. While all of the identified challenges had policy implications, two specific challenges are driving policy decisions on many campuses at the moment. The easiest one to address is creating policies that better advance digital literacy. Governments at both the national and local level are already making ample headway. The Massachusetts Department of Education, for example, has convened expert panelists from higher education and K-12 to develop "Digital Literacy and Computer Science Standards." Tapping into the knowledge and experiences of university leaders and instructors, the goal is to better prepare students in understanding and creatively applying technology before they even step foot on campus.[100]

A more challenging policy area is that there is a great deal of competition from new models of education. The growing abundance of free online learning courses and resources that can be digested at the learner's own pace is calling into question the need for traditional four-year institutions. In the US, President Obama and the US Department of Education took actions to redefine the credit hour to encompass different kinds of activities that reflect learning outcomes.[101]

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge.

Leadership. Again, while all the identified challenges have leadership implications that are discussed in the following pages, two pose roadblocks to employing effective vision and leadership. There is a major need to integrate more personalized learning into university courses and accommodate each student's needs, but this will not be possible overnight. The Bill & Melinda Gates Foundation has been instrumental in working to solve this challenge. They recently founded the Personal Learning Network which convenes more than one dozen colleges and universities to investigate and implement potential applications of personalized and adaptive learning.[102]

The lack of rewards for exemplary teaching is considered by the panel as a wicked challenge that requires visionary leadership. Universities are set up in ways that inherently emphasize research over teaching. Carnegie Mellon University's Center for Teaching Excellence and Educational Innovation is focused on being an incubator for progressive pedagogies. Noteworthy professors are selected for the Spotlight on Innovative Teaching program, where they impart their wisdom to other educators in the form of workshops.[103]

Practice. Each of the six challenges identified by the expert panel presents numerous impediments for advancing teaching and learning, but two in particular are presenting unique obstacles. Fortunately, the expert panel perceives the blending of formal and informal learning to be a solvable challenge. Cork Institute of

Technology in Ireland is providing a compelling model for other universities by incorporating and rewarding work experience and other kinds of learning experience into a formal setting.[104]

Teaching more complex thinking has also been a challenge for higher education institutions, especially in very singularly focused disciplines such as biology and mechanical engineering. At Yale University, a molecular, cellular, and developmental virology professor designed a four-course series to train postdoctoral and graduate science students in creating effective presentations and public speeches.[105]

The following pages provide a discussion of each of the challenges highlighted by this year's expert panel that includes an overview of the challenge, its implications, and a set of curated recommendations for further reading on the topic.

Blending Formal and Informal Learning

Solvable Challenge: Those that we understand and know how to solve

Traditional approaches to teaching and learning with roots in the 18th century and earlier are still very common in many institutions, and often stifle learning as much as they foster it. As the Internet has brought the ability to learn something about almost anything to the palm of one's hand, there is an increasing interest in the kinds of self-directed, curiosity-based learning that has long been common in museums, science centers, and personal learning networks. These and other more serendipitous forms of learning fall under the banner of informal learning, and serve to enhance student engagement by encouraging them to follow their own learning pathways and interests. Many experts believe that a blending of formal and informal methods of teaching and learning can create a higher education environment that fosters experimentation, curiosity, and above all, creativity.[106]

Overview

The blending of informal learning into formal education is an intriguing notion, but hampered by the lack of ways to acknowledge and qualify learning that happens beyond the classroom. Adding complexity to the matter is the ability for institutions to quantify the kinds of informal learning experiences in which students engage. Some argue that in order to integrate informal education into the formal higher education system, skills that have tangible, transferable value in the real world must be identified and promoted as key competencies.[107] Many workplaces already encourage informal learning methods for professional development; Cisco's Technology Evangelist even cites the act of convening with like-minded people at a restaurant or coffee shop to discuss pressing topics in the IT industry as a creative example.[108] However, people rarely receive formal or substantial recognition for these experiences, setting a shaky precedent for informal learning at universities and colleges.

Regardless of whether or not it is being rewarded, informal learning is already impacting how students gain and demonstrate knowledge. According to an article published in the *EDUCAUSE Review*, "A growing appreciation for the porous boundaries between the classroom and life experience, along with the power of social learning, authentic audiences, and integrative contexts, has created not only promising changes in learning but also disruptive moments in teaching."[109] Indeed, the ways in which people learn have been expanding as more and more interactive content has been made freely available via the web. *The Hechinger Report* points to games and videos as two of the primary ways that students learn outside of their schooling. Games are cited specifically for their applications in developing inductive reasoning skills.[110] An increasing number of universities, such as Stanford University[111] and MIT[112] are leveraging the soft skills that games have proven to instill in learners, integrating games into their curriculum designs to simulate real world activities.

Social media and its tapestry of networks, articles, videos, and other resources are also making learning more ubiquitous. The 2013 "E-Expectations Report" found that students trust information delivered through universities' social media more than if the same content was posted to universities' websites.[113] Social media has transcended its initial usage for building social connections;[114] people increasingly rely on their Facebook and Twitter newsfeeds, for example, to stay up to date on major global events, and even use these platforms as a vehicle for sharing and garnering feedback on personal creative works. The book *Personal Learning Networks* explores the ways in which social media can stimulate new learning pathways.[115] As an example, social networks enable the creation of learning teams that mimic interest groups — students are able to congregate by areas of curiosity and even learn from each other.

Implications for Policy, Leadership, or Practice

While much work has been done to define and explore aspects of informal learning, ways to formally evaluate those experiences are not as well understood. There is a need for national policies that guide the substantiation of informal learning across education systems. Launched by European University Continuing Education Network, VALERU is the development of methodology for validating informal learning in Russia.[116] VALERU is focused on how students' learning outcomes that were generated outside of higher education can be integrated into study programs. Using the framework that initiative leaders aim to devise over the next few years, more experts will be trained to expand the pool of informal learning validators in Russia.

At a global leadership level, OECD has acknowledged that learning happens constantly, and that capturing insights around informal learning can provide governments with critical information for improving educational opportunities. In 2010, they worked with representatives from 22 countries to compile their experiences in a report entitled "Recognising Non-Formal and Informal Learning," which provides a foundation for countries to begin defining learning and skills gained outside of formal institutions.[117] The goal of this work is a massive undertaking — to be able to accurately assess human capital within a nation with the aim of strengthening the economy.[118] A similar report by JISC, "Learning in a Digital Age," discussed the growing use of blogs, wikis, podcasting, social networking, and other tools as vehicles to deepen learning.[119] In the US, the National Science Foundation Directorate for Education and Human Resources is funding grants that emphasize the need to gain a better grip on informal learning,[120] with projects including Advancing Informal STEM Learning.[121]

Researchers and faculty at the Cork Institute of Technology in Ireland have been dedicated to incorporating informal learning experiences into their offerings. As described in the paper "Capturing and Valuing Non Formal and Informal Learning: Higher Education can Support Learning Gained in Life," they hosted Cork City's Lifelong Learning Festival, which joined together adult learners who had re-enrolled at local universities and colleges. The event highlighted the development of a digital archive where students can present on their most influential informal learning experiences as they unfold. Additionally, the Institute held a workshop that introduced students to e-portfolios with the goal of understanding how they can be best applied to showcase informal learning and creative projects that occur outside of the college.[122] Educators are also major beneficiaries of solutions to this challenge as there is a growing host of informal professional development opportunities for them — many of which take place exclusively online, including the NMC's own Academy for teacher training,[123] HP LIFE e-Learning,[124] and the European Schoolnet Academy.[125]

For Further Reading

The following resources are recommended for those who wish to learn more about blending formal and informal learning:

Building an Expanded, Effective, and Integrated Post-School System
go.nmc.org/post
(South Africa Department of Higher Education and Training, 20 November 2013.) This white paper lays out a plan to introduce community colleges that will be differentiated from the university systems. > *Policy*

The Digital Degree
go.nmc.org/digdeg
(*The Economist*, 28 June 2014.) The European Union signed the Lisbon Recognition Convention to recognize skills and competences gained informally to promote student mobility throughout EU Member States. This agreement is presented as a model for the gradual integration and validation of informal learning into formal education. > *Policy*

Formalizing Informal Learning: Assessment and Accreditation Challenges Within Disaggregated Systems
go.nmc.org/accredit
(Rory McGreal et al., Open Praxis, April 2014.) This report presents key economic and governance challenges for universities to consider when implementing assessment and accreditation policies in efforts to validate post secondary informal learning experiences. > *Policy*

Building Learning Societies: Promoting Validation of Non-formal and Informal Learning
go.nmc.org/validation
(EUCIS-LLL, 17 October 2014.) This project aims to develop an awareness-raising campaign for the validation of learning outcomes of non-formal and informal learning as a tool to improve adults' career perspectives and stimulate their further education and training. > *Leadership*

ePortfolios and Open Badges Maturity Matrix
go.nmc.org/matr
(LearningFutures.eu, 6 July 2014.) The ePortfolios and Open Badges Maturity Matrix is an initiative to provide a framework for practice and future improvement of ePortfolio and open badge use. > *Leadership*

Capturing and Valuing Non Formal and Informal Learning; Higher Education can Support Learning Gained in Life
go.nmc.org/captur
(Phil O'Leary, ResearchGate, 31 May 2014.) This article describes the need to teach students to develop a habit of lifelong learning, so that they are self-aware in the skills and competencies they learn outside of a formal education environment. > *Practice*

Open Education Resources and the Rising Importance of Non-Formal and Informal Learning
go.nmc.org/iflatrend
(IFLA, accessed 4 January 2015) In a review of literature of social trends, IFLA highlighted that increasing use of OER will intensify the need for recognizing skills gained informally by learners. > *Practice*

Improving Digital Literacy

Solvable Challenge: Those that we understand and know how to solve

With the proliferation of the Internet, mobile devices, and other technologies that are now pervasive in education, the traditional view of literacy as the ability to read and write has expanded to encompass understanding digital tools and information. This new category of competence is affecting how education institutions address literacy issues in their curriculum objectives and teacher development programs. Lack of consensus on what comprises digital literacy is impeding many colleges and universities from formulating adequate policies and programs that address this challenge. Discussions among educators have included the idea of digital literacy as equating to competence with a wide range of digital tools for varied educational purposes, or as an indicator of having the ability to critically evaluate resources available on the web.[126] However, both definitions are broad and ambiguous. Compounding this issue is the notion that digital literacy encompasses skills that differ for educators and learners, as teaching with technology is inherently different from learning with it. Supporting digital literacy will require policies that both address digital fluency training in pre- and in-service teachers, along with the students they teach.

Overview

While this challenge is widespread in higher education, the 2015 Horizon Project Expert Panel recognized it as solvable as it has already been made actionable by local and national governments. In the UK, the Leicester City Council hosted a live panel to tackle this challenge, and set out to establish a common definition of digital literacy, characterizing it as a life-long practice that includes critical thinking about how the skills can be applied and used for social engagement.[127] A JISC consultant at the event stated that developing digital literacy in practice requires individual scaffolding and support along with helping learners as they manage conflict between practice and different contexts. As an example, a student's notion of what is considered referencing a resource versus plagiarizing it may differ from that of their university's official policy.

Researchers at Kennesaw State University recently published the paper "Unraveling the Digital Literacy Paradox: How Higher Education Fails at the Fourth Literacy," which critically examines the current landscape of this topic. They believe that an often-overlooked aspect of digital literacy is finding training techniques that prioritize creativity. Understanding how to use technologies is a key first step, but being able to leverage them for innovation is vital to fostering real transformation in higher education.[128] Current definitions of literacy only account for the gaining of new knowledge, skills, and attitudes, but do not include the deeper components of intention, reflection, and generativity. The addition of aptitude and creativity to the definition emphasizes that digital literacy is an iterative process that involves students learning about, interacting with, and then demonstrating or sharing their new knowledge.

Now that a deeper understanding of the topic is emerging, higher education institutions have recognized that in order to instill digital literacy in their students, they must better equip their faculty. While universities and colleges around the world have launched a number of professional development programs and centers, not all of them are entirely effective. *Campus Technology* cautions that programs with one-size-fits-all training approaches that assume all faculty are at the same level of digital literacy pose a higher risk of failure. The Director of the Center for Academic Technology at the University of the District of Columbia asserts that university leaders must first comprehend the wide spectrum of faculty IT needs before designing professional development opportunities. A data-driven approach that depicts faculty use of the university's technology can reveal patterns of their literacy and help leaders to identify areas for improvement.[129]

Implications for Policy, Leadership, or Practice

Governing bodies are developing guidelines for digital literacy to help students learn skills that will be critical to their success in the workplace. The Australian government recently established the Commonwealth Science Council,[130] chaired by the Prime Minister, to advise on science and technology issues and policies and help the education system produce workplace-ready graduates.[131] At a local government level, the Massachusetts Department of Education is designing "Digital Literacy and Computer Science Standards" with

an expert panel that consist of leaders in both K-12 and higher education.[132] Library organizations have also been instrumental in creating literacy standards. The Association of College & Research Libraries developed the "Information Literacy Competency Standards for Higher Education," which provide a framework to evaluate students' literacy levels, including their lower and higher order thinking skills.[133] Individual institutions are also creating their own standards. In the UK, The Open University designed the "Digital and Information Framework," and emphasizes the importance of students learning how to collaborate with technology.[134]

In order for educators to better integrate digital literacy into curricula, they must receive ongoing training. It requires substantial leadership to create effective programs that enable busy educators to take time to learn new skills. St. Mary's University of Texas, for example, institutionalized their faculty development structure, offering a yearlong program with ongoing follow-up workshops.[135] So far, this initiative has aided instructors in flipping their classrooms, incorporating mobile devices into their curriculum, and using video assessment. Additionally, the St. Mary's Faculty Institute includes roundtable discussions with the students to get a better sense of their digital literacy and technology use.[136] Through Arcadia University, teachers have the opportunity to pursue a Certificate in Digital Literacy, which focuses on integrating technology into innovative pedagogies.[137]

Solving this challenge also calls for better digital literacy support for students. Cornell University developed the public "Digital Literacy Resources" to help their student body become more adept at creating media-centric presentations, conducting research, understanding intellectual property rights, and more.[138] As part of their Mobile Development Bachelor's Degree plan, Full Sail University offers a digital literacy course, teaching students to leverage digital tools in order to navigate, evaluate, create, and critically apply information.[139] Many graduate programs are also increasingly emphasizing the importance of digital literacy. Medical students at the University of California-Irvine, for example, can enroll in "Health 2.0 + Digital Literacy" to learn about trends in healthcare technology and social media.[140] Content from the course has been made freely available in a special collection in iTunes U.[141]

For Further Reading

The following resources are recommended for those who wish to learn more about improving digital literacy:

JISC Developing Digital Literacies Infokit
go.nmc.org/diglit
(Northumbria University, 6 March 2014.) JISC has created a set of practical guidelines, tools, and approaches to digital literacy, examining both the 'top down' strategic considerations involved in developing digital literacies across an institution, as well as an 'on the ground' view of what this means in practice. > *Policy*

The Digital Literacies Working Group
go.nmc.org/digil
(University of Liverpool, accessed 7 January 2015.) The Digital Literacies Working Group at the University of Liverpool facilitates projects and activities that encourage students and faculty to explore the capabilities that an individual needs to live, learn, and work in a digital society. > *Leadership*

Journal of Digital and Media Literacy (JoDML)
go.nmc.org/jod
(Sarah Williams et al, *JoDML*, 15 December 2014.) *JoDML* is an academic, peer-reviewed journal that seeks to examine the ways people use technology to create, sustain, and impact communities on local, national, and global levels. > *Leadership*

Tools of Engagement Project (TOEP)
go.nmc.org/toep
(The State University of New York, accessed 7 January 2015.) The TOEP community launched by the State University of New York provides a safe and supportive environment for faculty to work alongside peers in understanding, using, and reflecting on how emerging technology tools impact the ways we collaborate and communicate. > *Leadership*

20 Things Educators Need To Know About Digital Literacy Skills
go.nmc.org/exce
(Saga Briggs, *Innovation Excellence*, 12 August 2014.) This article describes some practices that can have a negative impact on cultivating digital literacy as well as habits that naturally promote the understanding and leveraging of technology. > *Practice*

Grand Valley State University Technology Showcase
go.nmc.org/gvsu
(Grand Valley State University, accessed 12 January 2015.) The Information Technology department at Grand Valley State University created an open technology showcase to immerse faculty, staff, and students in discovering how emerging technologies can enhance teaching and learning. > *Practice*

Personalizing Learning

Difficult Challenge: Those that we understand but for which solutions are elusive

Personalized learning refers to the range of educational programs, learning experiences, instructional approaches, and academic-support strategies intended to address the specific learning needs, interests, aspirations, or cultural backgrounds of individual students.[142] While there is a demand for personalized learning, it is not adequately supported by current technology or practices. The increasing focus on customizing instruction to meet students' unique needs is driving the development of new technologies that provide more learner choice and allow for differentiated instruction. Advances such as online learning environments and adaptive learning technologies make it possible to support a learner's individual learning path. The biggest barrier to personalized learning, however, is that scientific, data-driven approaches to effectively facilitate personalization have only recently begun to emerge; learning analytics, for example, is still evolving and gaining traction within higher education.

Overview

The goal of personalized learning is to enable students to determine the strategy and pace at which they learn. Though effective personalized learning strategies focus on the learner and not the technology, personalized learning may significantly draw on enabling technologies and tools. The underlying technologies needed to support personalized learning are relatively straightforward and readily available. For example, a person's smartphone or tablet and their personal collection of apps directly represents their assortment of interests. Universities are taking advantage of mobile technology to meet students where they are to offer tailored educational content and tools. The University of Texas System, for example, is creating a mobile-first stack of technology services called TEx (Total Educational Experience) for use in STEM and medical science courses in order to improve completion rates in areas of high employment demand.[143]

Education researchers have emphasized the need for learning settings to be adaptable and flexible in order for personalized learning to take root. Students' preferences and needs must be understood accurately before designing or implementing personalized learning scenarios and activities. The goal is to give the student the flexibility to make their learning as effective and efficient as possible, but adequate mentorship is still a clear necessity.[144] Enabling technology, such as E2Coach, is helping to address this challenge of inadequate support for faculty in high-enrollment introductory science courses at the University of Michigan. The E2Coach web application delivers customized student websites and pushes out personalized messages about course content, advice on study methods and resources, and reminders. An evaluation on the effectiveness of this personalized learning tool found that users of the service performed better academically than nonusers by a notable amount.[145]

While the benefits of personalized learning are becoming increasingly clear, there is still debate on what defines personalized learning and an unwillingness of some faculty to embrace new technological advancements — some are concerned that the use of automated software for tutoring is of lesser quality than traditional college approaches.[146] There is also a lack of research on the effectiveness of personalized learning in higher education. The assessments that exist are primarily in the K-12 arena and offer words of caution. A recently released report by the National Education Policy Center found that personalized instruction shows mixed results ranging from modest impacts to no impact at all in K-12 settings.[147]

Implications for Policy, Leadership, or Practice

While scalable methods and concepts will take some time to refine, there is considerable consensus among government, policymakers, funders, and higher education leaders of the growing importance of personalized learning. The Association of Public and Land-grant Universities (APLU), in coordination with the Coalition of Urban Serving Universities, has awarded grants to seven universities including Florida International University, Georgia State University, University of Akron, and others, to improve student success through different personalized learning strategies. University of Akron, for example, is investigating how to measure, assess, and credential what students learn on their own, on the job, or at the university — by using modularized course content, students can test out of certain concepts, accelerating

the time needed to graduate. The findings from these different projects are being shared beyond the cohort to more than 200 public universities in the APLU, helping to create greater awareness of best practices in this emerging field for action in the policy arena.[148]

Early research conducted through Carnegie Mellon University's Open Learning Initiative revealed that the intelligent tutoring characteristic of adaptive learning environments proved almost as effective as one-on-one human tutors.[149] For the past few years, the Bill & Melinda Gates Foundation has been leading the charge in the field of adaptive learning. In 2012, they announced that they would be allocating $9 million in grants to support breakthrough learning models, specifically investing in several organizations and institutions that were developing adaptive learning solutions.[150] Later that year, they established a Personal Learning Network, consisting of leaders at more than one dozen universities, colleges, and university systems in an effort to advance the field of adaptive learning by launching research initiatives and incubating pilot programs.[151]

Innovations in personalizing the consumer experience are now being harnessed for higher education, fulfilling the role of academic advisor and recommender service. One such example is the SHERPA at Saddleback College. The SHERPA software uses the types of algorithms found in recommender services of Netflix and Amazon to personalize course enrollment. Student preferences, schedules, and courses help to create individual profiles that respond to their individual needs. For instance, if a student enters their work schedule and they encounter a class that is full, SHERPA suggests other classes that are open at an individual's preferred times.[152] Similarly, the bX Recommender being used at Flinders University in Australia is a resource that offers students article suggestions based on their individual area of interest. The service takes an article a researcher is viewing and displays a list of relevant articles that were accessed by other users of the platform.[153]

For Further Reading

The following resources are recommended for those who wish to learn more about personalizing learning:

Career Pathways Explained: A Strategy to Help Workers and Employers Meet Today's Job Skill Demands
go.nmc.org/pathway
(Center for Law and Social Policy, 2014.) This article describes how personalized career pathways and systems can integrate four functions: quality education and training, consistent and non-duplicative assessments of assets and needs, support services and career navigation assistance, and employment services and work experiences. > *Policy*

Innovations in Personalized Learning
go.nmc.org/personalised
(Criterion Conferences, accessed 5 January 2015.) The Innovations in Personalized Learning Conference in Australia brought together higher education educators to discuss emerging technologies, learning environments, and online delivery models that support more personalized learning experiences. > *Leadership*

Personalized Learning Strategies for Higher Education
go.nmc.org/aut
(Mike Keppell, Australian Digital Futures Institute, accessed 4 January 2015.) This excerpt describes personalized learning as consisting of six broad concepts: digital citizenship, seamless learning, learner engagement, learning-oriented assessment, life-long and life-wide learning, and desire paths. > *Leadership*

The University of Texas System Makes Bold Move into Competency-Based Education
go.nmc.org/utcbe
(Jenny LaCoste-Caputo and Karen Adler, The University of Texas System, 3 November 2014.) The University of Texas is launching a statewide personalized, competency-based education program offered in flexible online and hybrid options that allow learners to start as early as high school and progress through post-graduate studies.
> *Leadership*

FlexPath
go.nmc.org/flexp
(Capella University, accessed 4 January 2015.) Capella University's FlexPath is a self-paced competency-based learning option that allows students to gain a degree by paying a flat tuition rate each quarter and progressing through content without preset deadlines. > *Practice*

Personalized Learning Changes Everything
go.nmc.org/umpi
(The Univerity of Maine at Presque Isle, accessed 4 January 2015.) The University of Maine at Presque Isle's proficiency-based learning approach allows students to choose how they learn best and progress at their own speed, demonstrating their knowledge regardless of whether the learning takes place online, in the classroom, or through an off-campus internship. > *Practice*

Teaching Complex Thinking

Difficult Challenge: Those that we understand but for which solutions are elusive

In today's world, higher-order thinking is not only a valuable skill, but necessary for understanding and solving complex, real world problems. Equally important is the ability to communicate complex information surrounding global dilemmas in ways that are accessible to the general public. In the age of big data, conditions are optimal for developing new research processes to examine systems and our environment in greater depth. Massive quantities of data traverse the Internet every day, and many sectors are tapping into these myriad data sets to decipher and resolve complex issues. As a result, demand for data specialists is expected to rise by 243% over the next five years in the UK alone, according to SAS.[154] In this environment, institutions have a responsibility to prepare learners to take advantage of the latest tools and techniques to help them tackle complex problems and influence systemic change through their mode of communication. Other emerging technologies including semantic web and modeling software, among other innovations, are contributing to the experimental conditions that have the potential to train learners in complex and systems thinking.

Overview

The term "complex thinking" refers to the ability to understand complexity, or to comprehend how systems work in order to solve problems.[155] Complex thinking is the application of systems thinking, which is the capacity to decipher how individual components work together as part of a whole, dynamic unit that creates patterns over time.[156] Computational thinking is another higher-order thinking skill that complements complex thinking, and it entails logical analysis and organization of data; modeling, abstractions, and simulations; and identifying, testing, and implementing possible solutions.[157] Emphasis on these approaches in education is helping equip learners with essential skills for deciphering the real-world systems and solving complex problems on a global scale. The difficulty in this challenge is in introducing complex thinking to students that have not yet had exposure to these modes of problem-solving along with related communication techniques.

Making complex ideas digestible for students has become easier with the use of innovative approaches such as data visualization, also referred to as infographics, a form of visual communication that coveys a succinct narrative. This method of data analysis and presentation has moved beyond the sciences to a more mainstream platform — journalism. Data journalism is an emerging field that leverages data visualization and engaging infographics to tell compelling stories, and the Open Knowledge Foundation and the European Journalism Centre who partnered to produce *The Data Journalism Handbook* in 2011 have formalized its use.[158] With over 70 contributors sourced from universities and media firms from around the world, *The Data Journalism Handbook* includes chapters about the symbiotic relationship between journalists and coders, the various methods of gathering and presenting data, as well as a range of case studies to support this mode of storytelling.

Creating compelling presentations is also becoming more important to scientists and researchers at universities, as they are increasingly expected to be able to communicate their findings and connect with the public. A growing number of universities have established programs that are focused on developing young scientists in this area. Typically guided by an artistic director or acting coach, learners are taught improvisational techniques that encourage relaxed communication and positive attitudes about failure. The Alan Alda Center for Communicating Science at Stony Brook University has pioneered instruction in this area. Located within the Stony Brook School of Journalism, the project has been helping young scientists deliver on their responsibility of sharing the meaning and implications of their work since 2009.[159]

Implications for Policy, Leadership, or Practice

Encouraging complex thinking and communication is challenging because educators have only just started articulating this multifaceted need in higher education. PBS's Media Shift coordinated educators from University of Miami, Columbia University, Temple University, University of Wisconsin-Madison, and technology contributors from *The New York Times* to discuss the rising importance of integrating data visualization into journalism education.[160] Via a Twitter-mediated discussion, these leaders touched on the power of visualization to reveal patterns that are shrouded in complexity and data. Commentators also remarked

on data visualization's ability to convey complex relationships to the public that are not possible through traditional forms of reporting. Dialogs like this are paving the way for policies in support of integrating complex thinking and communication into core activities.

Much of the difficulty of this challenge lies in the diversity and intricacy of the skills it entails, which means there is no one-size-fits-all solution. Some institutions, however, are developing specialized schools of thought to address complex problem-solving and systemic change. In 2012, Stanford University's Hasso Plattner Institute of Design launched the d.school fellowship program, which invites burgeoning and experienced professionals to learn formal design-thinking processes as they develop human-centric solutions that influence systems-level impact in their areas of expertise. Supported by instruction and resources from Stanford and Silicon Valley, the fellows represent a diverse group of multidisciplinary thinkers with strong communication skills. Among the 2014-15 d.school fellows are journalists, artists, educators, and public servants that have developed prototypes for innovative organizational models they intend to reinforce through systems and design-thinking processes.[161]

Some departmental leaders are emphasizing communication as an integral skill for scientists, and have made significant progress on this front for their institutions. Robert Bazell, a molecular, cellular, and developmental virology professor at Yale University was instrumental in the development and implementation of a novel, four-course program at his institution for postdoctoral and graduate students in the sciences that focus on presentation and public speaking. Bazell, the former chief science and health correspondent for NBC News, said that he was intent on starting the program to develop Yale's emerging scientists as competent communicators.[162] Focused on improvisation and acting games, the sessions have earned positive feedback from the students who have expressed their satisfaction with gaining newfound perspectives and understanding of their fields.

For Further Reading

The following resources are recommended for those who wish to learn more about teaching complex thinking:

Thinking Chair
go.nmc.org/chair
(Colleen Flaherty, *Inside Higher Ed*, 16 September 2014.) RIT has developed an endowed chair to promote critical thinking. This person works closely with faculty to bring them together across disciplines around addressing issues with and better incorporating applied critical thinking. > *Policy*

The National Council for Excellence in Critical Thinking
go.nmc.org/ncect
(Critical Thinking, accessed 5 January 2015.) The National Council for Excellence in Critical Thinking seeks to articulate, preserve, and foster intellectual standards in critical thinking research, scholarship, and instruction by disseminating information that aids educators and others in identifying quality critical thinking programs and approaches. > *Leadership*

Natural Born Engineers
go.nmc.org/born
(Kate Parker, *E&T*, 22 October 2014.) Examining studies from around the world on the role of habits of mind in education systems, the Centre for Real-World Learning developed six engineering habits of mind: systems thinking, problem-finding, visualizing, improving, creative problem-solving, and adapting. > *Leadership*

The Persuasive Power of Data Visualization
go.nmc.org/nyviz
(Anshul Vikram Pandey et al., New York University Public Law and Legal Theory Working Papers, July 2014.) A group of researchers from New York University School of Law studied data visualization as a communication tool to answer the question: "Does graphical depiction of data have a more persuasive effect than textual or tabular information?" > *Practice*

PhD Candidate Makes Complex Scientific Research Sound Simple
go.nmc.org/tomlin
(Paula Katinas, *Brooklyn Daily Eagle*, 21 April 2014.) A young scientist won the National FameLab USA competition, a contest that challenges students to present their research in a way that can be easily understood by the general public. > *Practice*

UW Interactive Data Lab
go.nmc.org/idl
(University of Washington, accessed 5 January 2015.) Faculty and students at the University of Washington's Interactive Data Lab design new interactive systems for data visualization and analysis for domains ranging from large-scale text analysis to population genomics.
> *Practice*

Why Systems Thinking Is the Next Step in Sustainability
go.nmc.org/sysinc
(Maureen Kline, *Inc.*, 23 October 2014.) An expert in corporate sustainability and social responsibility writes about the "fourth wave" in sustainability — systems thinking — an approach that frames problems and solutions in terms of systems, which rely on cooperation and coordination to effect dramatic change. > *Practice*

Competing Models of Education

Wicked Challenge: Those that are complex to even define, much less address

New models of education are bringing unprecedented competition to the traditional models of higher education where students typically receive instruction by faculty or teaching assistants per credit hour over four years, on-campus. Across the board, institutions are looking for ways to provide a high quality of service and more learning opportunities at lower costs.[163] While massive open online courses are at the forefront of these discussions, a range of adult learning programs are creating innovative models that emphasize human interaction and multidimensional learning by cultivating 21st century skills such as intercultural communication and social entrepreneurship.[164] Additionally, competency-based education, which tracks student skills instead of credit hours, is emerging to disrupt existing credit-hour systems.[165] As these new platforms arise, there is a growing need to frankly evaluate the models and determine how to best support collaboration, interaction, and assessment at scale. It is clear that simply capitalizing on new technology is not enough; the new models must use these tools and services to engage students on a deeper level.

Overview

With free and low-cost, high-quality content accessible via the Internet, both formal and informal online learning is becoming increasingly widespread, which some fear could dampen the appeal of traditional higher education degrees and institutions. MOOCs have surfaced as one of the highest profile examples of a competing model. While MOOCs have experienced a meteoric rise followed by skepticism, experts believe that they will continue to be a potent disruptive technology that will jeopardize the futures of many inefficient universities. The rising cost of private and public university tuition is compounding this challenge, making students rethink the value of a traditional college education across the globe.[166] New models that provide both the opportunity to save money and progress more quickly through degree programs will become increasingly sought after.[167]

Interest in competency-based degree programs, which allow for more flexible and personalized degree options, is on the rise. According to EDUCAUSE, competency-based education provides academic credit for the mastery of clearly defined competencies, and it leverages the potential of online learning by saving students time and money.[168] Northern Arizona University is one of a handful of online competency-based programs that enables students to earn degrees through self-paced modules and assessment rather than in traditional semester-long programs. Capella University also offers FlexPath degree programs for Business, Information Technology, and Psychology. FlexPath is a style of learning that allows students to work at their own pace and spend more time working through new and challenging material by recognizing knowledge already gained on the job.[169] The appeal of these more flexible models is how the degrees are earned — as direct-assessment degrees, students receive competencies rather than credits. Along with their credit equivalencies, students must pass a summative assessment that is based on their learning portfolio.[170]

Experimentation using alternative models of learning is beginning to increase in both size and type to address challenges related to high costs, deficient student engagement, and unsatisfactory student graduation rates in higher education.[171] Three examples include Northeastern University's cooperative education courses that offer on-the-job experience,[172] Western Governors University competency-based education that involves the combination of expertise in both industry knowledge and academics,[173] and Florida College System's meta-majors or pathways that are a collection of related content aligned with potential academic and career goals.[174] Critics caution that there is a need to examine these new approaches through a critical lens to ensure they are effective and provide long-term benefits equivalent to a traditional higher education experience.[175]

Implications for Policy, Leadership, or Practice

Competition from new pedagogies is not likely to foster widespread change unless there is regulatory reform in the political arena. While the general sentiment is that the US federal government has been primarily hands-off, existing regulatory barriers such as accreditation, state authorization regulations for distance learning, and federal financial aid eligibility rules still favor traditional institutions of higher education. In the US, recent actions

by the President and US Department of Education in redefining the credit hour to include amount of work represented by learning outcomes is a step forward, helping foster the growth of these innovative approaches.[176] While there is a more supportive environment in the US, there is concern in India that over-regulation is stifling innovation and impeding the growth of online courses there. Government leaders there cite that ensuring quality control is the main obstacle, while businesses such as Coursera argue that MOOCs should be embraced and allowed to flourish because they do a better job at preparing students for the workforce.[177]

Increasing workforce preparedness has been cited as one of the forces encouraging more innovative pedagogical models, and projects such as Liverpool John Moores University's World of Work program is serving as a leader in this area. As one of the UK's new generation universities, the research university stresses work-related learning and skill development through the involvement of business experts from leading organizations such as Airbus, Ford Europe, and Sony. Students develop a set of skills that are verified through an employer-approved Skills Statement and interview during the course of their studies. Quest University in Canada is a lauded example of how institutions are engaging students at a deeper level. During the first two years of study, students complete the same foundational courses in a seminar-discussion format then select individual learning paths based on their personal interests and passion. There are no grades or lectures at Quest University; instead students receive check marks to indicate they are engaged in their learning.[178]

Online learning is helping to facilitate entire new areas of focus and growth beyond MOOCs at global higher education institutions. Minerva University, for example, is a radically different university that focuses on key skill building in various cities instead of information transferring on a single campus. The university recently took in its first cohort of 33 students from different parts of the world — they do not take classes, but engage in intensive interactive online seminars. Students begin their journey their first year in California, then spend each semester in a different city around the world where they use the cities' infrastructures to explore and create their own university experiences.[179] Creating a new model that reduces geographical barriers and exposes students to global issues is also the focus of the work of Aga Khan University and University of Toronto. They have recently begun using blended learning strategies to connect students from different backgrounds and expose them to challenges facing the global health community.[180]

For Further Reading

The following resources are recommended for those who wish to learn more about competing models of education:

Are We Ready for Innovation? A Bold New Model for Higher Education
go.nmc.org/bold
(Mohammad H. Qayoumi et al., San Jose University, accessed 6 January 2015.) San Jose State has proposed a framework that universities can use to transform their undergraduate education offerings in ways that adapt to the modern educational landscape. > *Policy*

Universities of Art and Design Adapt to Show the Value of Their Degrees
go.nmc.org/value
(Rosanna Tamburri, *University Affairs*, 29 October 2014.) In response to pressures from the job market and to prove their degrees are valuable, many universities of art and design are evolving to combine other disciplines into their programs like engineering, business, science, and research. > *Policy*

Is Minerva University Redefining 21st Century Education?
go.nmc.org/experience
(Laju Arenyeka, *All Africa*, 7 November 2014.) Minerva University is a new model of higher education that offers intensive, interactive seminars in a virtual environment. The students spend each semester in a different part of the world, and at the end of their four-year degree will have experienced living in at least seven different cities. > *Leadership*

Students Explore New Models of Higher Education with Dean Pritchett
go.nmc.org/pritch
(University of Pennsylvania Law School, 8 December 2014.) The University of Pennsylvania Law School created a course called "New Models for Post-Secondary Education" in which students examine and confront challenges to earning a degree by exploring alternative educational models. > *Leadership*

What MOOCs Are Teaching Universities About Active Learning
go.nmc.org/mteach
(*MindShift*, 30 October 2014.) While MOOCs have yet to replace expensive college degrees, the edX CEO maintains that MOOCs have made a powerful impact on the higher education environment by inspiring new approaches to learning such as the flipped classroom. > *Practice*

Rewarding Teaching

Wicked Challenge: Those that are complex to even define, much less address

Teaching is often rated lower than research in academia. In the global education marketplace, a university's status is largely determined on the quantity and quality of its research. In the Times Higher Education's World University Rankings methodology, an institution's research influence is the single most influential indicator out of their 13 criteria.[181] There is an overarching sense in the academic world that research credentials are a more valuable asset than talent and skill as an instructor. Because of this way of thinking, efforts to implement effective pedagogies are lacking. Adjunct professors and students feel the brunt of this challenge, as teaching-only contracts are underrated and underpaid, and learners are subject to the outdated teaching styles of the university's primary researchers. Overemphasis on research has caused a number of negative ramifications, including an excessive dependence on part-time faculty, which has diminished mobility within higher education, complicating the dilemma even further.[182]

Overview

It is largely understood that when university administrators are considering candidates for tenured, full-time positions, extent of research is weighted more heavily than student evaluations or effectiveness of instruction.[183] This is the result of a higher education system in which funding and prestige are derived from an institution's scholarly imprint, which has created an inhospitable environment for educators who like to teach.[184] *The Guardian* explored this dilemma in the context of the EU where universities are competing to earn funding from the Research Excellence Framework (REF), an initiative of the UK government that will provide funding to institutions with outstanding rankings. Because of REF, universities are putting pressure on faculty to publish research, invoking negative reactions among professors and teaching fellows who believe that quality of instruction is undervalued.[185]

One of the effects of this wicked challenge is that reliance on part-time faculty has increased substantially, but this is not necessarily a benefit for adjunct instructors. More and more American universities are favoring part-time employment over long-term, tenured positions.[186] A 2014 report by the American Association of University Professors showed that adjunct professors comprise 76.4% of US faculty across institutions, from liberal arts colleges to research universities to community colleges.[187] This challenge has engendered a struggle for teachers in higher education. *The Atlantic* recently covered a labor movement that has coalesced as more part-time professors find themselves living below the poverty line and working between several colleges. The affected instructors are calling for systemic change that will allow them mobility in higher education, which requires time, space, and resources to develop as educators and scholars.

The roots of this issue are interwoven with past trends in university funding, which have generated a host of negative consequences. According to Jeffrey Selingo, author of *College (Un)Bound: The Future of Higher Education and What It Means for Students*, changes in hiring practices have been caused by shifting priorities of university administrators.[188] As the competition among colleges in the US grows fiercer, universities have focused funding on improving student services and amenities over improving teaching and learning within the classroom. Moreover, in a recent commentary for *The Chronicle on Higher Education*, Selingo points to this "mission creep" as a result of institutions trying to gain prestige by inflating their degree offerings to justify increases in tuition and the hiring of more administration. These funding trends have affected students at regional public colleges the most because they are expected to pay more for a mediocre graduate experience that fails to live up to the quality of its associated flagship research university.[189]

Implications for Policy, Leadership, or Practice

Acknowledgement of the issue at a national level has offered a starting point for addressing this complex issue. The EU has recognized this multifaceted dilemma in the 2013 "Report to the European Commission on Improving the Quality of Teaching and Learning in Europe's Higher Education Institutions," which laid out three main points of this challenge: the need to prioritize teaching and learning over research, the importance of training faculty members to teach at a first-rate standard, and for policymakers and thought leaders to push institutions of higher education to reevaluate their missions so that teaching is a keystone.[190] The Australian government

has also recognized the quality of learning experiences in higher education by allocating grant funds from their 2014-2015 Department of Education and Training Budget to the Promotion of Excellence in Learning and Teaching in Higher Education.[191]

There are a number of institutions that have taken the lead in improving and prioritizing the quality of instruction. At the Eberly Center for Teaching Excellence and Educational Innovation, professors at Carnegie Mellon University are selected for the Spotlight on Innovative Teaching, a semester-long period of recognition where they host workshops to impart their techniques to other educators.[192] In Canada, administrators at York University plan to hire over 200 faculty members that will be teaching-focused. While the workload balance between research and instruction is more even in Canadian higher education, administrations have justified the need to create more teaching-centered positions, especially in regional public universities rather than flagship research institutions. It is important to point out that for Canadian universities, teaching-focused faculty are offered comparable pay, benefits, and tenure.[193]

Overemphasis on research can be corrected within the classroom, through the use of more effective pedagogies, which are often adopted at the departmental level. At The University of Texas, instructors in the Department of Mathematics have turned to inquiry-based learning (IBL) to help students become active generators of mathematical concepts instead of passive consumers of lectures. Since their initial success with Number Theory, the department now employs IBL across a range of mathematics courses.[194] Similarly, the flipped classroom promotes hands-on learning and interaction during class, and has been adopted by faculty at the Department of Electrical and Computer Engineering (ECE) at the University of Utah. In discussing the hype surrounding this method of instruction, an ECE educator commented that the flipped classroom is simply an application of technology that enables high-quality teaching practices.[195]

For Further Reading

The following resources are recommended for those who wish to learn more about rewarding teaching:

Faculty Not On Tenure Track Rises Steadily Over Past 4 Decades
go.nmc.org/strike
(*NPR*, 20 February 2014.) A faculty strike canceled classes at the University of Illinois at Chicago. Tenure track, non-tenure track, and contingent faculty all stood together to push for contingent faculty members who are full-timers to have their pay increased. > *Policy*

Student Outcomes Assessment Among the New Non-Tenure-Track Faculty Majority
go.nmc.org/outcomes
(Adrianna Kezar and Daniel Maxey, Learning Outcome Assessment, July 2014.) This paper presents three current courses of action for campus leaders to consider that would allow them to foster more robust assessment models to support the work of today's faculty and improve conditions facing non-tenure-track faculty. > *Policy*

The Wal-Mart-ization of Higher Education: How Young Professors are Getting Screwed
go.nmc.org/walmart
(Keith Hoeller, *Salon*, 16 February 2014.) This article highlights that 75% of all college professors in the US teach off the tenure track. Thus the academic two-tier system must change so that it includes rewards and recognition for non-tenure track educators instead of only the tenured. > *Policy*

The Core
go.nmc.org/core
(University of Oklahoma, accessed 8 January 2015.) The University of Oklahoma created an Active Learning Faculty Fellows program in which professors are awarded a stipend for their participation and paired with an active learning mentor to assist with transitioning an existing course into an outstanding example of an innovative, team-based active learning class. > *Leadership*

Rewarding Creative Curriculum
go.nmc.org/creacurr
(Brendan Cosgrove, Northwestern University, 19 May 2014.) Northwestern University recently awarded two professors a $12,500 grant cosponsored by the Alumnae of Northwestern University and the Office of the Provost that will support the development of their innovative course ideas. > *Leadership*

I Used to Be a Good Teacher
go.nmc.org/usedto
(Alice Umber, *Chronicle Vitae*, 20 August 2014.) In this article an adjunct professor explains why she gave up the tenure track and the difficulties that have come with that decision. > *Practice*

Important Developments in Educational Technology for Higher Education

Each of the six developments in educational technology detailed in this section were selected by the project's expert panel using the Horizon Project's Delphi-based process of iterative rounds of study, discussion, and voting. In the NMC Horizon Project, educational technology is defined in a broad sense as tools and resources that are used to improve teaching, learning, and creative inquiry. While many of the technologies considered were not developed for the sole purpose of education, they have clear applications in the field.

The technologies, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories — near-term technologies that are expected to achieve widespread adoption in one year or less; mid-term technologies that will take two to three years; and far-term technologies, which are forecasted to enter the mainstream of education within four to five years. Each technology topic opens with an overview of the topic.

The initial list of topics considered by the expert panel was arranged into categories that were based on the primary origin and use of the technology. The potential applications of the technologies featured, specifically in the context of global higher education, were considered in a series of online discussions that can be viewed at horizon.wiki.nmc.org/Horizon+Topics.

The expert panel was provided with an extensive set of background materials when the project began that identified and documented a range of existing technologies used in both education and beyond. The panel was also encouraged to consider emerging technologies whose applications for higher education institutions may still be distant. A key criterion for the inclusion of a new technology in this edition was its potential relevance to teaching, learning, and creative inquiry in higher education.

In the first round of voting, the expert group reduced the master set, shown on the next page, to 12 technologies that were then researched in much greater depth by the NMC staff. Each was then written up in the format of the *NMC Horizon Report* and used to inform the final round of voting. Technologies that do not make the interim results or the final report are often thoroughly discussed on the project wiki at horizon.wiki.nmc.org. Sometimes a candidate technology does not get voted in because the expert panel believes it is already in widespread use in higher education, or, in other cases, they believe the technology is more than five years away from widespread adoption. Some technologies, while intriguing, do not have enough credible project examples to substantiate them.

There are currently seven categories of technologies, tools, and strategies for their use that the NMC monitors continuously. These are not a closed set, but rather are intended to provide a way to illustrate and organize emerging technologies into pathways of development that are or may be relevant to learning and creative inquiry. The list of seven categories has proven fairly consistent, but new technologies are added within these categories in almost every research cycle; others are merged or updated. Collectively, the categories serve as lenses for thinking about innovation; each is defined below.

> **Consumer technologies** are tools created for recreational and professional purposes and were not designed, at least initially, for educational use — though they may serve well as learning aids and be quite adaptable for use in universities and colleges. These technologies find their ways into institutions because people are using them at home or in other settings.

> **Digital strategies** are not so much technologies as they are ways of using devices and software to enrich teaching and learning, whether inside or outside of the classroom. Effective digital strategies can be used in both formal and informal learning; what makes them interesting is that they transcend conventional ideas to create something that feels new, meaningful, and 21st century.

> **Enabling technologies** are those technologies that have the potential to transform what we expect of our devices and tools. The link to learning in this category is less easy to make, but this group of technologies is where substantive technological innovation begins to be visible. Enabling technologies expand the reach of our tools, make them more capable and useful, and often easier to use as well.

- **Internet technologies** include techniques and essential infrastructure that help to make the technologies underlying how we interact with the network more transparent, less obtrusive, and easier to use.
- **Learning technologies** include both tools and resources developed expressly for the education sector, as well as pathways of development that may include tools adapted from other purposes that are matched with strategies to make them useful for learning. These include technologies that are changing the landscape of learning, whether formal or informal, by making it more accessible and personalized.
- **Social media technologies** could have been subsumed under the consumer technology category, but they have become so ever-present and so widely used in every part of society that they have been elevated to their own category. As well established as social media is, it continues to evolve at a rapid pace, with new ideas, tools, and developments coming online constantly.
- **Visualization technologies** run the gamut from simple infographics to complex forms of visual data analysis. What they have in common is that they tap the brain's inherent ability to rapidly process visual information, identify patterns, and sense order in complex situations. These technologies are a growing cluster of tools and processes for mining large data sets, exploring dynamic processes, and generally making the complex simple.

The following pages provide a discussion of the six technologies highlighted by the 2015 Higher Education Expert Panel, who agree that they have the potential to foster real changes in education, particularly in the development of progressive pedagogies and learning strategies; the organization of teachers' work; and the arrangement and delivery of content. As such, each section includes an overview of the technology; a discussion of its relevance to teaching, learning, or creative inquiry; and curated project examples and recommendations for further reading.

Consumer Technologies
- 3D Video
- Drones
- Electronic Publishing
- Mobile Apps
- Quantified Self
- Tablet Computing
- Telepresence
- Wearable Technology

Digital Strategies
- Bring Your Own Device (BYOD)
- Flipped Classroom
- Games and Gamification
- Location Intelligence
- Makerspaces
- Preservation/Conservation Technologies

Internet Technologies
- Cloud Computing
- The Internet of Things
- Real-Time Translation
- Semantic Applications
- Single Sign-On
- Syndication Tools

Learning Technologies
- Badges/Microcredit
- Learning Analytics
- Massive Open Online Courses
- Mobile Learning
- Online Learning
- Open Content
- Open Licensing
- Virtual and Remote Laboratories

Social Media Technologies
- Collaborative Environments
- Collective Intelligence
- Crowdfunding
- Crowdsourcing
- Digital Identity
- Social Networks
- Tacit Intelligence

Visualization Technologies
- 3D Printing/Rapid Prototyping
- Augmented Reality
- Information Visualization
- Visual Data Analysis
- Volumetric and Holographic Displays

Enabling Technologies
- Affective Computing
- Cellular Networks
- Electrovibration
- Flexible Displays
- Geolocation
- Location-Based Services
- Machine Learning
- Mesh Networks
- Mobile Broadband
- Natural User Interfaces
- Near Field Communication
- Next-Generation Batteries
- Open Hardware
- Speech-to-Speech Translation
- Statistical Machine Translation
- Virtual Assistants
- Wireless Power

Bring Your Own Device (BYOD)

Time-to-Adoption Horizon: One Year or Less

BYOD, also referred to as BYOT (Bring Your Own Technology), refers to the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to the learning or work environment. Intel coined the term in 2009, when the company observed that an increasing number of its employees were using their own devices and connecting them to the corporate network. Since implementing BYOD policies, the company has reported up to 5 million hours of annual productivity gains, a statistic that is compelling many other companies to consider BYOD.[196] In higher education, the BYOD movement addresses the same reality; many students are entering the classroom with their own devices, which they use to connect to the institutions' networks. While BYOD policies have been shown to reduce overall technology spending, they are gaining traction more so because they reflect the contemporary lifestyle and way of working. A 2013 Cisco Partner Network Study found that BYOD practices are becoming more common across industries, particularly in education; over 95% of educators surveyed responded that they use their own device for work purposes.[197] Although higher education institutions have cited IT security concerns, technology gap issues, and platform neutrality as challenges to the uptake of this technology, a growing number of models in practice are paving the way for BYOD to enter the mainstream.

Overview

The link between the use of personal devices and increases in productivity gets stronger each passing year as more organizations adopt BYOD policies. The integration of personal smartphones, tablets, and PCs into the workflow supports an on-the-go mentality, changing the nature of work and learning activities so that they can happen anywhere, at anytime. Employers and higher education institutions are finding that when given the opportunity to choose their device, users are saved from the effort and time needed to get accustomed to new devices and can therefore accomplish tasks with more ease and efficiency. A recent study by Gartner predicted that by 2017, half of the world's employers will expect their employees to supply their own device for work.[198]

Adoption of BYOD policy into the corporate sphere has provided a model for educational contexts, and the practice is gaining acceptance in universities and colleges all over the world. The latest "College Explorer" study from re:fuel reveals that on average, college students spend more than 3.5 hours per day using their mobile phones,[199] and *Information Week* reports that students own an average of 2.7 devices.[200] Using this technology has become an essential part of the learning process; a study at California State University found that students could only engage in educational activities for six minutes before turning to their devices for support.[201] Devices have become the gateways to personal working and learning environments that facilitate the exploration of new subjects at a pace that is unique to each learner.

BYOD proponents at Griffith University in Australia cite personal mobile device use as a way for students to engage with learning material more effectively; they have instant access to more resources to gain a better understanding of the subjects at hand.[202] The BYOD movement is enabling students to learn using the technology with which they are already familiar and comfortable. Universities and colleges are following suit as a Bradford Network Study revealed that 85% of the responding educational institutions allow faculty and students to use their own devices on campus, and 52% said that those devices are being integrated into the class experience.[203] However, discussions around the topic have raised concerns regarding a digital divide — some pundits caution that BYOD could alienate students who cannot afford the latest technologies. To alleviate this issue, several institutions purchase tablets for all students who need them, including Bethel University, Seton Hill University, and Illinois Institute of Technology.[204] Södertörn University in Sweden provides 13,000 students and 850 staff with access to both PCs and Macs.[205]

Relevance for Teaching, Learning, or Creative Inquiry

For higher education institutions, often BYOD is less about the devices and more about the personalized content that users have loaded onto them. Rarely do two devices share the same content or settings, and BYOD enables students and educators to leverage the tools that make them most efficient. In many cases, their devices are already populated with productivity apps,

such as Skitch[206] and iTunes U,[207] helping them to better organize their notes, syllabi, and schedules on campus and beyond. Furthermore, instructors can leverage this mobile device use by implementing polling and other interactive features during class. At Manchester Medical School, students use iPads during class to annotate instructors' slides, record lectures, take notes, and create mind maps to illustrate their understanding of complex topics. Students are also able to share documents with each other more easily through the Dropbox app.[208] In a do-it-yourself manner, biology students at Missouri University of Science and Technology are using their smartphones, along with cheap plywood, Plexiglass, and LED laser pointers to design their own microscopes to use for lab work.[209]

Higher education institutions are increasingly updating their IT infrastructures to accommodate BYOD policies. University College London, for example, is home to a dedicated IT service desk that helps connect students to their wireless network, Eduroam.[210] However, one of the inherent challenges in the growing BYOD trend is facilitating learning environments that are device-agnostic; when students have the flexibility to use the technology of their choosing, sufficient infrastructure must be in place to support devices of all kinds. University CTOs are being tasked with forging solutions. In an article from *Higher Ed Tech Decisions*, campus IT experts provided critical tips for success, including the need for more radio waves within the wireless access points and focusing on devising BYOD policies well ahead of deployment.[211]

EDUCAUSE has published BYOD considerations for higher education, emphasizing best practices for secure networks, systems, and sensitive data. The CIO of Roche Diagnostics asserts that creating effective BYOD policy is less about the technology and more about understanding and anticipating the needs and behaviors of students and faculty.[212] In 2014, the University of Scranton published their BYOD strategy, which outlined their plans for students to access virtual laboratories through their mobile devices. Additionally, they believe implementing BYOD will foster better hybrid learning models, allowing faculty and students to both capture and access lectures online. University of Scranton leaders assert that BYOD policies will also impact the physical environment of the classroom, and that rigid furniture should be replaced with more flexible workspaces to accommodate the collaboration that mobile apps and other features promote.[213]

Bring Your Own Device in Practice

The following links provide examples of BYOD in use that have direct implications for higher education settings:

Managing the BYOD Program at Broward College
go.nmc.org/ster
Broward College in Florida has successfully managed their BYOD at a large scale. They currently have an estimated 20,000 personally and college-owned devices on the network. > *Leadership*

BYOD at King's College London
go.nmc.org/kin
King's College London implemented a private cloud platform that allows students and faculty from 150 countries to use their own devices to access a virtual desktop. > *Practice*

Scalable Collaborative Learning Spaces at Pitt
go.nmc.org/scal
The University of Pittsburgh is constructing three innovative classrooms that will serve as models for future learning spaces, featuring technologies that enable students and instructors to use their own mobile devices to wirelessly and securely share documents, collaborate on projects, and display content in the rooms. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about BYOD:

Preparing for the BYOD Invasion on Your Campus
go.nmc.org/inv
(Frank Andrus, *University Business*, January 2014.) This list of guidelines describes how universities can prepare for BYOD while balancing critical security needs by conducting an in-depth analysis of network visibility and security, creating a policy that enables remote registration and guest access, and communicating that policy effectively. > *Policy*

Bring Everything: BYOD's Evolution in Higher Education
go.nmc.org/helman
(Brian Helman, *Information Week*, 28 February 2014.) A university technologist describes how campus wireless infrastructure has been challenged to meet the needs of students that are connecting more than just laptops and smartphones to their campus network. > *Leadership*

How Can We Get the Best Devices into HigherEd BYOD Classrooms?
go.nmc.org/howcan
(*Edcetera*, 11 February 2014.) This list of dos and don'ts aims to help teachers, administrators and IT staff as they guide students in bringing the best devices to class.
> *Practice*

Flipped Classroom

Time-to-Adoption Horizon: One Year or Less

The flipped classroom refers to a model of learning that rearranges how time is spent both in and out of class to shift the ownership of learning from the educators to the students. In the flipped classroom model, valuable class time is devoted to higher cognitive, more active, project-based learning where students work together to solve local or global challenges — or other real-world applications — to gain a deeper understanding of the subject. Rather than the instructor using class time to dispense information, that work is done by each student after class, and could take the form of watching video lectures, listening to podcasts, perusing enhanced e-book content, or collaborating with peers in online communities.[214] Students access the online tools and resources any time they need them. Faculty can then devote more time to interacting with each individual. After class, students manage the content they use, the pace and style of learning, and the ways in which they demonstrate their knowledge; the instructor adapts instructional and collaborative approaches to suit their learning needs and personal learning journeys.

Overview

The flipped classroom model is part of a larger pedagogical movement that overlaps with blended learning, inquiry-based learning, and other instructional approaches and tools that are meant to be flexible, active, and more engaging for students. The first well-documented example of the flipped classroom was in 2007 when two chemistry teachers at Woodland Park High School in Colorado wanted to address the issue of students missing class when they were traveling to and from school activities. Students were struggling to keep up with their work. The teachers experimented with using screen capture software and PowerPoint to record live lessons and post them on YouTube. They immediately observed a dramatic change in the classroom: the focus shifted to increasing interactions and fostering deeper connections between them and their students, as well as between students.[215]

Eight years after the first iteration of flipped learning, educators all over the world have successfully adopted the model. Whereas many learning technology trends first take off in higher education before seeing applications in schools, the flipped classroom reflects an opposite trajectory. Today, many universities and colleges are increasingly embracing this approach. Flipped learning is seen as especially suited for higher education because the rearranging of class time gives students in large introductory lecture courses more opportunity to engage and interact with their peers. Instructors also make more efficient use of their time by focusing on content that is especially challenging for students — handheld clickers in large seminars are often paired with this method in order to help understand students' comprehension of material and customize discussions accordingly.[216]

The flipped classroom is seeing its most widespread use in the US. The Center for Digital Education's survey of higher education instructors found that 29% of faculty were using the flipped classroom and another 27% said they planned to use it within a year.[217] Cultural differences may contribute to the lack of mainstream adoption worldwide. In the report, "The Flipped Classroom: Viewpoints in Asian Universities," researchers claim that Western and Eastern differences in learning styles may explain why the model is still in infancy in Asian countries. The flipped classroom requires a lot of autonomous work, which may be disorienting to students who prefer to rely on the teacher as the leading source of information.[218]

Relevance for Teaching, Learning, or Creative Inquiry

The flipped classroom can invoke a broad spectrum of implementation — from an instructor integrating several minutes of hands-on learning in exchange for less lecture time to designing an entire course where content is delivered through video lectures or pre-class readings, with class time used solely for group work activities. To help both researchers and practitioners make sense of this vast landscape, there is a growing array of resources available. The Flipped Learning Network is an organization working to help define and differentiate flipped learning approaches by providing an analysis of research studies, archived webinars, examples of instructor videos, and more.[219] Additionally, at the institution level, Cornell University's Center for Teaching Excellence provides resources on their website that detail how instructors can flip their classroom, what

types of learning and assessment opportunities can be accomplished, and who to contact on campus to consult on flipping a particular course.[220]

Beyond watching recorded video lectures, other technologies such as e-books with collaborative annotation and discussion software enable instructors to be more in tune with their students' learning patterns. By reviewing the comments and questions that students pose online, instructors can better prepare for class and address particularly challenging ideas. The learning environment transforms into a dynamic and more social space where students can participate in critiques or work through problems in teams. A Columbia University biochemistry professor flipped his large lecture course because of the troubling number of students who came to class unprepared. His strategy was to create weekly PowerPoint presentations paired with screen-recording software ScreenFlow and post them to YouTube and his learning management system. Using embedded quizzes, he could ensure that the students would come to class ready to engage in livelier discussions.[221]

While there is little national research on the effectiveness of the flipped classroom model as compared with traditional lectures, there are several experiments underway that are helping to establish a valuable baseline. Villanova University piloted four flipped introductory engineering classes in 2013 that were so successful that they ran eight additional flipped classes in the fall of 2014. Students in the bottom third performed on average seven percentage points better than their counterparts in a traditional classroom.[222] Faculty at Harvey Mudd College are currently in the second year of a four-year controlled study comparing active learning lecture classes in flipped classrooms in engineering and math courses. While preliminary results show no significant difference in learning, metacognitive, or affective gains, students reported preferring the flipped classroom model because they had access to lectures online and could replay sections they did not understand. While class subject might be a factor in the success of the project, more data is needed to verify this hypothesis.[223]

Flipped Classroom in Practice

The following links provide examples of the flipped classroom in use that have direct implications for higher education settings:

SwinEcho Lecture Recording
go.nmc.org/swinech
Swinburne University has implemented Echo360 across the campus to automate lecture capture and deliver the recordings into the relevant unit within the Learning Management System. > *Policy*

Flipped and Blended Learning Course
go.nmc.org/ubcflipped
The University of British Columbia created a course on flipped learning that outlines teaching philosophies aligned with the model and explores four case studies. The course provides three discussion activities to promote dialog between educators on the utility of the approaches. > *Leadership*

Collaborative Lecture Annotation System (CLAS)
go.nmc.org/clas
CLAS is a social annotation technology being developed at the University of South Australia to allow students to annotate lecture videos, giving instructors the ability to identify group areas of convergence or divergence, and allowing students to assess and organize their learning. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the flipped classroom:

BU Collaboration and Network Enhanced Course Transformations
go.nmc.org/bucon
(Boston University, accessed 8 January 2015.) Boston University has developed and begun implementing a new flipped course model that depends on building local, collaborative learning communities of faculty, graduate, and undergraduate students in departments and colleges. > *Policy*

A Novel Integration of Online and Flipped Classroom Instructional Models in Public Health Higher Education
go.nmc.org/fliphealth
(Galway et al., *BMC Medical Education*, 2014.) This paper describes an analysis of flipping a master's level Environmental and Occupational Health course at a Canadian University. Students in the flipped course rated their course experience more highly and reported positive learning experiences and an increase in self-perceived knowledge. > *Practice*

The Promise of the Flipped Classroom in Higher Education
go.nmc.org/prom
(Tanya Roscoria, Center for Digital Education, 27 May 2014.) A chemistry lecturer at Ohio State University has been flipping his classroom for the past two and a half years, and is now revising his model by leveraging the Learning Catalytics response system to increase classroom interaction. > *Practice*

Makerspaces

Time-to-Adoption Horizon: Two to Three Years

The turn of the 21st century has signaled a shift in what types of skillsets have real, applicable value in a rapidly advancing world. In this landscape, creativity, design, and engineering are making their way to the forefront of educational considerations, as tools such as 3D printers, robotics, and 3D modeling web-based applications become accessible to more people. Proponents of makerspaces for education highlight the benefit of engaging learners in creative, higher-order problem solving through hands-on design, construction, and iteration.[224] The question of how to renovate or repurpose classrooms to address the needs of the future is being answered through the concept of makerspaces, or workshops that offer tools and the learning experiences needed to help people carry out their ideas. Makerspaces are intended to appeal to people of all ages, and are founded on openness to experiment, iterate, and create. The driving force behind makerspaces is rooted in the maker movement, a following comprised of artists, tech enthusiasts, engineers, builders, tinkerers, and anyone else with a passion for making things.[225] The foundation of the maker movement was built on the success of the Maker Faire, a gathering that launched in 2006 and has since propagated itself into numerous community-driven events all over the world.[226]

Overview

Makerspaces, also referred to as hackerspaces, hack labs, or fab labs, are community-oriented workshops where tech enthusiasts meet regularly to share and explore electronic hardware, manufacturing tools, and programming techniques and tricks.[227] Much of the hype around this cultural trend burgeoned around 3D MakerBot printers, a rapid-prototyping technology that requires a DIY mentality to assemble, operate, and replicate it.[228] Other tools that are commonly found in makerspaces include laser cutters, soldering irons, Legos, Arduinos and Raspberry Pi computers, and circuitry gadgets, among others. Whatever the supplies, the overarching goal of a makerspace is to be a place where people are free to experiment and make things, on their own, and as part of a productive community.

Widespread enthusiasm behind makerspaces is steadily growing. Dale Dougherty, the CEO of Maker Media, Editor of *Make* magazine, and creator of Maker Faire, is a major advocate of installing makerspaces into learning environments and has been helping put the concept at the forefront of national discussions. This year, the White House hosted its first ever Maker Faire, leading President Obama to publicly highlight the power of DIY to revolutionize American manufacturing and stoke innovation and job growth.[229] During a recent talk at ISTE 2014, Dougherty related his experience of bringing the Maker Faire to the White House, and described "making" as a universal language of learning and discovery.[230] Dougherty continues to educate the public about makerspaces and maker culture in schools, college campuses, and communities everywhere.

Makerspaces are becoming a more relevant part of cultural and economic discussions, and universities are taking notice. Florida Polytechnic University, a STEM-focused college and new school of the State University System of Florida, recently partnered with MakerBot 3D Printing. Its inaugural class is already benefitting from the Innovation, Science, and Technology building, a state-of-the art facility that is home to the Rapid Application Development (RAD) makerspace, which is equipped with 55 MakerBot 3D Printers and Scanners.[231] The Plymouth College of Art administration has entered a partnership with Europe's leading fab labs as part of the Made@EU project in order to design a program of workshops and residencies that will facilitate exchange of ideas across borders. In the Fab Lab Plymouth, students and members of the community can freely access 3D printers and scanners, CNC milling machines, a CNC router, a laser cutter, and a vinyl cutter.[232]

Relevance for Teaching, Learning, or Creative Inquiry

Institutions are taking advantage of makerspaces to provide students and faculty a place that is integrated into the community to do their tinkering. Sierra College in Rocklin has partnered with the Hacker Lab of Sacramento, California to open a co-working makerspace that offers office space at accessible month-to-month rates. The Sierra Joint Community College District President commented that the makerspace's downtown location makes it more accessible to members of the community beyond the university, including local start-ups and small businesses.[233] In a similar agreement, the

Nova Scotia College of Art & Design (NSCAD) worked with the Halifax Makerspace to create a place on campus that can be accessed by the entire community.[234] Located in the NSCAD Institute for Applied Creativity on the Halifax Seaport, the makerspace invites students, faculty, retired people, high schoolers, and everyone in between to enjoy the space and take advantage of a room full of tools.[235]

A growing number of universities have established makerspaces as interdisciplinary hubs where students can experiment with computer-assisted design (CAD) software and invent products. At the University of Nairobi's Science and Technology Park, a first-year electrical engineering student has invented and prototyped a 3D printed device that will help doctors place intravenous needles accurately on infant children. The student carried out this process in the university's fab lab, which is one of three in Kenya.[236] A Turkish design student created an award-winning 3D printed lightweight cast called The Osteoid that incorporates an ultrasound system to stimulate bone growth.[237]

Substantial discussions are taking place about how makerspaces can bolster not only science and engineering departments, but media and journalism schools as well. *PBS EducationShift* interviewed faculty members from higher education institutions that are creating makerspaces to support the production of digital media and other storytelling activities. Currently, West Virginia University is in the process of designing the Media and Innovation Center that will feature a makerspace, a digital storytelling lab, spaces for collaboration, and an augmented reality studio. Houston Community College is working on a similar project, the West Houston Institute, which is a dedicated building that will have active learning classrooms and support for media production. These makerspaces share the common goal of being a collaborative workspace where learners from every discipline can feel comfortable learning skills outside of the curriculum and engage in meaningful learning.[238]

Makerspaces in Practice

The following links provide examples of makerspaces in use that have direct implications for higher education settings:

Higher Education Maker Summit
go.nmc.org/makesum
Arizona State University held a Maker Summit to explore how to infuse elements of making into existing degree programs, develop local makerspaces, integrate making into the admission process, and expand university access to local makers. > *Leadership*

Brennan by Design
go.nmc.org/bren
A Harvard professor has evolved her classroom into an open, inviting environment that engages students in inquiry and creativity. The maker space/lab has replaced what was once a traditional lecture hall. > *Practice*

Digital Media Commons Design Labs
go.nmc.org/deslab
The University of Michigan's Design Labs allow students to bridge disciplines as they collaborate on projects. Student content experts serve as consultants who can help guide research and learning activities as well as prototyping. > *Practice*

The Garage
go.nmc.org/gara
At the USC Jimmy Iovine and Andre Young Academy, a space called the Garage serves as a unique environment that promotes enhanced student creation via advanced design and prototyping technologies, in addition to industry mentors who help students realize their ideas for new products. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about makerspaces:

Learning by Making: Agency by Design and the Rise of Maker-Centered Education
go.nmc.org/agen
(Bari Walsh, Harvard Graduate School of Education, 7 October 2014.) Agency by Design, a multi-year research initiative at the Harvard Graduate School of Education's Project Zero, is investigating how a maker-centered approach to learning can help develop students' sense of competency or agency. > *Leadership*

Remaking Higher Education: The Maker Lab at Abilene Christian University
go.nmc.org/rema
(John B. Weaver, Ideas Lab, 13 January 2014.) Abilene Christian University built a Maker Lab to spur a constructionist and student-led teaching and learning approach. The main contribution of the Maker Lab is not necessarily the tools and technology, but the community of makers that is focused on sharing expertise and resources in the pursuit of building skills and making things. > *Leadership*

The Maker Movement and the Humanities: Giving Students A Larger Toolbox
go.nmc.org/humaker
(Ashley Champagne, *The Huffington Post*, 18 December 2014.) This article underscores that makerspaces, though often tightly tied to STEM departments, are also an integral part of liberal arts education. > *Practice*

Wearable Technology

Time-to-Adoption Horizon: Two to Three Years

Wearable technology refers to computer-based devices that can be worn by users, taking the form of an accessory such as jewelry, eyewear, or even actual items of clothing such as shoes or a jacket. The benefit of wearable technology is that it can conveniently integrate tools that track sleep, movement, location, and social media interactions or it can enable virtual reality. There are even new classes of devices that are seamlessly integrated with a user's everyday life and movements. Google Glass is one of the best known, enabling users to see information about their surroundings displayed in front of them. Smart watches from Samsung, Sony, and Pebble are already allowing users to check emails and perform other productive tasks through a tiny interface. A rapidly growing category of wearable technology takes advantage of the burgeoning interest in the "quantified self." Jawbone, Nike, and Fitbit bracelets are three product examples accounting for 97% of all smartphone-enabled tracker sales that monitor how people eat, sleep, and move.[239] Empowered by these insights, many individuals now rely on these technologies to improve their lifestyle and health. Today's wearables not only track where a person goes, what they do, and how much time they spend doing it, but now what their aspirations are and when those can be accomplished.

Overview

Wearable technology is not a new category; one of the most popular early incarnations of the technology was HP's calculator watch, which was introduced in the 1980s.[240] Since then, the field has advanced significantly, but the overarching theme behind the technology remains the same — convenience. Portable, lightweight, and often taking the place of an accessory that the user already has, wearable tools are meant to go anywhere. Effective wearable devices become an extension of the person wearing them, allowing them to comfortably engage in everyday activities, such as checking and responding to emails and other tasks that help instructors and students to stay productive on-the-go.

Wearable technology is poised to see significant growth in the coming years, spurring experimentation in higher education because the demand for wearables is seen to be coming in large part from college-aged students; a recent poll showed that 21% of US adult students use wearables. Further, another report by GlobalWebIndex revealed that 71% of students ages 16 to 24 want to use wearable technology such as smart watches, wristbands, or glasses.[241] The global wearable technology market as a whole is expected to grow at a compound annual rate of 35% over the next five years primarily dominated by Apple and Google, who already comprise 90% of the mobile platform market. While North America and Europe are the largest players in the global market, Asia is expected to show increased growth rates over the next several years.[242]

A notable recent advancement in wearable technology involves the release of the Oculus Rift and its capability of providing virtual reality through goggles. YouVisit has adapted over 1,000 virtual college tours so they can be viewed on Oculus Rift headsets. Stony Brook University in New York and University of New Haven in Connecticut, for example, plan to implement this wearable technology into their marketing efforts. Virtual tours will allow students to go into campus spaces not typically open to visitors.[243] The Oculus Rift headset is also enabling students to explore potentially dangerous situations from the safety of the classroom. One virtual education expert has created a virtual construction worksite where engineering students can identify unsafe areas without exposure to harm. Health care research and training continues to advance the potential of wearable technology, as well. The Medical Virtual Reality group at the University of Southern California has developed simulations for wearable technology use for clinical purposes.[244] One of their projects focuses on medical training under simulated battlefield conditions.[245]

Relevance for Teaching, Learning, or Creative Inquiry

Google Glass' ability to display information in a hands-free format, enable communication via voice command, and broadcast and record student training activities is giving medical school leaders the confidence to begin integrating it into their degree programs. Students are gaining an unprecedented first-person perspective, learning medical procedures from a faculty member or becoming more empathetic by taking a patient's point of view. The University of California Irvine School of

Medicine is incorporating Google Glass into its degree program, from first- and second-year anatomy courses to third- and fourth-year hospital rotations.[246] Similarly, SUNY Cobleskill is piloting the use of Google Glass devices to show how instructors perform paramedic or animal hoof health procedures.[247] Beyond medical training, Google Glass is seeing applications in other fields. At University of Wisconsin-Madison, a finance professor is using it to record himself grading assignments. By verbalizing the grading process, students are able to get personalized feedback that would otherwise be lost.[248]

The number of new wearable devices in the consumer sector seems to be increasing daily, greatly outpacing the implementation of this technology in universities. The higher education sector is just beginning to experiment with wearable technologies, though potential applications for athletic and health-related uses are already being realized. Most fitness sensors that are currently available can only measure a person's pace or their heart rate, but recent innovations are adding the dimension of chemical information analysis. Researchers at University of California San Diego, for example, are creating disposable and embeddable sensors to analyze a person's perspiration and saliva to improve fitness, wellness, and performance.[249] The University of Michigan is also developing a vapor sensor that can help monitor the health of patients with diabetes and lung disease as well as detect airborne chemicals. This monitoring system can be extended to the laboratory by registering the presence of hazardous chemical leaks and alerting students of danger.[250]

While universities continue to experiment with wearable technologies and formally integrate them into educational settings, there is increased activity in university research departments where they are pushing the boundaries to provide a foundation for future wearables. In New Zealand, two University of Canterbury psychology and engineering researchers are joining forces to examine ways to make wearable technology systems easier to use. Their goal is to create an interface with sensors, data storage, and memory, to minimize distractions so a user is more in tune with their physical surroundings while composing and sending a text or email.[251] The University of Surrey and University of Oldenburg are leveraging wearable technology so that researchers can gather data on brain behavior in real-time during real world activities. By using new electroencephalography (EEG) systems worn by participants doing everyday activities outside of traditional laboratory settings, researchers hope to understand brain structures, functions, and processes.[252]

Wearable Technology in Practice

The following links provide examples of wearable technology in use that have direct implications for higher education:

E-Textile/Wearable Education Incubator
go.nmc.org/etextile
The E-Textile/Wearable Research Team at New Jersey City University is exploring educational applications of wearable technology and e-textiles. They are working to build technical capacity among non-technical educators to teach with e-textile kits. > *Leadership*

Intel's Make It Wearable Challenge
go.nmc.org/miw
Intel's Make It Wearable Challenge — part-competition, part-entrepreneurial mentorship program — challenged thousands of global participants to inspire the next big idea in wearable technology. > *Leadership*

Google Glass at WSU Library System
go.nmc.org/wayne
Wayne State University Libraries recently created their first custom app for Google Glass called "Wayne State Campus Explorer," which provides users information on their surroundings as they wander through campus.
> *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about wearable technology:

Imagining the Classroom of 2016, Empowered by Wearable Technology
go.nmc.org/empower
(Rick Delgado, *Emerging EdTech*, 20 April 2014.) A technologist envisions applications of wearable devices in learning environments, such as creating instructional videos. He also advises that university leaders will need to begin factoring in wearable technology for BYOD policies. > *Policy*

Google Glass Infographic
go.nmc.org/glassmight
(Open Colleges Australia, accessed 12 January 2014.) This interactive infographic explores the potential of Google Glass in education for activities including documenting learning, more natural and easily integrated scheduling, and remote teaching and interaction. > *Practice*

What Does Wearable Computing Mean for Education?
go.nmc.org/wearab
(Ben Stern, *EduMusings*, 7 January 2014.) Wearables can provide real-world contexts and enable learning to occur anywhere and anytime. Companies are developing apps for wearable devices that allow students to demonstrate their learning. > *Practice*

Adaptive Learning Technologies

Time-to-Adoption Horizon: Four to Five Years

Adaptive learning technologies refer to software and online platforms that adjust to individual students' needs as they learn. According to a paper commissioned by the Bill & Melinda Gates Foundation and authored by Education Growth Advisors, adaptive learning is a "sophisticated, data-driven, and in some cases, nonlinear approach to instruction and remediation, adjusting to a learner's interactions and demonstrated performance level, and subsequently anticipating what types of content and resources learners need at a specific point in time to make progress."[253] In this sense, contemporary educational tools are now capable of learning the way people learn; enabled by machine learning technologies, they can adapt to each student's progress and adjust content in real-time or provide customized exercises when they need it. In higher education, many faculty envision these adaptive platforms as new, patient tutors that can provide personalized instruction on a large scale. There are two levels to adaptive learning technologies — the first platform reacts to individual user data and adapts instructional material accordingly, while the second leverages aggregated data across a large sample of users for insights into the design and adaptation of curricula.

Overview

The emergence of adaptive learning technologies reflects a movement in academia towards customizing learning experiences for each individual. Governments and campuses across the globe are increasingly recognizing that the one-size-fits-all approach to teaching alienates students who are struggling with specific concepts — along with students who are grasping the material more quickly than their peers.[254] In higher education settings, especially in large, introductory courses, instructors rarely have the capacity to design curricula and lectures that uniquely cater to every student enrolled. Integrating personalized learning was cited as a difficult challenge in this report, and adaptive learning technologies provide one pathway for tailoring educational opportunities. While adaptive learning technologies are still at least four years away from widespread use in higher education, a number of studies highlight their potential for transforming traditional learning paradigms, and an important next step is developing standards and best practices.[255]

Adaptive learning is best suited to take place in hybrid and online learning environments, where student activities are conducted virtually and can be monitored by software and tracking applications. Historically categorized as intelligent tutoring, adaptive learning takes advantage of the latest developments in artificial intelligence to adjust to students' personal preferences.[256] At the most basic level, the adaptive component of the platforms involve algorithms that employ an "if this, then that" approach. More robust models entail algorithms that link specific concepts and skills from the course to how students are interacting with the material; a student, for example, may spend a disproportionate amount of time reading a single passage that summarizes String Theory, signaling the algorithm to serve up more resources for them to better comprehend the concept.

Upon collecting students' behavioral data, adaptive learning technologies often display data visualizations in the form of comprehensive dashboards that can be regularly monitored by instructors.[257] These dashboards are often viewable by students so they can gain a better understanding of their progress through the course as well as what habits and activities are helping them learn more effectively. Instructor dashboards present data on a granular level, identifying which students may be at risk of failing their courses with the goal of increasing student retention. On a broader level, adaptive learning dashboards can help faculty better evaluate the effectiveness of their course design by examining student data collectively and making comparisons across all courses.

Relevance for Teaching, Learning, or Creative Inquiry

While adaptive learning technologies have the potential to be a game-changer and foster more personalized learning for students while providing institutions with key insights about the effectiveness of their instruction, current applications in higher education have been mostly limited to research, development, and pilot programs,[258] justifying the topic's position on the far-term horizon. There is a growing host of companies entirely

dedicated to developing adaptive learning platforms, including Knewton,[259] Smart Sparrow,[260] and Cerego.[261] Some education leaders, however, have expressed a need for adaptive learning platforms that integrate smoothly into campus' existing learning management systems and courseware;[262] standalone products may be a bigger investment for higher education institutions because they often require state-of-the-art technology infrastructures.

Some universities are staying ahead of the curve and have developed their own adaptive learning platforms. This is especially the case in the for-profit education sector; in 2013, a patent was issued to the University of Phoenix for its adaptive learning platform "Academic Activity Stream" — a billion dollar investment.[263] "Academic Activity Stream" is similar in appearance and functionality to social networks, ranking information for students based on their unique interests, performance history, and learning objectives. Similarly, the University of Michigan created "Gradecraft," an online platform that encourages risk-taking and multiple pathways towards mastery as students progress through course material.[264] The "Gradecraft" environment is gamified, enabling students to see how their choices directly impact how well they absorb and demonstrate their understanding of new material as they move from level to level.[265]

In one of the most large scale applications of adaptive learning technologies, major educational publisher Pearson teamed up with adaptive learning provider Knewton to provide thousands of science and business students at Arizona State University (ASU) with access to MyLab, adaptive services that detect patterns of students' successes and failures with the course material and provide them with guidance accordingly.[266] The data collected depicts the amount of time students spend on specific elements of an online resource, such as video and text, in correlation with their exam performances and assignments. After discerning patterns in student behavior, MyLab recommends to each student tailored content that will further their knowledge of the subject.[267] Though initial results from the pilot were mixed, ASU reported that in many cases, instructors who were using MyLab more prominently experienced better outcomes. Preliminary findings indicated an 18% increase in pass rates, and a 47% decrease in ASU's student dropout rate.[268]

Adaptive Learning Technologies in Practice

The following links provide examples of adaptive learning technologies in use that have direct implications for higher education settings:

Enhancing a MOOC With Adaptive Learning
go.nmc.org/ulus
A math professor and instructional designer from The Ohio State University created an add-on for MOOCs called "MOOCulus" that is designed to feed students progressively harder questions based on previous answers while at the same time collecting vast amounts of data on learning patterns. > *Practice*

Flat World Education
go.nmc.org/flatm
Education content and software company Flat World Education partnered with Brandman University in California to offer an online, competency based business administration degree using deep adaptive learning technologies. > *Practice*

INTUITEL
go.nmc.org/intu
The INTUITEL system, funded by education partners from the European Union, responds to each learner, monitors their progress and behavior, combines these data with pedagogical and methodological knowledge, and then deduces optimal guidance and feedback. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about adaptive learning technologies:

Rethinking Higher Ed: A Case for Adaptive Learning
go.nmc.org/zimmer
(Tim Zimmer, *Forbes*, 22 October 2014.) A recent Gallup and *Inside Higher Ed* survey revealed that two out of three college and university presidents believes adaptive learning would positively impact higher education.
> *Leadership*

The Great Adaptive Learning Experiment
go.nmc.org/jwaters
(John K. Waters, *Campus Technology*, 16 April 2014.) Conclusions gathered from early adopters of adaptive learning technologies, including Arizona State University and Rio Salado College, have contributed to a growing body of research in support of adaptive learning.
> *Practice*

Learning to Adapt
go.nmc.org/alpop
(Paul Fain, *Inside Higher Ed*, 13 June 2014.) With many large institutions experimenting with adaptive learning, the author explores different conceptions of the term, from personalized learning to data-driven courseware.
> *Practice*

The Internet of Things

Time-to-Adoption Horizon: Four to Five Years

The Internet of Things (IoT) is a network of connected objects that link the physical world with the world of information through the web. When TCP/IPv6 launched in 2006, the new network expanded the capabilities of the Internet and enabled objects, sensors, and devices to be addressable and communicate across the Internet.[269] This augmented address space became particularly useful for automating industrial and manufacturing processes, enabling tracking technologies that monitor sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, and identification.[270] Embedded chips, sensors, or tiny processors attached to an object can transmit information about the object such as cost, age, temperature, color, pressure, or humidity to another smart device or piece of machinery. This networked connection allows remote management, status monitoring, tracking, and alerts if the objects they are attached to are in danger of being damaged or spoiled. On another level, IoT is being applied by municipal governments and education institutions that are using automation to streamline processes, leverage data, and promote sustainability.[271]

Overview

It is no longer far-fetched to envision a world where all people, objects, and devices are connected to act in concert, regardless of brand or vendor. This idea is also known as The Internet of Everything (IoE), which is comprised of machine-to-machine (M2M), machine-to-person, and person-to-person networked technologies. In this environment, sensors embedded on machines, people, and objects can capture events, which are sent through the IPv6 network to applications that create actionable information. Many consumers are already familiar with IoT through their experience with Nest, a next-generation thermostat that programs itself based on its surroundings and can be controlled via a smartphone.[272] On the industry side, M2M IoT technologies are being used to modernize railways, agricultural equipment, and construction machinery with real-time monitoring capabilities.[273] In the world where the Internet of Everything is realized, many choices and decisions will be automated, making life, and potentially learning, an efficient, streamlined experience.

Enabling technologies such as smart sensors and chips are all well understood, easily mass-produced, and inexpensive, and a number of universities are already incorporating IoT technologies on their campuses. At the College of the Holy Cross, sensors within the biology lab freezers send warning emails when temperatures need to be adjusted, and students doing laundry in their dormitories can check availability of washing machines via their smartphones.[274] Seeing potential for massive growth in this area and beyond, technology companies are setting their sights on realizing the potential for connected device technologies. After only a year of operation, Intel's Internet of Things business unit is expected to reach $2 billion a year in revenue with nearly 20 percent annual growth.[275] Currently, Intel provides energy management systems for clients in the commercial and industrial sector and equips cars with connected technology, although investments into wearables are on the horizon.[276]

On a more comprehensive scale, urban planners are designing cityscapes with connectivity in mind, embedding networks into major infrastructures including roads, intersections, and parking lots. In 2013, the mayor of Barcelona announced a 10-year plan that leverages IoE and a citywide wireless network to communicate with citizens, streamline operations, and conserve resources.[277] Investments in devices that remotely monitor water pressure and pipe leakage are saving an estimated $58 million, and networked streetlights are reducing annual maintenance costs by one-third.[278] The World Economic Forum (WEF) is keeping tabs on where the next smart city will pop up with the Networked Readiness Index (NRI), an assessment of 148 countries; in their *2014 Global Information Technology Report*, Singapore, Finland, and Sweden were ranked as the top three countries with a level of information and communication technologies that are developed enough to support IoE design.[279]

Relevance for Teaching, Learning, or Creative Inquiry

Use of IoT in educational environments is finally coming into focus as terms such as "hypersituation" are being coined to explain the potential of IoT in learning situations. Hypersituating is the ability to amplify knowledge based on the user's location. In other words,

learners that carry connected devices with them can benefit from a host of interdisciplinary information that is pushed to them from their surroundings. For instance, a learner exploring a city with a rich historical past can explore their environment through an architectural, political, or biological lens, depending on how the surroundings are equipped. IoT can also create an environment where learners are informed by crowdsourced contributions and observations from the community via networked objects.[280]

At the institutional level, Cisco Systems has laid out a four pillar vision for networked technologies that interweave people, processes, and data. For instruction, IoT in higher education takes the form of blended learning models that integrate personalized materials and formative assessment technologies that deliver instant feedback. In this landscape, students will have the ability to monitor their own environment and collect real-time data for further study. Similar to hypersituating, Cisco Systems also envisions a context-aware environment, where objects can communicate with students and vice versa to create relevant, interactive learning experiences.[281] Data gleaned from networked environments has been positioned as the great enabler of this scenario.[282] While IoT for higher education is a relatively new area for Cisco Systems, the company's CEO recently announced that their long-term strategy will focus efforts almost entirely on developing and creating networked environments for every sector.[283]

As understanding around this emerging technology develops, universities are taking advantage of opportunities to give learners greater insight into the power of IoT. In summer 2014, Internet2 and micro-car maker Innova UEV partnered to give Innova Dash electric smart cars to Colorado State University, University of Pittsburg, University of Washington, and the University of Wisconsin-Madison. Each of these institutions will be embarking on a sustainable research project, using vehicle sensor data to investigate a host of questions related to the effectiveness of public transportation, physiological effects on drivers, and gamification, among others. Ultimately, the institutions that were selected intend to use their research to promote sustainable practice and support initiatives to reduce energy consumption.[284]

The Internet of Things in Practice

The following links provide examples of the Internet of Things in use that have direct implications for higher education settings:

Internet of Things Hackathon in Brazil
go.nmc.org/javahack
SouJava and Oracle Technology Network organized a week-long hackathon for developers, students, and gamers in Brazil to create IoT projects using Raspberry Pi and Java. > *Leadership*

University of Wisconsin Internet of Things Lab
go.nmc.org/uwiot
The University of Wisconsin Internet of Things Lab is a campus hub for learning, research, and hands-on experimentation to discover and demonstrate applications of the Internet of Things. > *Practice*

No-Power Wi-Fi Connectivity Could Fuel Internet of Things Reality
go.nmc.org/radio
University of Washington engineers have designed a new communication system called Wi-Fi backscatter that uses radio frequency signals as a power source and reuses existing Wi-Fi infrastructure to provide Internet connectivity. > *Practice*

Cisco and Swinburne Team Up for 'Internet of Everything'
go.nmc.org/everything
Melbourne's Swinburne University of Technology and multinational networking giant Cisco have signed an agreement to collaborate on new research initiatives on the Internet of Things. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the Internet of Things:

How Universities Are Adapting To The Internet Of Things Revolution
go.nmc.org/iotrevolution
(*Forbes*, 14 April 2014.) This article explores how the academic world is leading the way in IoT innovation both in the classroom and through research. > *Leadership*

The Internet of Things Will Thrive by 2025
go.nmc.org/thrive
(Pew Research Center, 14 May 2014.) This report is an analysis of opinions about the likely expansion of the Internet of Things, covering over 1,600 responses that were offered when asked where the Internet of Things would stand by the year 2025. > *Practice*

Student Projects Apply 'Internet of Things' Principles in Sustainability and Product Design
go.nmc.org/iotdesign
(David Ongchoco, *The Huffington Post*, 31 December 2014.) University of Pennsylvania students are creating new products that integrate the power of data and Internet connectivity into everyday objects. > *Practice*

The 2015 Higher Education Expert Panel

Larry Johnson
Co-Principal Investigator
New Media Consortium
United States

Malcolm Brown
Co-Principal Investigator
EDUCAUSE Learning Initiative
United States

Samantha Adams Becker
Horizon Project Director
New Media Consortium
United States

Michele Cummins
Research Manager
New Media Consortium
United States

Veronica Diaz
Researcher
EDUCAUSE Learning Initiative
United States

Bryan Alexander
Bryan Alexander Consulting, LLC
United States

Kumiko Aoki
Open University of Japan
Japan

Armagan Ateskan
Bilkent University
Turkey

Helga Bechmann
Multimedia Kontor Hamburg GmbH
Germany

Michael Berman
California State University Channel Islands
United States

Melody Buckner
University of Arizona
United States

Daniel Burgos
Universidad Internacional de La Rioja
Spain

Joseph Cevetello
University of Southern California
United States

Jaime Chaire
Universidad da Vinci
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