NMC

Horizon Report > 2016 Higher Education Edition

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The *NMC Horizon Report: 2016 Higher Education Edition*
is a collaboration between The NEW MEDIA CONSORTIUM and The EDUCAUSE Learning Initiative, an EDUCAUSE Program.

The research behind the *NMC Horizon Report: 2016 Higher Education Edition* is jointly conducted by the New Media Consortium (NMC) and the EDUCAUSE Learning Initiative (ELI), an EDUCAUSE Program. The ELI's critical participation in the production of this report and their strong support for the NMC Horizon Project is gratefully acknowledged. To learn more about ELI, visit www.educause.edu/eli; to learn more about the NMC, visit www.nmc.org.

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Executive Summary

What is on the five-year horizon for higher education institutions? Which trends and technology developments 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 58 experts to produce the *NMC Horizon Report: 2016 Higher Education Edition*, in partnership with the EDUCAUSE Learning Initiative (ELI). This *NMC Horizon Report* series charts the five-year horizon for the impact of emerging technologies in colleges and universities across the globe. With more than 14 years of research and publications, it can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

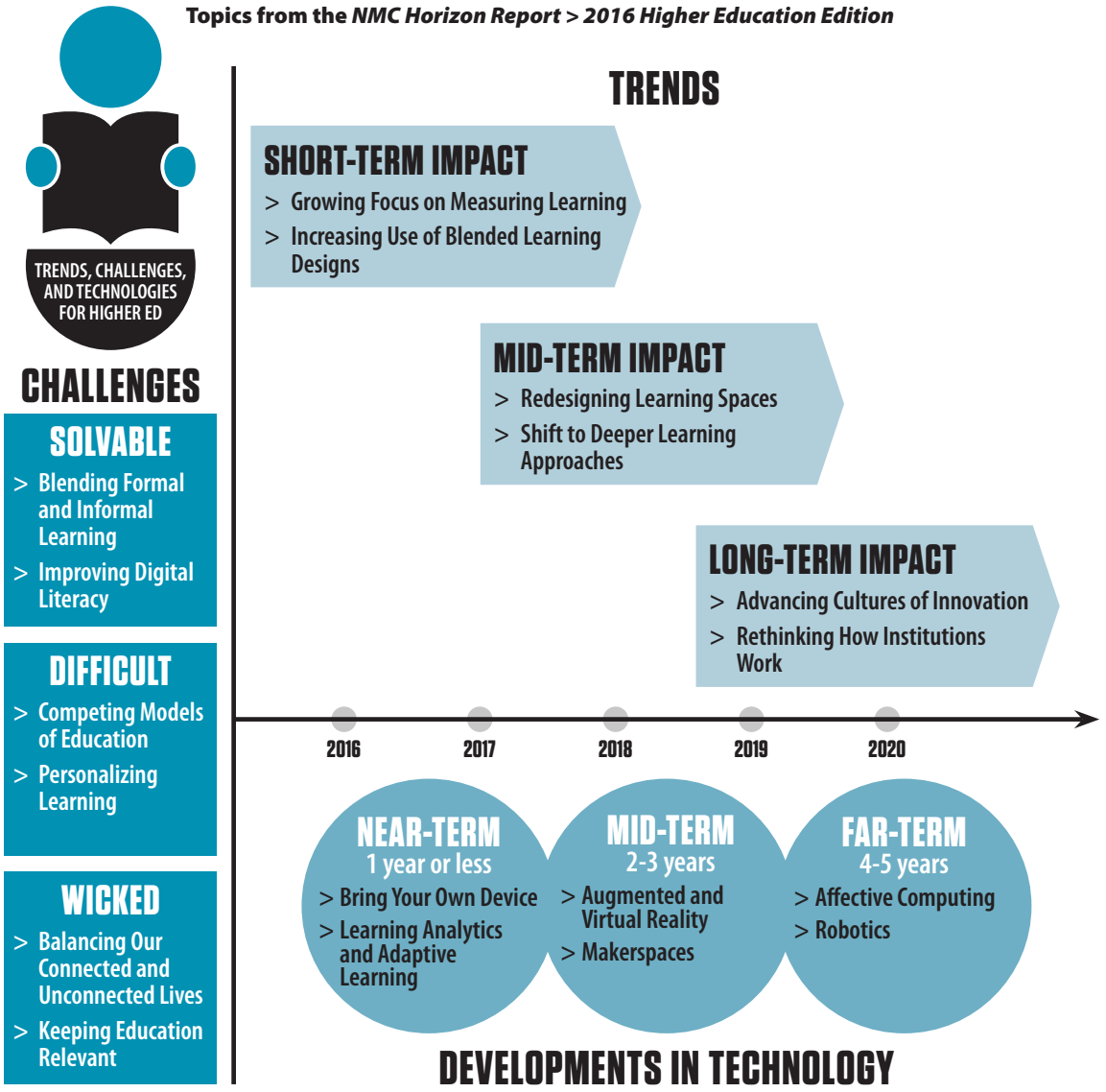
The experts agreed on two long-term impact trends: advancing cultures of innovation, as well as fundamentally rethinking how universities and colleges work. These are just two of the 18 topics analyzed in the *NMC Horizon Report: 2016 Higher Education Edition*, indicating the key trends, significant challenges, and important technological developments that are very likely to impact changes in higher education around the world over the next five years.

Regarding the major obstacles for higher education, blending formal and informal learning is considered one of the solvable challenges — one that is already being addressed by programs at individual institutions. Cork Institute of Technology in Ireland has long recognized non-formal and prior learning, integrating students' previous work and life experience into their curriculum designs.[1] Some universities are also finding creative ways to leverage informal resources into coursework; marketing students at Indiana University, for example, use Instagram to explore and share successful campaign ideas.[2] On the other hand, the experts identified balancing learners' connected and unconnected lives as a wicked challenge — one that is impossible to define, let alone solve. As educational technology is rapidly advancing and evolving, it is difficult to always discern when and how to properly implement it to foster real transformation.

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.

In view of the trends and challenges observed, the panel also signaled the technological developments that could support these drivers of innovation and change. Bring Your Own Device (BYOD), along with learning analytics and adaptive learning, are expected to be increasingly adopted by higher education institutions in one year's time or less to make use of mobile learning and student data that can be gathered through online learning environments. The time-to-adoption for augmented and virtual reality, along with makerspaces, is estimated within two to three years, while affective computing and robotics are expected to be more prominent in colleges and universities within four to five years.

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: 2016 Higher Education Edition* is presented.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Introduction

The *NMC Horizon Report: 2016 Higher Education Edition* was produced by the NMC in collaboration with the EDUCAUSE Learning Initiative (ELI). 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 important developments in technology likely to have a large impact over the coming five years in education around the globe.

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.

In the pages that follow, 18 topics carefully selected by the 2016 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 (2016-2020). 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 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 higher education-focused institutions and organizations. The inclusion of these three elements acknowledges that it takes a combination of governance, vision, and action to advance positive trends and surmount pressing challenges. Relevant readings and examples conclude each trend and challenge description to elaborate on the topics.

The responses from across the world to these drivers of and obstacles to change will ultimately determine the tools and digital strategies that comprise the third section of the report. Six important developments in technology poised to disrupt higher education are profiled and analyzed for their relevance to teaching, learning, and creative inquiry. Each technology development closes with an annotated list of suggested readings and additional examples that expand on the discussions in the report.

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The process used to research and create the *NMC Horizon Report: 2016 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 important developments in technology are examined for possible inclusion in the report for each edition before the expert panel selects the 18 topics profiled here.

Every report draws on the expertise of an international expert panel that first considers a broad set of important trends, challenges, and developments in educational technology, and then explores each of them in progressively more detail, reducing the set until

the final listing of trends, challenges, and technology developments 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: 2016 Higher Education Edition* can be found at horizon.wiki.nmc.org.

The panel was composed of 58 education and technology experts from 16 countries on five 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 topics will have a significant impact on the practice of higher education around the globe over the next five years.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over the now 14 years of producing the *NMC Horizon Report* series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, yet each member brings a relevant expertise. Over the years of the NMC Horizon Project research, nearly 2,000 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 and can be submitted at go.nmc.org/panel.

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 technology developments, trends and challenges, current research and reports, and more. Panelists 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. 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 panelists.

Following the review of the literature, the expert panel engages in the central focus of the process — the research questions that are at the core of the NMC Horizon Project. The group discusses existing applications and manifestations of trends, challenges, and technology developments while also brainstorming 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.

These research questions are designed to elicit a comprehensive listing of interesting technology developments, challenges, and trends from the panel:

1 Which of the important developments in educational technology catalogued in the NMC Horizon Project Listing will be most important to teaching, learning, or creative inquiry for higher education within the next five years?

2 What important developments in educational technology are missing from our list? Consider these related questions:

- **What would you list among the established developments in technology that some institutions are using today that arguably all higher education 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 developments in technology you see advancing to the point that higher education institutions should begin to take notice during the next four to five years?**

3 What key trends do you expect to accelerate educational technology uptake in higher education?

4 What do you see as the significant challenges impeding educational technology uptake in higher education 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 developments in technology 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 colleges and universities. A

significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to practitioners.

The semi-finalist topics of the interim results are then ranked yet again. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2016 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 impact trends that typically have already been affecting decision-making, and will continue to be important for more than five years; mid-term impact trends that will likely continue to be a factor in decision-making for the next three to five years; and short-term impact trends that are driving educational technology adoption now, but will likely remain important for only one to two years, either becoming commonplace or fading away in that time.

While long-term impact trends have already been the topic of many education leaders' discussions and extensive research, short-term impact 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 institutions; 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 colleges and related settings.

Policy. While all of the identified trends had policy implications, two in particular are expected to have a strong impact on policy decisions in the next five years. Rethinking how institutions work is a long-term impact trend that requires governments to prioritize major education reforms that help colleges and universities structure themselves around increasing the employability of their students. The European Higher Education Area (EHEA) launched a governing body, the Bologna Process, to create policies that help institutions adapt their models to better support evolving student and workplace needs.[3]

Measuring learning through data-driven practice and assessment, identified by the expert panel as a short-term impact trend, is raising privacy concerns that universities are addressing by establishing prudent policies and processes. When designing an algorithm that strips data of specific student identifiers for their learning record repository, Marist College worked with their Institutional Review Board to develop guidelines for student data privacy that also adhered to a code of ethics.[4]

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 shift to deeper learning approaches that favor hands-on and student-centered experiences requires institutions to prepare instructors for new roles as guides and mentors. At the University of Delaware, problem-based learning workshops train educators by putting them in the role of students. Faculty mirror the process their learners would go through to collaboratively solve complex societal problems and subsequently develop resources to better integrate the approach into their courses.[5]

Similarly, the emergent trend of blended learning designs has caused institutional leadership to design relevant professional development opportunities for their faculty and staff. The University of Pennsylvania's

Virtual Online Teaching (VOLT) Certificate Program equips instructors with the skills to critically evaluate the use of technologies in their blended learning environments before implementing them.[6]

Practice. Each of the six trends identified by the expert panel has numerous implications for teaching and learning practices, and current examples are easy to find. Institutions' progress in fostering cultures of innovation, highlighted as a long-term impact trend, has been in progress for some time already. In Australia, Curtin University's undergraduate degree in entrepreneurship exposes students to business development activities with the goal of helping them launch their own enterprises. The way students in the program are arranged in working teams reflects the realities of the contemporary workforce, and they are also privy to guest lecturers and mentors from industry.[7]

All over the world, universities and colleges have been redesigning their learning spaces to accommodate the new pedagogies and active learning models described across a number of topics in this report. Traditional classroom setups that position rows of seats in front of a podium are being remodeled to facilitate deeper learning experiences and interactions. Singapore's Nanyang Technological University Learning Hub is home to cornerless rooms that all face a central atrium to encourage students and faculty in different disciplines to work together. The building is also designed to attract plenty of natural light to promote greater emotional well-being.[8]

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 Innovation

Long-Term Impact Trends: 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.[9] In order to breed innovation and adapt to economic needs, higher education institutions must be structured in ways that allow for flexibility while spurring creativity and entrepreneurial thinking. There is a growing consensus among many higher education thought leaders that institutional leadership and curricula could benefit from adopting 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.[10] 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 a compelling model for higher education leaders to consider.[11]

Overview

The Lean Startup movement was largely cultivated in Silicon Valley, the hub of technology innovation, with roots in higher education. Many graduates of Stanford University, for example, have become successful entrepreneurs because of the experience they gain developing business strategies through hands-on curriculum.[12] Stanford alumni entrepreneurs are responsible for global revenue of $2.7 trillion annually.[13] Similarly in the UK, the Cambridge University Entrepreneurs group has helped generate companies with approximately £100 million of investment over a 15-year period.[14] In many ways, the career trajectory of graduates reflects the offerings of the institutions they attend, making it vital for universities and colleges to exemplify the principles they wish to foster in their students. Like startups, institutions are becoming structured in ways that allow them to constantly evolve, reflecting and pushing the boundaries of the global marketplace.[15] This includes deviating from hierarchical decision-making processes to promote collaborative strategies and incorporate student voices.

The contemporary workforce calls for employees that are agile, adaptable, and inventive[16] and universities and colleges are increasingly revamping their existing programs and creating new ones to nurture these key skills.[17] In the US alone, the number of formal entrepreneurial courses in higher education has grown exponentially over the past two decades with nearly 25% of today's college students aspiring to be entrepreneurs.[18] While this trend has been materializing more gradually, the positive impact is evident. A study prepared for the European Commission revealed that in comparison with their peers, university alumni who engaged in entrepreneurial programs were able to secure jobs more quickly and were more confident in their abilities to innovate in the workplace and start new businesses.[19] The Consortium for Entrepreneurship Education also cites major benefits for improving aspects of student attitude including self-awareness, self-management, and creativity.[20]

In order to breed these progressive cultures, higher education institutions and their faculty must be equipped with proper strategies. In Poland, Kozminski University (KU), known for their leading graduate management program, found that a large pool of incoming students who had received undergraduate degrees elsewhere were not adequately prepared. As a result, KU launched an initiative to introduce entrepreneurship courses to 40 local non-business universities and train lecturers in other disciplines, such as engineering, agriculture, and art.[21] Additionally, *Harvard Business Review* recommends that institutions work with industry leaders to integrate more experience-based learning.[22] This notion is being increasingly embraced by universities around the world; San Jose State University, for example, recently partnered with Facebook to expose more young women to computer science with the long-term goal of boosting the company's cyber security efforts.[23]

Implications for Policy, Leadership, or Practice

The Innovation Policy Platform (IPP) asserts that universities should bolster entrepreneurship courses to attract and accommodate more students, while nurturing faculty that can meet high-quality teaching standards. Educators in these programs must understand the complex pedagogies that support more

interactive learning; universities should even encourage faculty and staff to hone their own entrepreneurial skills through professional development and opportunities to participate in startups. The IPP recommends that training policies move beyond business development and management to emphasize the challenges of enterprise growth, risk-taking, and building strategic alliances. Additionally, institutional policies should promote frequent guest lectures from industry to strengthen the link between coursework and real-world settings.[24] At the government level, the Association of American Universities' Task Force on American Innovation published a call-to-action in 2015 urging Congress to make investments in higher education programs that spur global competitiveness.[25]

In 2015, University of Massachusetts Lowell hosted the Deshpande Symposium for Innovation and Entrepreneurship in Higher Education.[26] Leaders from more than 45 North American colleges, universities, and companies shared best practices for integrating entrepreneurial practices into all aspects of campus life to drive economic development. The overarching goal of their event was to map new strategies for institutions to teach and invest in the next generation of big thinkers, doers, and creators across all disciplines. Five institutions were recognized as innovators in this area. Rice University's Alliance for Technology and Entrepreneurship, for example, has been an incubator for fresh ideas, initiating or aiding over 1,500 technology startups while raising $3 billion in funding.[27]

As this trend is well established, there are already many institutions maximizing its impact. The Shipley Center for Innovation at Clarkson University has a hybrid university-industry culture in which students work with faculty and business leaders to accelerate new ideas and turn them into products or services. Students have launched numerous successful ventures including designing a cold climate greenhouse that leverages renewable energy for an integrated food and waste management system, a technology that can change the lighting of a concert venue with every changing musical note, and an app that enables event attendees to order concession items directly to their seats.[28] Curtin University in Australia offers an undergraduate entrepreneurship degree for aspiring business owners. Students often work in teams and capitalize on each other's strengths and expertise. They also receive advice from successful entrepreneurs and mentor incoming students.[29]

For Further Reading

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

Building a Culture of Innovation in Higher Education: Design & Practice for Leaders
go.nmc.org/buildculture
(Bryan Setser and Holly E. Morris, EDUCAUSE, 16 April 2015.) EDUCAUSE provides a toolkit to aid universities, colleges, not-for-profits, and organizations that serve the higher education landscape in assessing their policy environment to create better policies that reward innovative behaviors. > *Policy*

Intrapreneurs Need These 4 Super Skills To Master The Art Of Institutional Innovation
go.nmc.org/intra
(Ashoka, *Forbes*, 2 November 2015.) The author draws from her own experience as co-founder of Ashoka U, which helps embed social innovation in university culture and curriculum, to explain how four essential skills can help leaders navigate complex organizations and leverage the networks and resources necessary to affect people at scale. > *Leadership*

Introducing the CAIT Matrix
go.nmc.org/cait
(SUNY Commons, accessed 15 January 2016.) Five universities have formed the Collective for Academic Innovation and Transformation (CAIT) that is creating a taxonomy to identify and share academic innovations across multiple institutions. > *Leadership*

MIT Innovation Initiative
go.nmc.org/innin
(MIT Innovation Initiative, accessed 12 January 2016.) This institute-wide agenda consists of practice programs advancing the science of innovation through research and policy advocacy, cultivating innovation communities, and equipping the MIT community with the infrastructure to create solutions to 21st-century challenges. > *Leadership*

Universities Need to Adapt to Become Part of Shaping a Better Future
go.nmc.org/betterfuture
(Robin Moore, *The Conversation*, 4 August 2015.) This article urges universities to consider changing their administrative systems to models that can be more responsive and nimble, as well as developing teams that are dedicated to researching complex issues of sustainability and resilience. > *Leadership*

How Are Universities Grooming the Next Great Innovators?
go.nmc.org/nextgreat
(Li Zhou, Smithsonian, 14 July 2015). Stanford University's d.school brings together students across disciplines to learn processes for problem-solving and innovation, tackling real-world issues such as water scarcity and helping students launch products. > *Practice*

Rethinking How Institutions Work

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

Changes in higher education are upending the traditional notion of the university and transforming the paradigm for how postsecondary learning works. These developments are being fueled by a growing body of research that highlights the disconnect between the demands of the 21st century economy and what college graduates are prepared to do when they leave academia.[30] Part of the effort to make students more work-savvy is taking place through new policy initiatives, programs, and curriculum that encourage students to work with peers from different disciplinary backgrounds on innovative solutions to complex problems. Another feature of this trend is the emphasis on exploring alternate methods of delivery and credentialing in order to accommodate a rapidly increasing student population and the diversity of their needs. Emerging models, such as hybrid learning and competency-based education, are revealing the inefficiencies of the traditional system for nontraditional students. These new paradigms are centered on online learning, a method that allows universities to cater to consumer demand, make college credentials more accessible, and design programs that offer a better value proposition for learners at all stages.[31]

Overview

Today's digital landscape has created additional learning opportunities for students outside of brick-and-mortar institutions, and universities are gradually changing to accommodate evolving expectations. In addition to advancing cultures of innovation, a trend explored previously in this report, there are other signs that higher education is undergoing a long-term transformation. Findings from the *International Trends in Higher Education 2015* report from the University of Oxford underlined the political measures countries have taken to internationalize higher education with the goal of improving quality and driving economic competitiveness through doctoral programs that lead to transferable skills for the workplace.[32] Another report from European University Association reveals that an increasing number of institutions are creating initiatives that better meet economic and social needs by enhancing the employability of graduates.[33]

These factors are leading to the development of programs that realize profound, sustained change through cross-disciplinary activities. Recently, Central European University launched the Intellectual Themes project to join together disparate groups and departments to expand their interdisciplinary offerings. The university is currently accepting proposals from faculty for new courses, conferences, or workshops on four themes: social mind, inequalities and social justice, energy and society, and governance.[34] The University of South Carolina has been implementing cross-disciplinary learning since 2011 with the start of their Interprofessional Education (IPE) for the Health Sciences Initiative. The program convenes students from various healthcare fields to explore a range of subjects including nursing, medicine, and pharmacy, in addition to brand new course offerings such as public health and social work. The Dean of Medicine believes that the IPE is a way to produce graduates who are "ready, able, and willing to do interdisciplinary teamwork."[35]

Emerging business models, enabled by advancements in online learning, are also creating fundamental changes in higher education. An interesting take on this trend has been described as adopting the "Education-as-a-Service" (EaaS) model, a delivery system that unbundles the components of higher education, giving students the option to pay for only the courses they want and need. Using the Salesforce.com cloud service as an analogy, an expert argues that the EaaS model will result in a "customer for life" mentality that will retain students through services that make their skills obvious and accessible to their employers, making their return on tuition investment more immediate.[36] Additionally, an American Enterprise Institute paper highlights competency-based education (CBE), which awards credit based on a student's demonstrated competencies, as an effective vehicle for personalizing the higher education experience and helping disenfranchised student populations earn their degrees.[37] This student-centered mode of education has been acknowledged by thought leaders as having a crucial role in the evolution of higher education.[38]

Implications for Policy, Leadership, or Practice

Enacting transformational change requires policies and legislative procedures that are as flexible as the

programs they espouse. The European Higher Education Area (EHEA) has established the Bologna Process, a dynamic policymaking body that governs higher education in 48 countries.[39] Meeting every several years, EHEA working groups regularly advance system-level reforms that aim to keep European universities inclusive and focused on increasing the employability of their graduates, resulting in incremental change that adapts to the diverse needs of students.[40] In the US, state-level policymakers are beginning to understand the growing role of competency-based education providers and the need to include them in statewide financial aid programs. In Indiana and Tennessee, where governing boards have the authority to determine eligibility for aid programs, it is much easier to make way for CBE than in states where existing aid statutes must be changed through new legislation.[41]

The impact of this trend is magnified in South Asia, where the rising student population is challenging education providers to pioneer non-traditional avenues of credentialing. In this climate, online learning, blended learning, and massive open online courses (MOOCs) have become viable methods of delivering higher education. In India, BITS Pilani, a polytechnic institution that serves more than 20,000 students off campus, has joined forces with IIT Bombay University to offer small private online courses through MOOC provider edX. This format makes it possible to deliver quality degree programs, given that there are a limited number of faculty members to teach large classes of thousands of students.[42] Similarly, universities in Pakistan are experimenting with a mix of emerging online learning technologies to meet the growing demand for higher education. At the International Technology Institute, Pakistan, students engage in cross-disciplinary, design-centered learning through a blend of MOOCs and campus-based versions.

A number of universities are actively breaking down academic silos to form an interdisciplinary community of scholars and problem-solvers. The MnDRIVE Transdisciplinary Research Program at the University of Minnesota funds collaborative research projects that incorporate at least three of these four research areas: discoveries and treatments for brain conditions; robotics, sensors, and advanced manufacturing; advancing industry and environment conservation; and global food ventures.[43] Students at Boise State University can take a two-week intensive course that brings together students in biology, geology, and sociology to create a baseline for communication across the fields. With water management as the overarching topic, learners explore differences in spatial and temporal scales, modeling options, and terminology in order to form interdisciplinary approaches that solve complex problems.[44]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking how institutions work:

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 10 January 2016.) 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*

Educational Quality through Innovative Partnerships (EQUIP)
go.nmc.org/equip
(*HomeRoom*, accessed 12 January 2016.) The US Department of Education has awarded $60 million to help colleges and universities design and test innovative educational opportunities, such as intensive boot camps to build skills in particular fields and programs that award certificates aligned to employer needs. > *Policy*

Building a New Global Higher Education Model
go.nmc.org/globalhied
(C. L. Max Nikias et al., USC, 17 September 2015.) The University of Southern California, Hong Kong University of Science and Technology, and Universitá Commerciale Luigi Bocconi created the World Bachelor in Business program, which is an experiential business program that places students in four different countries so students can understand foreign workplace cultures and business climates. > *Leadership*

The Future of the University
go.nmc.org/spec
(David J. Staley, *Educause Review*, 9 November 2015.) This essay proposes five models of innovation in higher education by conceptualizing the ideas as blueprints for educational startups that could potentially be the beginnings of actual universities. > *Leadership*

Higher Education: Lifetime Training or a Path to the Next Job?
go.nmc.org/pathto
(Tara García Mathewson, *Education Dive*, 28 September 2015.) Higher education leaders are grappling with how to structure higher education so that it imparts a variety of foundational and soft skills that allow students the flexibility to move across fields, yet still provides them with tangible real-world training and pathways to specific technical skills. > *Practice*

Redesigning Learning Spaces

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

Some thought leaders believe that new forms of teaching and learning necessitate new classroom configurations. More universities are helping to facilitate emerging pedagogies and strategies, such as the flipped classroom, by rearranging learning environments to accommodate more active learning.[45] Educational settings are increasingly designed to support project-based interactions with attention to greater mobility, flexibility, and multiple device usage. Institutions are upgrading wireless bandwidth to create "smart rooms" that support web conferencing and other methods of remote, collaborative communication.[46] 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 lessons and toward more hands-on scenarios, college and university classrooms are starting 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.[47] The benefits of renovated learning spaces are being recognized; a three-year study at Ball State University, for example, found that students were more likely to be engaged in innovative learning spaces.[48] Institutions including the University of Queensland have broken the mold of the traditional classroom to accommodate new pedagogies.[49] Their Extension Learning Centre, a blended learning space for engineers, facilitates team-based activities with a more dynamic layout. These redesigned spaces support what is often referred to as flexible or active learning.[50] Some argue that these new learning environments, characterized by design enabling collaboration and project-based learning, will soon be augmented by equipment allowing students to model and create objects. This concept will be expanded upon in the makerspaces section of this report.[51]

While current discussions focus on reimagining physical spaces for learning, space design that promotes better online learning is ripe for investigation. Purdue University, for example, created a flexible learning area that serves both on-campus and distance learning students. With acoustic panels and ceiling microphones for the capturing of audio without disruption, and mobile furniture for flexible arrangements, their engineering classroom creates a better experience for both types of students.[52] This integration of physical and virtual learning spaces has introduced a new way of thinking about blended learning. Polysynchronous learning refers to a mix of face-to-face, asynchronous, and synchronous channels of online communication; participation by students in diverse locations is cited as a key benefit. It requires physical classrooms to be designed to enable students to seamlessly communicate with others face-to-face and virtually.[53]

The Internet and mobile technologies have revolutionized how people find, consume, and interact with content. One manifestation of this trend is the removal of books and serial journals from the shelves of academic and research libraries, which has proven controversial for some academic communities.[54] Libraries are replacing stacks with new kinds of spaces that offer more collaborative and individual study areas. For several years, Cornell University's Mann Library has been working with students to best support their needs with furniture, technology, and spaces. Their current phase of work includes adding more seating, study spaces, writing surfaces, and adjustable furniture.[55] Similarly, Deakin University has recognized that their students require an informal learning space that is always available. Inside the entrance of the institution's Waurn Ponds Library is a 24-hour area with couches and study nooks where students can access e-books and online resources within close proximity to refreshments.[56]

Implications for Policy, Leadership, or Practice

While many learning spaces are governed by universities' general use policies, the evaluation of new spaces is being guided by a number of ratings, guidelines, and standards. EDUCAUSE's Learning Spaces Rating System 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.[57]

InfoComm International's *V/IT Infrastructure Guidelines for Higher Education* document is intended to assist designers and technology managers with planning and implementing audiovisual systems at universities. Part one of the publication focuses specifically on teaching and learning spaces as well as accompanying technologies.[58] The Association for Quality in Audio Visual Technology complements InfoComm International's guidelines with a certification designed to ensure that AV companies providing services are following appropriate standards and best practices.[59]

When assessing current spaces or planning a redesign, campus leaders can look to the work of instructional technologists and strategists. The Ideaspaces Network outlines a plan for structuring learning spaces through a hierarchy of decision-making principles that begins with physical spaces at the bottom, time for iterating ideas at the next level, and the creation of organizational structures that nurture innovation and change at the top.[60] North Carolina State University partnered with Brightspot Strategy and AECOM to produce a toolkit containing resources for planning, evaluating, and supporting technology-rich informal learning spaces.[61] In Europe, JISC developed a quick guide on evaluating and designing learning spaces that provides a detailed framework for the development of new and repurposed educational environments to support more collaborative learning.[62]

With years of thorough research and thoughtful design, campuses worldwide are building state-of-the-art classrooms and other spaces that foster greater collaboration in healthier environments. Oregon State University's new Learning Innovation Center, for example, features "in the round" classrooms that enable faculty to get in close proximity to every student in even the largest of courses. The placement of classrooms in the center of the building allows for greater flow between classes, and added informal learning spaces enable students and faculty to work together outside of class.[63] Similarly, Nanyang Technological University in Singapore is drawing praise for their new Learning Hub building that features clusters of cornerless rooms that face a central atrium, allowing students and faculty from various disciplines to meet and interact.[64] The building's greenery and abundant sunlight relate to the growing interest in biophilic building design that has benefits in learning, productivity, and emotional well-being.[65]

For Further Reading

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

Learning Spaces Accessibility Guidelines
go.nmc.org/temple
(Temple University Accessible Technology, accessed 6 January 2016.) Temple University has developed guidelines for equipment and technologies in campus learning spaces to ensure that they are capable of supporting instructors and students with disabilities. > *Policy*

Active Learning Initiative
go.nmc.org/crwuali
(Case Western Reserve University, accessed 20 January 2016.) Case Western Reserve University has made a significant investment toward changing its culture of teaching and learning with the development of state-of-the-art learning spaces and an active learning faculty fellowship program. > *Leadership*

Art & Design - Learning Space Innovation
go.nmc.org/beacproj
(Beacon Project Blog, accessed 5 January 2016.) Sheffield Hallam University's Beacon Project is investigating how beacons can be used to support a smart, connected learning environment that facilitates context-aware engagement and connects faculty and students to timely information within a studio space. > *Leadership*

Beyond Active Learning: Transformation of the Learning Space
go.nmc.org/transformspace
(Mark S. Valenti, *EDUCAUSE Review*, 22 June 2015.) This article describes how technology is enabling colleges and universities to create flexible, multimodal, and active learning environments that allow more natural and authentic learning experiences. > *Practice*

Queensland University of Technology: The Cube
go.nmc.org/qutcube
(Queensland University of Technology, accessed 5 January 2016.) Queensland's two-story Cube was built to support hands-on, interactive workshops and programs by allowing visualization, immersion, and interaction with research projects using advanced digital technology, including 14 high-definition projectors, 48 multi-touch screens, and advanced audio technology. > *Practice*

The West Houston Institute
go.nmc.org/westhou
(Houston Community College, accessed 5 January 2016.) Houston Community College's West Houston Institute combines experiential classrooms and labs, a makerspace, a facilitated collaboration space, a conference space, and a learning commons with integrated technology including a large, interactive wall that serves as an open lab. > *Practice*

Shift to Deeper Learning Approaches

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

There is a growing emphasis in higher education on deeper learning approaches, defined by the William and Flora Hewlett Foundation as the mastery of content that engages students in critical thinking, problem-solving, collaboration, and self-directed learning.[66] In order to remain motivated, students need to be able to make clear connections between the curriculum and the real world, and how the new knowledge and skills will impact them. Project-based learning,[67] challenge-based learning,[68] inquiry-based learning,[69] and similar methods are fostering more active learning experiences, both inside and outside the classroom. As the enabling role of technologies for learning crystalizes, instructors are leveraging these tools to relate materials and assignments with real life applications. These approaches are decidedly more student-centered, allowing learners to take control of how they engage with a subject, even brainstorming solutions to pressing global problems and beginning to implement them in their communities.

Overview

A primary goal of higher education is to equip students with the skills they need to be successful in the workforce and to make an impact on the world. A recent study conducted by the Association of American Colleges and Universities revealed employers' sentiments that recent graduates should be more prepared in vital areas such as critical thinking.[70] Many progressive higher education institutions have been unpacking this premise for some time, making major strides in developing programs and curricula that provide learners with more hands-on, real-world experiences. Just as in the workplace where employees devise their own effective approaches to fulfill concrete deliverables, deeper learning revolves around students *learning to learn* the methods that will enable them to accomplish any goals.[71]

Understanding the difference between deeper and surface learning is essential to maximizing the impact of this positive trend. According to the University of Technology Sydney, surface learning involves students simply reproducing information to meet assessment demands; this often takes the form of multiple-choice exams, which rely on fact memorization. In contrast, deeper learning compels students to focus on the meaning of the content, relating several ideas and connecting them to previous experiences to foster their own personal understanding.[72] The goal is to move away from rote learning towards experiences that cultivate a genuine curiosity in students so they are excited to explore subjects further. Deeper learning ultimately emphasizes a shift in pedagogy; instead of instructors dispensing information they are becoming flexible guides and coaches, brainstorming alongside students and modeling inquisitive behavior.[73]

Project-based learning (PBL) is widely perceived as a method for facilitating this active and self-directed learning. In the PBL model, a central concept or question drives students' investigation of defined objectives that lead to significant knowledge-building. Learners strategize the tasks, processes, and products needed to demonstrate newfound knowledge, engaging in deep reflection along the way.[74] Technology plays a major role in facilitating this approach, helping students collaborate, design, and create. Stratasys, for example, recently launched a free 3D printing curriculum that integrates PBL[75] and Wentworth Institute of Technology was among the first institutions to pilot it. The subsequent course built upon several in-depth lectures with class discussions and 3D printing projects for engineering and industrial design students. As a result, a laboratory that was once underused became a busy hub of innovation. Participating students noted their excitement in having more freedom to be creative without rigid guidelines. Though they reported that the projects were challenging at times, they were highly motivated to learn and grow their skillsets.[76]

Implications for Policy, Leadership, or Practice

While there are no explicit policies mandating project-based learning or other deeper learning approaches in colleges and universities, governments around the world are prioritizing education reforms that emphasize more innovative, 21st century practices. The European Union's Modernizing Universities agenda, for example, includes the development of higher education programs that promote autonomous, active, and entrepreneurial learning, geared towards student skill acquisition that is directly aligned with the workforce and strengthening the national economy.[77] Education

advocacy organizations such as Jobs for the Future (JFF) are also providing recommendations to governments to encourage the widespread understanding and adoption of deeper learning. JFF's Student at the Center Deeper Learning Research Series aims to make accessible real outcomes of this approach to build knowledge in formats that are useful to policymakers.[78]

In order to advance deeper learning in global higher education, it needs to be perceived as effective in helping students gain high-quality credentials. The Lumina Foundation has been instrumental in pinpointing what comprises quality learning. Their Degree Qualification Profile calls for students to demonstrate their knowledge through project-based learning, engaging in fieldwork, using new media, and working collaboratively. Specialized knowledge is one of the five profile criteria they define, prompting students enrolled in bachelor's programs to "investigate a familiar but complex problem in the field of study by assembling, arranging, and reformulating ideas, concepts, designs and techniques."[79] Instructors can also benefit from ongoing leadership when shifting their pedagogies to deeper approaches. The University of Delaware hosts problem-based learning workshops to help educators better understand the model; placed in the role of students, participants work together to solve pressing challenges and then create materials to facilitate it in their own environments.[80]

The impact of this trend continues to grow as deeper learning is increasingly being put into practice. The Next Generation Learning Initiative awarded $1.7 million in grants to seven institutions to support deeper learning innovation in higher education.[81] One recipient, Abilene Christian University, designed a mobile-enhanced, inquiry-based learning model in which students leverage their smartphones to view tutorials and record their own video footage in their lab work. The approach has also been successfully applied at California University of Pennsylvania and Del Mar College, and the results revealed a significant increase in student expression of deeper learning; 81% achieved subject mastery and 91% demonstrated persistence throughout the course.[82] At RMIT University in Australia, the engineering school adopted a PBL model to nurture students' creativity and problem-solving skills, while accessing the latest technologies. Students learn from industry practitioners and work in teams to develop solutions to significant engineering problems.[83]

For Further Reading

The following resources are recommended for those who wish to learn more about the shift to deeper learning approaches:

A Dual Mandate for Adult Vocational Education (PDF)
go.nmc.org/businn
(Gov.UK, March 2015.) The Department for Business Innovation and Skills in the UK outlined a plan to reform vocational education and apprenticeships to meet the needs of employers and learners through funding, partnerships between government and businesses, and the development of a fast broadband and mobile infrastructure. > *Policy*

Auburn University Named Innovation and Economic Prosperity University
go.nmc.org/prosp
(Charles Martin, Auburn University, 24 June 2015.) The Association of Public and Land-grant Universities recognized Auburn for establishing partnerships that benefit students through real-world learning experiences. > *Leadership*

Digital Advertising Technology Becomes Bona Fide University Major
go.nmc.org/advert
(Scott Thomson, *CMO*, 13 October 2015.) Adobe and Swinburne University of Technology are creating a new major — digital advertising technology — with curriculum covering content management, user experience design, social media, video marketing data analytics, and campaign management. > *Leadership*

Levels of Learning in a New Curriculum
go.nmc.org/projectfamilies
(Rohan Shetty & Naman Trivedi, *The Hoya*, 10 November 2015.) Leaders from Georgetown University are developing "project families," which are evolving student groups that partake in progressively more challenging assignments to produce tangible results that showcase mastery of content. > *Leadership*

Facilitating Instructor Adoption of Inquiry-Based Learning in College Mathematics
go.nmc.org/ibl
(Charles N. Hayward et al., Springer International Publishing Switzerland, 25 November 2015.) This study reports findings from a series of successful professional development workshops that focused on incorporating inquiry-based learning in college mathematics. > *Practice*

Students Work on Live Projects and Get Mentored by Industry Experts at Aptech's 'Evolve 2015'
go.nmc.org/aptech
(Chirag Barotra, *HTCampus*, 11 February 2015.) In India, Aptech Computer Education's Evolve event gives Aptech students a chance to work on live projects with professionals and experts in their industry as well as attend informative sessions and workshops to better understand the IT industry and job market. > *Practice*

Growing Focus on Measuring Learning

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

The growing focus on measuring learning describes a renewed interest in assessment and the wide variety of methods and tools that educators use to evaluate, measure, and document academic readiness, learning progress, skill acquisition, and other educational needs of students.[84] As societal and economic factors redefine what skills are necessary in today's workforce, colleges and universities must rethink how to define, measure, and demonstrate subject mastery. The proliferation of data mining software and developments in online education, mobile learning, and learning management systems are coalescing toward learning environments that leverage analytics and visualization software to portray learning data in a multidimensional and portable manner. In online and blended courses, data can reveal how student actions contribute to their progress and specific learning gains.

Overview

In the consumer sector, data are routinely collected, measured, and analyzed 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 behaviors to improve learning for individual students as well as across institutions. The kinds of student data being analyzed include institutional information such as student demographics and course selections, pace of program completion, learning platform engagement statistics, and concept mastery.[85] While many experiments are underway, leaders are just beginning to understand which data are useful for advancing learning outcomes, in addition to the scope of privacy and ethics issues.[86] Tracking learners' cognitive behavior can lead to vital information about student success, enabling educators and technology developers to work together to improve future learning environments and materials.

Learning analytics and adaptive learning, featured later in this report, are a natural extension of the use of digital tools for learning. 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.[87] At the same time, the widespread use of learning management systems (LMS) including Blackboard and Moodle, which amass large amounts of data related to student activities, has generated increasing interest from universities in analyzing the available datasets. New and more robust incarnations of the LMS will be informed by a learning-centered model and rely on core functionality that includes personalization, analytics, advising, and learning assessment, as well as accessibility.[88]

A recent study conducted by Hanover Research suggested that students have a desire for immediate and continual feedback as they learn. The findings indicate that almost two-thirds of the participating students believe the impact of analytics reports on their academic performance is "very positive."[89] The Universidad Internacional de La Rioja's A4 Learning project combines data techniques with information visualization, providing each student with ongoing information that enables them to think critically about their learning progress and goals.[90] Universities are also experimenting with more portable, device-agnostic degree and course options that can track, store, and leverage data from a variety of contexts. Brandman University's mobile-accessible, competency-based Bachelor of Business Administration leverages simulations along with gamification elements. As students interact with their coursework, the system collects formative data on student performance and engagement.[91]

Implications for Policy, Leadership, or Practice

As digital learning environments capture data, more work is needed to structure appropriate policies to protect student privacy. Mounting concerns that legal and privacy guidelines are not advancing as quickly as practice has major implications for institutions, which are now tasked with establishing an ethical code for the use of data.[92] Marist College's application of data to increase student success provides an example of institutional best practices in securing sensitive student information for transparent learning measurement projects. They designed a process that anonymizes data imported into their learning record store, removing students' identifying information with a random algorithm. Marist College initially consulted their Institutional Review Board to establish a project mandate and develop parameters for data privacy and access, aligning the project with their code of ethics.[93]

University leaders are demonstrating their commitment to the use and protection of learning data through partnerships that disseminate best practices. One such initiative, the Predictive Analytics Reporting (PAR) Framework, involves the North Dakota University System and the University System of Maryland. PAR members share data on retention and advancement to benchmark their progress and explore returns on investment for student success programs.[94] In Canada, the Higher Education Quality Council of Ontario Learning Outcomes Assessment Consortium is piloting assessment tools and techniques including e-portfolios and analytic rubrics to measure student success at the institutional level.[95] Meanwhile, research and development in a variety of fields including informatics, machine learning, and affective computing continue to fine-tune algorithms and allow assessment and feedback from a wider variety of data formats, deepening the abilities and insights of analytics.

Data-driven projects at colleges and universities are starting to reveal promising results. Many are leveraging dashboards, visual representations of data that are integrated in the LMS, to personalize the learning experience. For example, the University of Edinburgh partnered with CogBooks to pilot an online adaptive learning and course delivery tool in two geoscience courses. The software's dashboard informs students of their progress as they move through course activities, while faculty can use the data to improve their teaching. After the pilot illuminated positive outcomes, the University of Edinburgh implemented the tool in four additional courses.[96] Further, institutions are engaging in evidence-based teaching and learning by using the built-in analytics of games, simulations, and mobile apps. The University of Colorado Boulder's PhET project is building math and science simulations that leverage the Metacog platform to provide formative feedback about learner interaction in real time. PhET's visualization and reporting tools enable deep analysis of learner-generated data.[97]

For Further Reading

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

'Learning Gain': Did Students Bulk Up in Mental Muscle?
go.nmc.org/muscle
(Jack Grove, *Times Higher Education*, 19 February 2015.) The Higher Education Funding Council for England is considering whether indicators of learning gain, also known as "value-added," could conceivably be collected from universities, and it is developing a robust method of collecting data that proves learning gain. > *Policy*

Technology-Enhanced Learning: Best Practices and Data Sharing in Higher Education
go.nmc.org/glc
(Global Learning Council, April 2015.) The Global Learning Council, an organization aimed at developing educational practices, policies, and technologies to substantially improve learning outcomes, proposes that a global, cross-sector taskforce be commissioned to specify ideas that relevant legal bodies can adopt to protect individuals' data privacy. > *Policy*

Data Wise Online Leadership Institute
go.nmc.org/datawise
(Harvard Graduate School of Education, accessed 21 January 2016.) Harvard University's Data Wise Online Leadership Institute engages teams of educators and administrators in an evidence-based instructional improvement process. The weeklong online workshop integrates the flexibility of online learning with the power of co-located teams and the structure of a professional development workshop. > *Leadership*

First Annual Open Learning Analytics Hackathon
go.nmc.org/lak15
(SoLAR, accessed 22 December 2015.) The Society for Learning Analytics Research (SoLAR) and the Apereo Learning Analytics Initiative hosted a hackathon to build on the OpenDashboard project and design a reusable learning analytics dashboard that works across college and university systems, uses emerging standards, and supports an open learning analytics framework.
> *Leadership*

Development of the Learning Analytics Dashboard to Support Students' Learning Performance
go.nmc.org/learper
(Yeonjeong Park and Il-Hyun Jo, *Journal of Universal Computer Science*, 2015.) Researchers at Ewha Womans University in South Korea have reviewed previous studies on the use of learning analytics dashboards (LAD) to identify important features that they used to design a LAD implemented in a large private university.
> *Practice*

Learning Analytics at "Small" Scale (PDF)
go.nmc.org/comgrou
(Sean Goggins et al., *Journal of Universal Computer Science, Vol. 21, No. 1*, 2015.) At University of Missouri, Columbia, researchers proposed a process-oriented, automatic formative assessment model for small-group learning environments that leverages a web-based tool to offer ongoing actionable intelligence for educators.
> *Practice*

Increasing Use of Blended Learning Designs

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

Perceptions of online learning have been shifting in its favor as more learners and educators see it as a supplement 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.[98] The affordances of blended learning 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. Higher education institutions are upping the ante of innovation in these digital environments, which are widely considered to be ripe for new ideas, services, and products. Progress in learning analytics, adaptive learning, and a combination of cutting-edge asynchronous and synchronous tools will continue to advance the state of blended learning and keep it compelling, though many of these methods are still the subjects of research by online learning providers and institutions.

Overview

Students have expectations that higher education will mirror the information accessibility and immediacy of their connected lives; a study by JISC indicated that technology impacted university choice for 32% of surveyed students.[99] Colleges and universities are increasingly adding online offerings to address pervasive issues of affordability and accessibility,[100] working to accommodate learners' financial constraints and helping students balance family and workplace responsibilities.[101] Blended learning integrates both online and face-to-face modalities to create a cohesive learning experience, providing learners with flexibility and support. These hybrid approaches hold the potential to foster independent learning and collaboration, as well as provide more channels of communication among students and instructors.

The integration of online tools provides instructors with the ability to track student success and engagement throughout the duration of the course. Faculty can then use that feedback to tailor their in-person instruction to better meet the learning needs of their students.[102] Blended learning takes many forms in higher education. Virtual laboratories, for instance, provide opportunities for risk-free, repeatable experimentation and simulation, while allowing universities to serve students beyond the limits of physical laboratory space.[103] Additionally, the flipped classroom is a blended learning model in which students can access discussion forums, problem-solve, and actively apply their newfound knowledge. Another approach combines massive open online courses with classroom instruction and peer interaction. An example of this is Pakistan's International Technology University, which employs a blended design where its students enroll in courses on the edX or Coursera platforms while simultaneously participating in on-campus modules for credit.[104]

Researchers analyzed the performance of students in an upper-division chemistry class at the University of Massachusetts over a five-year period, where the course was taught in the traditional classroom method for the first three years and then offered in a flipped approach for the final two years. Both versions of the course used the same online interactive content and assignments. The study found that the blended structure led to increased engagement with course material, which promoted more active learning during class meetings and ultimately improved student success.[105] The blended format generated a nearly 12% increase in student exam scores over the face-to-face course. Similarly, a publication funded by the Bill & Melinda Gates Foundation reviewed 20 studies on blended learning in higher education and reported that blended instruction produced higher academic achievement than exclusively face-to-face and online courses.[106] The report posited that some of the academic gains could be attributed to variables such as additional student time investment, higher volume of instructional content, and learner collaboration.

Implications for Policy, Leadership, or Practice

Supportive institutional policy can foster the creation of successful blended courses. The University of the Sunshine Coast has adopted a blended learning strategy to cultivate technology-based teaching and promote deeper learning through pedagogical innovation.[107] These goals are furthered by the school's Centre for Support and Advancement of Learning and Teaching, which provides academic staff with learning opportunities, curriculum design support,

technology evaluation, and grant application assistance to implement new tools or strategies that improve learning outcomes.[108] James Cook University (JCU) has also adopted principles and procedures for the use of blended learning environments, and has committed to supporting staff efforts by investing in infrastructure and learning technologies.[109] The policies address the diverse learning preferences and life circumstances of the student body with flexible delivery approaches; JCU faculty must take a holistic approach to curriculum design by incorporating technologies likely to improve student outcomes.

Advancing blended learning requires the promotion of scalable innovative course designs. Google has created opportunities for institutions to experiment with blended approaches through their Computer Science Capacity Awards program, which is funding the use of new course structures and technologies at eight universities during a three-year period.[110] One award-winning institution, Carnegie Mellon University, is launching a blended version of a Data Structures and Algorithms course, featuring video lectures, course software, and small breakout meetings to resolve academic struggles.[111] Further progress in this field can also be achieved through professional development for campus leaders to help spread effective blended course design. The University of Pennsylvania's Virtual Online Teaching (VOLT) Certificate Program teaches educators to assess technologies through a learner-centric lens.[112]

In practice, many higher education institutions are adopting innovative curriculum designs that blend online and face-to-face offerings that are benefiting their students. The Arab Open University combines online and multimedia course materials with small-group tutorials to provide its students with supported, flexible learning.[113] The Indian Institution of Technology Bombay has integrated MOOC lectures with classroom sessions, with professors reporting a rise in student engagement.[114] Peirce College in Philadelphia, which serves a student population primarily composed of working adults, has introduced a flexible course delivery model: each week, students can choose between in-person or online attendance.[115] The pilot test of this blended model reduced student absenteeism from 10.2% to 1.4%, and the institution will expand the flexible option to encompass all course offerings starting in Fall 2016.[116]

For Further Reading

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

The Open Education Licensing Project
go.nmc.org/opedlicensing
(Open Education Licensing, accessed 5 January 2016.) Swinburne University of Technology's "Open Education Licensing Project" is researching copyright and licensing issues related to open online education practices. The findings will be compiled into a toolkit that Australian universities can use as they build and incorporate online components into their courses. > *Policy*

Blended Learning Essentials: Getting Started
go.nmc.org/getstarted
(FutureLearn, accessed 29 December 2015.) The University of Leeds offers a blended learning essentials course through FutureLearn that guides educators in the effective use of free and affordable technologies and resources in blended learning practices. > *Leadership*

Blended Learning Innovations: Leadership and Change in One Australian Institution
go.nmc.org/blendin
(Negin Mirriahi et al., *International Journal of Education and Development using ICT*, 2015.) An Australian university redesigned three professional development programs to be delivered in blended and online formats, allowing professors to experience blended learning themselves in order to effectively take advantage of the teaching style. > *Leadership*

UCF's Blended Learning Toolkit
go.nmc.org/ucf
(Blended Learning Toolkit, accessed 5 January 2016.) Student evaluations have shown that University of Central Florida's blended courses consistently rank higher than both face-to-face and purely online courses. To document their success and assist others in developing blended courses, UCF has released an open repository of information. > *Leadership*

Exploring Future Teachers' Awareness, Competence, Confidence, and Attitudes Regarding Teaching Online
go.nmc.org/attitudes
(Suzanne Le-May Sheffield, *Canadian Journal of Higher Education*, 2015.) This study found that graduate students at Dalhousie University's Centre for Learning and Teaching increasingly valued the possibilities and benefits of blended learning after experiencing a blended course as part of their training. > *Practice*

More Arab Region Universities Offer Blended Learning
go.nmc.org/offerblended
(Anayat Durrani, *US News*, 10 November 2015.) The author describes a number of Arab universities that are delivering their courses in a blended format, using LMS such as Blackboard, Moodle, and Desire2Learn. Instructors and students enjoy the flexibility offered when resources are available online. > *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 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 at the government level and on many campuses at the moment. The expert panel considered blending formal and informal learning as the easiest one to address. The European Commission has set an important policy precedent with their report "Recognition of Prior Non-Formal and Informal Learning in Higher Education." The report lays out the variety of initiatives they have launched to identify ways to evaluate informal learning activities to be incorporated into higher education institutions.[117]

A more challenging policy area is to strike a balance between connected and unconnected learning as technology use continues to proliferate. More colleges and universities are taking advantage of the vast affordances enabled by digital tools, such as more ubiquitous Internet connectivity and on-the-go learning opportunities. However, questions have been raised about mindful use as overexposure can potentially lead to distractions and burnout. Education ministers recently convened with educators at the first Global Education Industry Summit in Finland to determine the kinds of policies and frameworks needed to advocate for transformative technology use that does not prioritize the agendas of technology corporations.[118]

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 pressing but solvable need to improve digital literacy at institutions across the world. Fortunately, the presence of academic libraries on campus is opening up channels for students to gain confidence in using technologies for the express purpose of learning. The Association of College & Research Libraries' Framework for Information Literacy for Higher Education has established a set of interconnected core concepts to help campuses better organize ideas about information, research, and scholarship into a comprehensive whole.[119]

The expert panel pinpointed keeping education relevant as a wicked challenge that requires visionary leadership to overcome. As unemployment is a rampant global issue, institutions need to rethink how they approach and structure their programs and curriculum in order for graduates to be successful in the workforce. Chinese citizens enrolled in vocational colleges in China can earn a bachelor's degree at SUNY Cobleskill through the Path Pro Program. This will equip them to earn better jobs with higher qualifications.

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. The expert panel perceives competing models of education as a disruption to formal institutions — one that is forcing colleges and universities to evolve their approaches. Minerva University, for example, holds all of their classes online with students dispersed across different countries to learn about and experience other cultures, thus becoming more globally aware citizens. An affordable master's program is also planned to help students gain two degrees in four years.[120]

Personalizing learning has also been a difficult challenge for higher education institutions, especially as the development of technology solutions by various companies is outpacing large-scale implementations and outcomes studies. However, existing pilot programs are showing promise. The University of Wisconsin–Milwaukee integrated a course developed by the American Psychological Association into their psychology program; their U-Pace course is self-paced and includes individual progress reports, supplemented by personalized feedback from instructors, to keep students motivated and help them understand their strengths and weaknesses. After completing the course, students performed 16% higher on cumulative exams than students who had not taken the U-Pace course.[121]

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

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 have long been common in museums, science centers, and personal learning networks.[122] These, along with life experience 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 interests. Higher education institutions have not yet been able to incorporate such experiences across their courses and programs at scale, though many experts believe that a blending of formal and informal methods of learning can create an environment that fosters experimentation, curiosity, and above all, creativity.[123] In this sense, an overarching goal is to cultivate the pursuit of lifelong learning in all students and faculty. However, methods of formally acknowledging and rewarding skills both instructors and students master outside of the classroom are compounding this challenge.[124]

Overview

In an age of video tutorials, open content, and social media, it is easy for people to find ways to learn and gain new skills anytime, anywhere. Informal learning recognizes that knowledge acquisition can happen in any given moment, no matter how casual the environment.[125] A student can spend years practicing advanced graphic design techniques, for example, only to be relegated to introductory design courses when enrolled at a university. Most higher education institutions still exclusively speak the language of course credits,[126] not incorporating prior informal experience as a placement factor. While the blending of formal and informal learning is an intriguing notion, it is hampered by the lack of scalable ways to qualify learning that happens beyond the classroom. Fortunately, UNESCO is setting a precedent, connecting informal learning outcomes to the goal of building societies of lifelong learners in their book *Global Perspectives on Recognizing Non-formal and Informal Learning: Why Recognition Matters*.[127]

Although the burden initially appears to be on formal institutions to deeply consider how informal learning experiences fit in with course objectives and assessment, students must also better understand what characterizes beneficial informal learning resources. This intersection encompasses a potential solution; universities and colleges are well poised to play a bigger role in helping students discover and maximize credible digital tools and resources as they pursue their curiosities.[128] Responses to the challenge can be easily mistaken for simply integrating informal opportunities, but the ultimate goal is to combine the two to achieve the best of both worlds. For example, an EDUCAUSE study revealed that even though students and instructors use mobile devices regularly, they still need technical, logistical, and pedagogical support from institutions to understand how to use them for learning purposes.[129]

Solving this challenge requires institutions and employers to view informal learning in a positive light. Ongoing learning is particularly important for working professionals who must continuously gain new skills to advance their careers. Traditionally, this has translated into pursuing graduate degrees. The rise of micro-credentials or "nanodegrees" is disrupting this paradigm as online learning providers like Udacity and Coursera have partnered with businesses including Google and Instagram to help people informally further their education in areas such as mobile app development.[130] Increasingly, social media is also being leveraged to display these kinds of accomplishments. LinkedIn, for example, enables users to list any skills that could appeal to prospective employers; open badging integration through Credly allows the sharing of verified achievements, such as completing an online course in coding.[131]

Implications for Policy, Leadership, or Practice

The European Commission has been instrumental in acknowledging the benefits of informal learning and setting policy precedents. Their report "Recognition of Prior Non-Formal and Informal Learning in Higher Education" describes an assortment of initiatives including Common European Principles for the Identification and Validation of Non-formal and Informal Learning and the European Guidelines for Validation of Non-formal and Informal Learning.[132] Understanding societal changes and their impact on education is key

to these programs. The world is moving away from the one-job-for-life culture towards a career succession that involves fast-paced, technology-rich environments. In the past few years, the EC has adopted the Council Recommendations inviting European Union countries to develop validation systems that enable individuals to obtain recognized qualifications based on informal learning experience.[133]

Part of solving this challenge means finding methods for recognizing informal learning at universities and colleges. Cork Institute of Technology in Ireland has been a leader in this area, referring to informal learning as "non-formal" and "prior learning," and surveying and integrating work experience of students, such as project management and event coordination, when designing their adult curriculum.[134] Additionally, the European Commission's Lifelong Learning Programme's TRAILER, which stands for Tagging, Recognition, and Acknowledgement of Informal Learning Experiences, aimed to bridge this gap with the help of seven participating universities across Spain, the Netherlands, the UK, Poland, Portugal, and Serbia. Using the TRAILER method, learners initially identified what and how they were learning, facilitated a dialog with their institutions, and then used online portfolio technology to enable formal displays of the newfound knowledge and skills.[135]

An increasing number of institutions are leveraging social media to connect outside learning practices to formal activities. Indiana University marketing students, for example, use Instagram to share compelling marketing ideas with each other through snapshots and hashtags. Students at Rhode Island College use Scoop.it to select relevant resources and add their own personal reflections, demonstrating how they can be social media producers rather than just consumers.[136] Another challenging aspect of blending formal and informal learning is moving informal learning recognition into practice. In Finland, Lahti University of Applied Science (LUAS) recently piloted an open badges program to validate informal achievements. LUAS incorporated the student voice in the development process. Students not only designed the badge templates, but also explored and compared different open badge management systems to make an informed selection. The first badges awarded were for international students that participated in a career planning exercise.[137]

For Further Reading

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

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*

The Right Signals Initiative
go.nmc.org/rightsig
(American Association of Community Colleges, accessed 22 December 2015.) The Right Signals Initiative is working toward a new national credentialing model that considers multiple quality credentials, including degrees, certificates, industry certifications, apprenticeships, and badges, to ensure that both formal and informal learning are acknowledged. **>** *Policy*

Deakin Digital
go.nmc.org/deakdig
(Deakin Digital, accessed 22 December 2015.) The Deakin Digital initiative allows students to credential skills they gained in work and life as a pathway to a graduate degree once they complete a full catalog of credentials and a single unit of study at Deakin University. **>** *Leadership*

Is Facebook the Next Frontier for Online Learning?
go.nmc.org/nextfro
(Christine Greenhow and Andy Henion, Michigan State University, 29 June 2015.) A Michigan State University professor found that a Facebook forum spurred students to engage in debate over scientific issues, and that these kinds of informal learning experiences can be leveraged to connect students with experts in the field and spur interest in careers. **>** *Practice*

Open SUNY COTE Badging
go.nmc.org/cote
(Credly, accessed 21 January 2016.) The Open SUNY Center for Online Teaching Excellence (COTE) is using badging to recognize, endorse, and certify various activities and accomplishments. The badging system is designed to guide development as online practitioners progress from novice to master and support sharing across the entire community. **>** *Practice*

You Can Now Get College Credit Without Ever Taking a Class
go.nmc.org/compbased
(Matt Krupnick, *The Hechinger Report*, 24 February 2015.) Many universities are designing competency-based programs to measure whether what people have already learned informally in life is enough for them to forgo prerequisite courses. **>** *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 higher education, the traditional view of literacy as the ability to read and write has expanded to encompass understanding digital tools and information.[138] This new category of competence is affecting how colleges and universities address literacy issues in their curriculum objectives and teacher training programs. Lack of consensus on what comprises digital literacy is impeding many institutions from formulating adequate policies and programs that address this challenge. Discussions among educators have described digital literacy as competence with a wide range of digital tools for varied educational purposes, or as an indicator of the ability to critically evaluate web resources.[139] However, both definitions are broad and ambiguous. Compounding this issue is the notion that digital literacy differs for educators and learners, as teaching with technology is inherently different from learning with it.[140]

Overview

A notable obstacle to improving digital literacy is developing a consensus of all of the elements it encompasses. The American Library Association defines digital literacy as "the ability to use information and communication technologies to find, understand, evaluate, create, and communicate digital information, an ability that requires both cognitive and technical skills."[141] By contrast, in Europe, JISC takes a more holistic stance and broadly describes the term as "those capabilities, which fit an individual for living, learning, and working in a digital society."[142] It is becoming clear that however defined, digital literacy is not a checklist of specific technical skills, but rather the development of critical thinking and reflection in various social and cultural contexts.[143]

Students today would appear to be more digitally literate than previous generations because many have grown up immersed in technology-rich environments, but research has shown that this does not necessarily equate to confidence, especially in an educational context.[144] The Organization for Economic Co-operation and Development's (OECD) most recent survey of adult skills found that millennials in the US placed nearly last in digital literacy as compared to other developed nations.[145] Illuminating this problem is the Rasmussen College study "Digital Literacy in 2015," which reports that one in four millennials want to improve their digital literacy, but 37% find the Internet "scary," more so than respondents aged 35 and over.[146] The US is not alone; studies around the world are debunking the myth that age plays a factor in comfortably using various technologies.[147]

While this challenge is widespread in higher education, the 2016 Horizon Project Expert Panel recognized it as solvable, as many projects to foster digital literacy are already underway. At Staffordshire University in the UK, faculty have developed a community of practice around the Digital U program, which provides staff with online resources as well as face-to-face opportunities for peer-to-peer learning.[148] Around the world, digital curation, defined by the Higher Education Academy as "the act of finding and selecting, grouping and contextualizing, preserving, maintaining, archiving, and sharing digital content,"[149] is viewed as a way to help students develop their digital literacy. For years educators have leveraged curation tools such as Scoop.it, Storify, and Pinterest to help students critically evaluate online resources.[150] Australian researchers, for example, have been studying the use of Scoop.it, in conjunction with goal-setting, to develop digital literacy skills and increase student engagement.[151]

Implications for Policy, Leadership, or Practice

Equipping students with the digital literacy skills necessary to be productive in a rapidly changing work environment is a key interest of stakeholders and policymakers.[152] The Digital Agenda in Europe 2020 was created to foster innovation and economic growth across the European Union; one of seven pillars to achieve these goals is the promotion of digital literacy, skills, and inclusion.[153] While this effort is an ambitious step in the right direction, progress remains uneven. A Dublin Institute of Technology report states that by the end of 2014, 39% of the EU workforce had insufficient technology skills and 14% had none at all.[154] In the US, the government recently announced the $100 million TechHire Initiative to provide educational opportunities for the growing number of technology-

centric jobs. It is a multi-sector effort that includes software development training and paid internships with technology companies.[155]

Through the creation of frameworks, higher education leaders are helping students and faculty learn skills for working in a digital society. The JISC Developing Digital Literacies Programme in Europe explored various institutional approaches to digital literacy development in higher education.[156] JISC called for approaches that focus on the curriculum; use frameworks as tools for engagement; provide timely information, guidance, and support; engage in partnerships, networks, and communities of practice; and embed digital literacies into professional development programs.[157] Library organizations have also been instrumental in creating related literacy standards. The Association of College & Research Libraries' Framework for Information Literacy for Higher Education provides a cluster of interconnected core concepts, which organize ideas about information, research, and scholarship into a comprehensive whole.[158]

Solving this challenge calls for innovative approaches to delivering digital literacy training to students, and a number of projects are well underway. Virginia Commonwealth University's "UNIV 200: Inquiry and the Craft of Argument" is a blended learning course that takes students through a number of exercises, such as discovering the work of innovators in the digital realm and developing personal learning networks through the creation of websites and social media communities.[159] At Ryerson University in Canada, coding is seen as an emerging and important literacy that will cultivate in students the skills needed to define and create the digital tools of the future. In their "Challenge Accepted" workshops, students learn how to create a mobile app in only three hours.[160] While not every graduate will pursue a career in computer science, at minimum, understanding how algorithms apply structured linear thinking to address a variety of problems will be a key workforce skill, even in non-technical fields.[161]

For Further Reading

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

IFLA Media and Information Literacy Recommendations
go.nmc.org/medinf
(IFLA, accessed 7 January 2016.) IFLA urges governments and intergovernmental organizations, as well as private institutions, to pursue policies that advocate for media and information literacy as an emerging field of human rights in an increasingly digital world. > *Policy*

Mapping Digital Literacy Policy and Practice in the Canadian Education Landscape
go.nmc.org/mapping
(Michael Hoechsmnan and Helen DeWaard, *MediaSmarts*, 30 March 2015.) There is considerable variance in digital literacy policies and implementation programs among provinces and territories in Canada. The goal of this report is to show Canadian educators and policymakers a comprehensive snapshot of digital literacy. > *Policy*

CI Keys: Unlocking the Web
go.nmc.org/cik
(CSU Channel Islands, accessed 23 December 2015.) CSU Channel Islands' CI Keys project provides faculty and students with open-source content creation tools to integrate into course projects so they are able to become familiar with building online portfolios, journals, wikis, and other kinds of digital resources. > *Leadership*

Elements of Digital Literacy
go.nmc.org/elem
(Deakin University, accessed 5 January 2016.) Deakin University Library has developed digital literacy guides for students and faculty that articulate the skills needed to appropriately find, use, and disseminate relevant information sources. > *Leadership*

Multimedia Literacy
go.nmc.org/multilit
(University of Delaware Library, accessed 5 January 2016.) The University of Delaware's Student Multimedia Design Center is a space within the library that houses resources to guide students through the multimedia design process as they work on their own projects, from pre-production through post-production. > *Practice*

Writing Program Administration and Technology: Toward a Critical Digital Literacy in Programmatic Contexts
go.nmc.org/toward
(Jenna Pack Sheffield, *UA Campus Repository*, 2015.) This study explores the relationship between writing programs and critical, theoretical understandings of digital literacy, comparing the digital literacy initiatives and related professional development opportunities in writing programs across the country. > *Practice*

Competing Models of Education

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

New educational models are bringing unprecedented competition to traditional models of higher education in which students typically receive on-campus instruction by faculty or teaching assistants per credit hour over four years. Institutions are increasingly looking for ways to provide high-quality offerings and more diverse learning opportunities at lower costs.[162] While MOOCs were at the forefront of discussions a few years ago, competency-based education, coding boot camps, and general unbundling of products and services are also disrupting existing credit-hour systems and degree programs.[163] As these new pathways arise, there is a growing need for education leaders to frankly evaluate the models and determine how to best support collaboration, interaction, and assessment at scale. It is clear that simply capitalizing on emerging technology is not enough; the new models must use these tools and services to engage students on a deeper level and ensure academic quality.

Overview

Calls to disrupt the traditional campus-based model to improve workforce readiness are coming from both inside and outside of academia, and are covered in more detail in the Keeping Education Relevant challenge featured later in this report. Alternatives to traditional postsecondary education are on the rise in response to students' evolving expectations. Both millennials and the growing majority of nontraditional college students are demanding greater flexibility and delivery models that leverage technology to foster more ubiquitous access to learning experiences. An Accenture survey of students in Australia, India, Singapore, the UK, and the US found that 85% of 1,500 college-bound respondents claimed that an institution's digital capabilities, such as classroom technology integration and availability of online learning options, were key determinants in their selections.[164]

The rising cost of private and public university tuition, along with questions regarding the return on investment, are compounding this challenge.[165] The College Board's "Trends in College Pricing 2015" found that tuition and fees at public four-year institutions are 40% higher in 2015-16 than in 2005-06, adjusted for inflation.[166] Demand is increasing for new models that provide both the opportunity to save money and progress more quickly to the workforce. A few years ago, MOOCs surfaced as a high-profile example of a competing model. While MOOCs experienced a meteoric rise followed by a backlash of skepticism, experts believe that recent developments in online learning will be disruptive. Coursera's "Data Science Sequence" course, for example, is priced at $470 and includes nine four-week online courses and a capstone project taught by Johns Hopkins University. Students receive a certificate and portfolio demonstrating their mastery of the material.[167]

Interest in competency-based degree programs, which allow for more flexible and personalized degree options, is also on the rise as a potential solution, but ensuring academic quality remains an obstacle.[168] According to EDUCAUSE, competency-based education (CBE) provides academic credit for mastery of clearly defined competencies, leveraging the potential of online learning by saving students time and money.[169] Brandman University has one of a handful of CBE-accredited bachelor's degree programs that enables students to earn degrees through self-paced modules and assessment rather than semester-long programs.[170] Alternative learning models are increasing in both size and type, especially for STEM careers. Three examples include Udacity's software developer nanodegree programs, built in partnership with industry leaders including Google and AT&T;[171] Code Louisville's coding boot camps, where students learn programming languages over 8 to 14 weeks;[172] and the Flatiron School, which provides 12-week app development courses where students earn at least $70,000 a year upon completion.[173]

Implications for Policy, Leadership, or Practice

Competition from new pedagogies is not likely to foster widespread change unless there is regulatory reform from government. The introduction of new funding models is slowly moving the needle. Higher education funding in the US is also slowly shifting from models that incentivize enrollment to student performance measures and other state goals and priorities.[174] Oregon, for example, approved a new approach that requires state funds to be allocated to universities based on

student access and successful completion.[175] While there is a move to more performance-based funding in the US, a recent report on the topic by the European University Association warns that expectations for this approach may be too high and urges caution about the impact of funding mechanisms.[176]

To get ahead of the shifting landscape of higher education, leaders have launched think tanks and conferences around the world. The American Council on Education's Presidential Innovation Lab was a multiyear effort that joined college and university presidents to understand new instructional and business models. They have discussed the implication of trends such as personalized learning, competency-based education, and global university models through a series of white papers.[177] The inaugural Summit on Innovating Academic Credentials was held in 2015 and convened education, business, philanthropy, and technology leaders to explore how technology is extending the reach and meaning of machine-readable academic credentials.[178] Similarly, in Australia, a recent international conference revolved around the theme of universities shaping the new era; topics included competitive advantages, industry engagement, and work-integrated learning in higher education.[179]

Online learning is helping to facilitate entirely new areas of focus and growth at universities beyond MOOCs. EMLYON Business School, for example, is leveraging IBM's big data and analytics capabilities to create smart cloud-based business courses that reduce geographical barriers and personalize the learning experience across multiple sites, devices, and languages.[180] Arizona State University's Global Freshman Academy is another innovative model that provides students with first-year credit after mastering a sequence of edX-hosted digital immersion courses. This initiative enables students to explore and complete courses before applying or paying for credit.[181] In Fall 2015, Minerva University disrupted the higher education paradigm when it welcomed its first cohort of freshman students. Consisting of 130 undergraduates from 36 countries, classes are held online in different countries every year. Minerva plans to add a master's degree program so that graduates will emerge from the program with two degrees in four years at $17,500 per year.[182]

For Further Reading

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

How Should Quality Assurance for Competency-Based Ed Work?
go.nmc.org/qualiya
(Michael B. Horn, *eCampus News*, 17 August 2015.) This article describes how the federal government can help harness the potential of emerging education models, like competency-based programs, by encouraging and funding a variety of experiments and research into approaches for evaluating program outcomes and efficacy. > *Policy*

Obama Has a $100M Plan to Fill the Tech Talent Shortage
go.nmc.org/techhire
(Issie Lapowsky, *Wired*, 9 March 2015.) The Obama Administration is working with the business advisory firm CEB to develop a guide for employers on how to recruit technology workers from less traditional places. > *Policy*

Beyond the Transcript
go.nmc.org/broad
(Paul Fain, *Inside Higher Ed*, 13 July 2015.) The American Association of Collegiate Registrars and Admissions Officers is partnering with higher education institutions to develop and test new models of a next generation student record to more comprehensively document student knowledge and experiences. > *Leadership*

Here's What Will Truly Change Higher Education: Online Degrees That Are Seen as Official
go.nmc.org/seenas
(Kevin Carey, *The New York Times*, 5 March 2015.) This article delves into why free or low-cost credentials have yet to revolutionize education, describing how college degrees are still deeply embedded in government regulation and standard human resources practices. > *Practice*

Stories from Students in Their First Semester of Distance Learning
go.nmc.org/stories
(Mark Brown et al., *International Review of Research in Open and Distributed Learning*, October 2015.) Online learning is the fastest growing sector of university-level education, but a gap exists in understanding the course design and learning support requirements for distance students. This study gathers insights from video diaries of 20 first-time, fully online students. > *Practice*

Universities Must Adapt to Meet Student Needs
go.nmc.org/mustadapt
(Patrick T. Harker, Philadelphia Media Network, 5 February 2015.) The author argues that universities must become more learner-centric, efficient, and transparent as innovative, less expensive degree paths are beginning to offer viable alternatives. > *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.[183] While there is demand for personalized learning, it is not adequately supported by current technology or practices — especially at scale. The increasing focus on customizing instruction to meet students' unique needs is driving the development of new technologies. Advancements in online learning environments and adaptive learning technologies are making it more possible to support learners' individual learning paths. A major barrier, however, is that scientific, data-driven approaches to effectively facilitate personalization have only recently begun to emerge; adaptive learning, for example, is still evolving and gaining traction within higher education. Compounding the challenge is the notion that technology is not the whole solution — personalized learning efforts must incorporate effective pedagogy and include faculty in the development process.[184]

Overview

Personalized learning consists of learning strategies, solutions, and interventions that align with individual learner goals and account for differences in background knowledge, passion or interest in topics, and subject mastery. The purpose of personalized learning is to empower students to take ownership of the learning experience and prime themselves for lifelong learning. Giving students more autonomy can increase motivation and engagement with the subject matter.[185] On the surface, the term "personal" may connote a solitary experience, but effective personalized learning approaches have the potential to facilitate a constant conversation between the student and instructor, providing each with crucial insights about what areas need further attention. This is particularly compelling for large, introductory courses at universities and colleges where students often decide whether or not to continue pursuing a specific major or discipline.

What makes personalizing learning a difficult challenge is that interest in the approach is outpacing the number of large-scale implementations; tangible outcomes in higher education are still scarce.[186] At the moment, many of the efforts in this space fall into the category of technology development, rather than pedagogical frameworks. Enabling technologies, such as adaptive learning solutions and digital courseware, detailed later in this report, aim to provide interventions on the level of one-on-one tutoring, showing students where improvement is needed as they move through the material.[187] EDUCAUSE reports that integrating the tools with appropriate curriculum design is key, "ensuring that the goals and the means of pursuing them are considered in tandem."[188] In this vision, a balance must be struck between computer intervention and human thinking as students must be actively involved in progressing their own understanding instead of simply relying on machine guidance.[189]

Though personalized learning is poised to have a profound impact on teaching and learning if approaches are designed and deployed effectively, detractors cite concerns over who has authority over the academic content in adaptive learning systems, and the extent to which the courseware will be perceived as a replacement for instructors. Others believe that at-risk students will still need more interactions with instructors and peers.[190] A top-down approach where faculty are mandated to use adaptive learning technologies without consideration of how they fit in with curriculum or desired learning outcomes could be harmful. Not only do instructors need more training opportunities around personalized learning, but they must also be heavily involved in the design of personalized learning initiatives.

Implications for Policy, Leadership, or Practice

UNESCO is setting important precedents to drive international discussions and policymaking sessions. In advance of the 2015 UNESCO Global High-Level Policy Forum, education leaders from 53 countries were surveyed on how to best achieve open, online, and flexible learning. Over 50% identified the importance of the faculty role in supporting students through personalized learning; UNESCO cites professional development for teachers and faculty as a critical part of the strategy, particularly around leveraging open educational resources. They also recommend development of systematic approaches that stimulate

more flexibility in online learning that ultimately engage students more deeply.[191] However, there are still complex privacy issues surrounding personalized learning policy that may impact technology adoption. Many laws, such as FERPA in the US, govern student record retention and data security on an institutional level, but do not provide privacy protections for students who sign up for personalized learning services directly with vendors.[192]

The Bill & Melinda Gates Foundation has been integral to advancing the field. Through a vast network of partners and grantees, they are investing in adaptive learning[193] and digital courseware[194] solutions that enable personalized learning and promote greater student success and equity[195] in higher education. One grantee, Association of Public & Land-grant Universities (APLU) was awarded $4.6 million in 2015 to support a consortium of institutions in scaling adaptive courseware across their campuses with the goal of improving student learning outcomes and accelerating degree completion.[196] APLU is deeply incorporating faculty into project leadership, creating a model for cross-institutional faculty collaboration on adaptive courses.[197] Personalized learning is also gaining steam broadly as influencers such as Mark Zuckerberg have publicly committed to investing in personalized learning, citing it as a pathway for students to gain skills and confidence to learn any subject they pursue.[198]

The University of Wisconsin–Milwaukee has already woven personalized learning into their psychology courses. Developed by the American Psychological Association, the U-Pace course leverages an instructional model that includes a self-paced learning tool that reveals to students their progress around core competencies. Instructors also provide personalized feedback and motivational support on a weekly basis. Six months after course completion, students performed 16% higher on cumulative exams than conventionally taught students, and the knowledge gap between low-income students and higher-income students significantly narrowed.[199] Further, institutions are increasingly exploring the science behind developing personalized learning initiatives. Stanford University's Open Learning Initiative is leveraging learning analytics, providing online students with targeted feedback along with self-assessment tools so they can better understand their knowledge gaps and adjust their study plans accordingly.[200]

For Further Reading

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

Open Education: Individualized Learning from Kindergarten to College
go.nmc.org/indiv
(Lindsey Burke and Vance Fried, The Heritage Foundation, 9 November 2015.) As interest mounts for personalized learning, policymakers and educators must work together to establish ways in which competency-based learning, facilitated by open educational systems, can be implemented. In higher education, accreditation policies are proving to be a barrier. > *Policy*

Liberal Arts - Personalized Learning
go.nmc.org/liba
(Northern Arizona University, accessed 23 December 2015.) Northern Arizona University has incorporated personalized learning into their degree plans by offering an autonomous, self-paced online liberal arts degree leveraging competency-based learning to promote mastery-level knowledge. > *Leadership*

Personalized Learning: An Overview (PDF)
go.nmc.org/itali
(Emma Bartle, The University of Queensland, 16 March 2015.) While the overall consensus about personalized learning seems optimistic, there are challenges that must be addressed before large-scale implementations, including clearly defining the role of educators and creating deeper learning approaches through online portals. > *Leadership*

PLORS: A Personalized Learning Object Recommender System (PDF)
go.nmc.org/plors
(Hazra Imran et al., *Vietnam Journal of Computer Science*, 30 July 2015.) Research on the potential LMS integration of a recommendations engine that is based on students' previous experience resulted in the creation of PLORS, a system that identifies the most useful learning objectives for students. > *Leadership*

Smart Libraries Will Power the Transition to Personalized Learning
go.nmc.org/smarli
(David Kim and Jeffrey Pomerantz, *EdSurge*, 22 September 2015.) This article illuminates the ways in which academic libraries can influence more personalized learning within higher education. By offering textbooks online, libraries can leverage student data to offer material recommendations and real-time analysis of student interaction with texts. > *Leadership*

Learning to Adapt
go.nmc.org/essex
(Paul Frain, *Inside Higher Ed*, 28 August 2015.) During Essex County College's personalized learning implementation, the biggest challenges were students regulating their own work unsuccessfully, along with the unwillingness of educators to adapt their teaching methods. > *Practice*

Balancing Our Connected and Unconnected Lives

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

With technology now at the center of many daily activities,[201] higher education institutions must help learners understand how to balance their usage with other developmental needs. To prevent students from getting lost in the abundant sea of digital tools, universities and colleges are tasked with encouraging mindful use while making them aware of their digital footprint and the accompanying implications.[202] As education aligns more closely with technological trends, instructors will have to promote this balance, facilitating opportunities where students feel, digest, reflect, and pursue sensorial experiences that are crucial to developing character and integrity. Guiding learners to personal success in their own habits is especially critical for incoming generations of students that have relied on technology from an early age. While there are plenty of studies and articles discussing healthy amounts of screen time for children,[203] there are no agreed-upon models for adults when it comes to learning. Furthermore, institutions have a responsibility to ensure that when students and faculty are connected it is with the purpose of transformation — not just replicating experiences that could take place without technology.[204]

Overview

The proliferation of always-connected devices, particularly mobiles, has made conducting research possible anywhere. With technology usage, however, there is a fine line between convenience and addiction, especially when it comes to taking advantages of the social networking and communication features. A survey conducted by Baylor University found that college students spend between eight to ten hours daily on their smartphones, with many agreeing that they are wasting their time or have become overly dependent.[205] There is freedom in being able to communicate with peers and find information any time, but if these online activities are not balanced properly with self-reflection and analysis, technology can become a crutch — an excuse not to engage in the kind of critical thinking that leads to meaningful discovery and deep understanding.

Compounding this wicked challenge is the inherent pressure placed on students to multi-task successfully, juggling coursework with extracurricular activities and social life, and excelling at all aspects. Psychologists believe that adding excessive technology use to this equation compels people to be reachable at all times, fueling concerns that if they do not respond to every email or see every social media post they will be missing out on something important. This fragmented mentality often leads to exhaustion and burnout.[206] While most institutions have acceptable use policies for mobiles and citing digital resources, the burden still falls squarely on learners to balance their time with and without technology. Students are increasingly encouraged to bring their devices to class,[207] but Michigan State University researchers found that even the highest-performing students struggled to use their devices for productive activities such as taking notes while managing the accompanying distractions.[208]

Technology has played a vital role for stimulating student creation, deeper learning, global awareness, and more;[209] implementing it in a balanced manner requires a careful consideration of how it relates to the learning process. One major challenge for educators is to assimilate digital tools in ways that are expressly tied to transformative learning experiences that make a genuine impact on students. The SAMR model provides a potential framework for ensuring technology is used with purpose. In the SAMR acronym, "S" is for Substitution — the most basic level of technology integration — where it acts as a direct tool substitute, with no functional change. An example would be an e-book that completely replicates the print version so nothing new is gained for students. The goal for instructors is to reach the "R" stage, which stands for Redefinition, in which the capabilities of the deployed technology allow for the creation of new tasks that were previously inconceivable.[210]

Implications for Policy, Leadership, or Practice

In 2015, education ministers, private companies, and educators convened at the inaugural Global Education Industry Summit in Finland to discuss frameworks for striking a balance between technology and high-quality teaching and learning. The result was a call to action for governments to develop national agendas that champion transformative technology use while avoiding institutions simply becoming "a marketplace for commercial self-interest of any corporation."[211] As educational technology

use is increasing, more institutions are both encouraging and attempting to regulate it. An article published by researchers at Canada's Laurentian University analyzes the policy implications in higher education and recommends ideal strategies. The authors noted it was important for policies not to be too rigid and that they are most effective when technology is primarily promoted as a vehicle for pedagogical innovation.[212] Otherwise, policies risk promoting technology just for technology's sake without any change in learning outcomes.[213]

A partnership between JISC, the University of Oxford, OCLC Research, and the University of North Carolina, Charlotte has exemplified leadership in bridging connected and unconnected learning. They recently created the guide "Evaluating Digital Services: A Visitors and Residents Approach," which explores the relationship between online and more traditional offerings to gain a better understanding of how students "navigate the overlapping worlds of the web and formal education." The guide's aim is to help education leaders critically evaluate the efficacy of technologies and web resources for promoting authentic learning. JISC and partners emphasize that fostering successful learner engagement with digital tools is about understanding the reasons behind their specific technology choices. Ultimately, practitioners must develop their own curricula that incorporate varying degrees of technology use, so they need to continuously collect feedback from learners to take into account student perspectives.[214]

The landmark project, "A Day Without Media," led by ICMPA and the University of Maryland, College Park, provided students with an opportunity to disconnect from technology to better understand how it has impacted them.[215] While most students did not enjoy being cut off from the constant flow of information, the experiment provided key insights: institutions must help them understand the moral and social implications of how they use technology.[216] A number of progressive universities are emphasizing outdoor education as a means of providing students with more sensory and hands-on experiences. At College of the Atlantic, for example, human ecology students work with people in their community, engaging primarily in field-based learning across organic farms and offshore island research stations.[217] Evergreen State College also holds most of their flexible classes outdoors, encouraging students to get involved with community gardens and campus farms that provide the food for the school cafeteria.[218]

For Further Reading

The following resources are recommended for those who wish to learn more about balancing our connected and unconnected lives:

Balancing Innovation and IP to Advance the Digital Economy
go.nmc.org/ntia
(Angela Simpson, NTIA, 27 October 2015.) The Commerce Department's National Telecommunications and Information Administration advocates for students learning through fair use of media by proposing exemptions from the Digital Millennium Copyright Act that enable innovation and free expression. > *Policy*

Mindful Check-ins Can Facilitate Use of Technology, Expert Says
go.nmc.org/checkin
(Appalachian State University, 26 October 2015.) A professor at the University of Washington traveled to Appalachian State University to discuss the intersection of technology and contemplative practices with students. Recognizing when and how they make choices can help students leverage their own intention to use technology to their advantage. > *Leadership*

New Tool Sheds Light on how Digital Technologies are Breaking Down Traditional Life Boundaries
go.nmc.org/digibrain
(Lancaster University, 2 October 2015). Researchers from several UK universities collaborated on the Digital Brain Switch Project, a study of the impact of digital technologies on work-life balance. The team created a web-based tool, MyLifeRocket, which enables users to report their moods and behaviors in conjunction with technology use. > *Leadership*

Educating Generation Next: Screen Media Use, Digital Competencies and Tertiary Education
go.nmc.org/genext
(Toija Cinque and Adam Brown, *Digital Culture & Education*, 1 March 2015.) In an effort to assess the competing discourses around the perceptions and actual use of technology for learning, this study of Australian first-year university students examines how they currently engage with media. > *Practice*

Robot for Mindful Technology Use?
go.nmc.org/robotformind
(Newshedgehog, 29 December 2015.) An MIT engineer created a robot aimed at helping users overcome screen addictions by supporting more natural face-to-face interaction. > *Practice*

Why the Modern World is Bad for Your Brain
go.nmc.org/modworld
(Daniel J Levitin, *The Guardian*, 18 January 2015.) The author draws attention to some of the downsides of having constant access to email and social media, describing the cognitive cost of multitasking and how people can develop a novelty-seeking neural addiction that neglects higher-level thinking skills. > *Practice*

Keeping Education Relevant

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

Today, a college degree no longer guarantees gainful employment. The Economic Policy Institute recently found that Americans under age 25 are more than twice as likely to be unemployed as other age groups.[219] This issue is not localized; rising youth unemployment rates and labor market research about the global skills gap leave many concerned that current higher education systems do not prepare learners for the workplace's rapid modernization.[220] Many countries have responded with initiatives prioritizing STEM training, yet critics of this movement defend studies of the humanities as promoting ethical inquiry and social justice.[221] Although vocational education and training (VET) has been framed as a promising solution, negative cultural perceptions are still driving students into formal education.[222] Addressing this challenge means envisioning new ways to earn a college degree that will equip students with applicable industry-specific skills while maintaining the ethical training and credibility of traditional academia.[182]

Overview

At a time when the Internet enables learners to gain new knowledge and skills freely, the formal four-year degree remains the hallmark of employability; the Georgetown Public Policy Institute predicts that by 2020, 65% of all jobs will require postsecondary education and training beyond high school.[223] While demand for formal education is still high, a wide range of factors are causing some to question its value. A recent survey of 400 companies found that 96% believe all students should have higher education experiences that teach them to solve problems collaboratively with people whose views are different from their own, with a strong emphasis on the importance of applied learning and teamwork. The vast majority of employers, however, said they feel recent graduates lack the skills needed to be successful in today's workplace.[224]

Some global leaders have acknowledged the skills gap, and are advancing reforms that encourage higher education institutions to remedy this issue. President of Japan Shinzō Abe recently announced a new economic growth strategy; this was followed by a decree from Japan's Minister of Education that forced national universities to shutter social science and humanities departments, or risk losing funding from the federal government.[225] This move has generated significant backlash from those who champion the humanities' steadfast role in post-secondary learning, citing their value in forming a well-rounded worldview. Some experts point to reasoning used in Aristotle's *Nicomachean Ethics* extolling the humanities as the middle ground that helps humans navigate society with practical wisdom to advance "the common good." In other words, they argue that scientific knowledge alone is not enough to address the multidimensional social problems people face today.[226]

A common response to this challenge has been the resurgence of interest in vocational education and training (VET) because of its proven success in providing students guaranteed work experience and employment. Yet, labor market researchers have identified a stigma against vocational schools that is funneling students continuously into formal higher education environments.[227] Recently, Central Queensland University announced plans to restructure its VET division after a $6 million loss due to a decline of more than 20% of vocational students in the last two years.[228] In many countries, vocational education is perceived as the inferior choice to traditional university pathways, although evidence increasingly demonstrates its widespread economic benefits.[229] In this climate, national and institutional leaders are challenged to devise new systems that combine the best of both worlds, offering learners a collegiate experience that prepares them for a meaningful life of work, production, and thoughtful inquiry.

Implications for Policy, Leadership, or Practice

For this wicked challenge, solution-oriented policies are just beginning to emerge. UNESCO recently published "Rethinking Education: Towards a Global Common Good?," a far-reaching philosophical treatise on what values should guide the evolution of teaching and learning in the 21st century. Positioning sustainable development as the ultimate goal of education, the authors reaffirm human-centered approaches to policymaking, directly informing strategies associated with economic globalization and rising youth employment.[230] In 2015, officials in India announced

a national policy to integrate vocational training with formal education. The policy seeks to redirect college dropouts into vocational pathways, while simultaneously enhancing the social status of those who study trades. One directive of the policy will align vocational courses to the National Skills Qualification Framework, which will allow polytechnic and community colleges to award bachelor's degrees for vocational studies.[231]

Several innovative programs are pioneering models that offer students opportunities to build industry-specific skills while participating in formal higher education environments. The UK has introduced the Degree Apprenticeships program, an initiative that promises to bring together "the best of higher and vocational education." By offering nine industry-designed pathways of study, the new strategy creates opportunities for students to earn bachelor's and master's degrees while receiving on-the-job training, with costs shared by the government and employers.[232] At SUNY Cobleskill, a small agricultural university in New York, Chinese citizens who have completed three years of vocational training can earn a bachelor's degree via the Path Pro Program. The first of its kind in the US, the Path Pro Program engages four vocational colleges in China, allowing Chinese learners to prepare for high-skilled industry jobs and benefit from the earning potential and social status that comes from a four-year college degree.[233]

While skills training is an important theme of this challenge, much attention has been paid to the idea of merging the humanities with scientific disciplines to inform broad perspectives. At Harvard University, the Project on Purpose and Values in Education has created co-curricular programming that helps students reflect on big questions of meaning, value, and purpose. Using best practices and resources from this project, Harvard faculty can integrate social and moral inquiries into technical subject matter, enabling learners to effectively advance the common good through any career path.[234] As part of its Common Curriculum, Yale-NUS College emphasizes the powerful dynamic between liberal arts and science for solving 21st century problems. Through courses such as "Scientific Inquiry and Quantitative Reasoning" alongside "Comparative Social Institutions and Literature and the Humanities," learners form an extensive knowledge base to drive critical thinking about global dilemmas.[235]

For Further Reading

The following resources are recommended for those who wish to learn more about keeping education relevant:

Better Information for Better College Choice & Institutional Performance
go.nmc.org/score
(US Department of Education, September 2015.) The US Department of Education's college scorecard and technical website provides students, families, and advisors with a transparent picture of college cost and value, comparing colleges and universities based on the degree to which the institution supports students through graduation. > *Policy*

Economic Engagement Framework
go.nmc.org/econom
(The Association of Public and Land-grant Universities, accessed 7 January 2016.) APLU has developed a set of tools to help universities plan, implement, assess, and advance their economic engagement efforts, which relates to how they engage with and enhance the competitiveness of their communities as well as serve the global society. > *Policy*

Employability Skills in Higher Education Curriculum
go.nmc.org/employskills
(The British Council, 11 June 2015.) The British Council, in partnership with the Higher Education Council of the Ministry of Education, organized the workshop "Embedding Employability Skills in the Curriculum," which supported participants in developing employability benchmarks to help bridge the gap between the higher education sector and workforce. > *Leadership*

Master of Tri-Sector Collaboration
go.nmc.org/mtsc
(Singapore Management University, accessed 7 January 2016.) Singapore Management University's Master of Tri-Sector Collaboration focuses on the importance of cross-sector collaboration. Students learn to make sense of megatrends affecting business-government-society interactions. > *Leadership*

Community Colleges Adapt to Job Trends with New Degrees, Student Support
go.nmc.org/comcollege
(Amy Lane, *Crain's Detroit Business*, 27 May 2015.) Many community colleges are taking cues from the market and building industry partnerships to design or redesign their degree programs and certificates so that they prepare students for future demands. > *Practice*

Keeping Competency-based Programs Relevant Over Time
go.nmc.org/keeping
(Brian Fleming, *Eduventures*, 11 August 2015.) Competency-based programs must actively pursue industry partnerships and solicit their input to align courses with employers' needs and ensure relevance and sustainability. > *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 technology developments, 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 development 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 development 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 developments in technology 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. Technology developments 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 it is more than five years away from widespread adoption. Some technology developments, while intriguing, do not have enough credible project examples to substantiate them.

A key criterion for the inclusion of a new technology development in this edition was its potential relevance to teaching, learning, and creative inquiry in higher education.

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 colleges and universities. 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 technology developments highlighted by the 2016 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
> Quantified Self
> Robotics
> Telepresence
> Wearable Technology

Digital Strategies
> Bring Your Own Device (BYOD)
> Flipped Classroom
> Location Intelligence
> Makerspaces
> Preservation/Conservation Technologies

Internet Technologies
> Bibliometrics and Citation Technologies
> Cloud Computing
> Networked Objects
> Semantic Applications
> Syndication Tools

Learning Technologies
> Digital Badges
> Learning Analytics and Adaptive Learning
> Mobile Learning
> Online Learning
> Open Content
> Open Licensing
> Virtual and Remote Laboratories

Social Media Technologies
> Crowdsourcing
> Online Identity
> Social Networks

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

Enabling Technologies
> Affective Computing
> Electrovibration
> Flexible Displays
> Machine Learning
> Mesh Networks
> Mobile Broadband
> Natural User Interfaces
> Near Field Communication
> Next-Generation Batteries
> Open Hardware
> Speech-to-Speech 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), is the practice of people bringing their own laptops, tablets, smartphones, or other portable devices with them to learning or work environments. As of 2015, millennials became the largest generation represented in the US workforce,[236] and as a group generally accustomed to mobiles being at the center of their lives, there is now an expectation that they can use them for many aspects of their work life.[237] 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. According to a 2015 study, at least 42% percent of colleges and universities in the US had implemented a BYOD strategy in 2014.[238] Even in the absence of concrete strategies, campuses across the world are accommodating and even encouraging the use of mobile devices for a wide range of teaching and learning activities.

Overview

As the link between the use of personal devices and learning has crystalized in recent years, the question is no longer whether to allow them in the classroom, but how to most effectively integrate and support them. The BYOD movement is enabling students to learn using the technology with which they are already familiar and comfortable, providing them with a greater sense of ownership over their learning. With 86% of undergraduate students owning a smartphone or tablet,[239] today's students expect to be able to use whatever devices they choose to access learning content, take notes, gather data, and communicate frequently with their peers and instructors. In this sense, the adoption of BYOD does not revolve around promoting technology use, but facilitating ubiquitous learning and productivity gains. At Indiana University, a one-day snapshot of student wireless activity in 2015 revealed 34,344 wireless registrations from 541 device types and 32 operating systems.[240]

BYOD policies have especially gained traction as institutions are developing more robust WiFi infrastructures to ensure faculty and students are constantly connected to the network with the ability to download and stream learning content quickly. Brunel University London, for example, recently partnered with Cisco to create a reliable solution that included more access points and controllers dispersed across 70 campus buildings.[241] For BYOD critics concerned about potential security risks, universities are proactively creating policies that emphasize safety. Lebanon Valley College (LVC) requires students to register their devices with the institution. This allows campus officials to identify the specific devices responsible for hacking incidents. It is also important to accommodate the notion that learning does not just take place in lecture halls; LVC has built a new learning commons to spur more collaboration. The space is equipped with large television monitors so that faculty and students can stream video from their mobile devices.[242]

Now that personal technologies are more pervasive at higher education institutions, the definition of BYOD is expanding beyond laptops, smartphones, and tablets. The increased use of mobiles has created an opening for other sorts of devices to enter the classroom. Wearables such as smartwatches are growing in popularity in the consumer sector as convenient and productive alternatives to smartphones. Forrester Research reports that more than 20% of Internet-connected adults regularly use a wearable device.[243] Smartwatches are now being piloted at higher education institutions such as Oral Roberts University for the purpose of fitness tracking in nutrition programs.[244] The rise of the Internet of Things is also making it possible for a range of portable smart objects to make a world of information available to and controlled by users, further encouraging mobility in the future workplace and across campuses.[245]

Relevance for Teaching, Learning, or Creative Inquiry

BYOD policies are enabling faculty to update the ways in which they deliver content and assess student learning. This is especially the case as progressive institutions are beginning to allow personal device use during testing. Instructors at Aarhus University in Denmark, for example, are leveraging the tool Wiseflow to allow students to eliminate paper tests and bring their own devices to class for digital exams. Wiseflow enables faculty to create

and manage exams, assign them to specific students, and assess the materials that they subsequently submit through their mobiles.[246] At University of Southern California, the French department piloted a new model of e-textbooks collaboratively created by faculty, which standardized the content and delivery between courses and allowed students to access important handouts and exercises from any connected device.[247]

As technological developments such as mobile learning, digital textbooks, and analytics continue to converge, educational content is increasingly being produced for consumption on smartphones and tablets. American Public University System (APUS) and University of Texas at Austin have launched course apps that leverage the Adobe toolset to foster more interactive and engaging experiences for students on the devices they choose. A history course app at APUS, for example, includes embedded videos and timelines, along with knowledge checks so students can continuously assess their learning.[248] This development is ultimately less about the devices and more about the content that can be loaded onto them; BYOD enables students and educators to leverage the tools that make them most efficient, including location-based services, social networks, and video streaming. A study conducted by McGraw-Hill Education and Hanover Research reported that 48% of surveyed students use their own mobile devices to study.[249]

It is now commonplace for colleges and universities to develop their own apps to maximize the benefits of their BYOD policies. Emory University recently went from two available apps to building 60, allowing 24,000 devices for 15,000 students and 28,000 employees on its network at any given time — and nearly all the apps work on any device. Staff now has instant access to the latest safety codes, and university hospital residents and surgeons can easily find information about transplant protocols.[250] Recognizing the importance that mobile devices play in productivity, students are also developing apps to assist their peers. For the AppJam at California State University Northridge, student teams competed by creating apps in two categories — student life or student finances. Notable entries included apps that students could use across any device to alert campus police to safety hazards, find other students to carpool to campus, and learn valuable investment skills.[251]

Bring Your Own Device in Practice

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

Colombian School Uses Citrix to Manage their Cali Campus
go.nmc.org/citrix
Pontificia Universidad Javeriana Cali in Colombia is using Citrix technology to create a virtualized environment of resources accessible to both faculty and students through their personal devices; this has increased productivity and cut costs related to licensing, rotation of equipment, energy, and maintenance. > *Leadership*

BYOD Seminar Rooms
go.nmc.org/uos
Form meets function in the BYOD seminar rooms at the University of Sydney, which are equipped with wireless Internet, device-charging stations, and lightweight furniture designed for easy rearranging. > *Practice*

MyTech: A BYOD App for Physics Labs
go.nmc.org/mytech
MyTech is a free mobile app developed by North Carolina State University for iOS and Android that replaces expensive lab equipment in introductory physics labs, allowing students to visualize, explore, and measure physical motion through their own devices. > *Practice*

For Further Reading

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

Welcome to Bring Your Own Access
go.nmc.org/byoa
(Nicci Fagan, *EdTech Magazine*, 21 December 2015.) The BYOD trend is raising a new issue, Bring Your Own Access (BYOA), which increases an institution's vulnerability to attacks and diminishes network performance. In response, many institutions are creating policies that prohibit or restrict BYOA. > *Policy*

The Impact of Digital Mobile Devices in Higher Education
go.nmc.org/impactin
(Luisa Sevillano-García and Esteban Vázquez-Cano, *Journal of Educational Technology and Society*, 28 April 2015.) This research examines the use of mobile devices within three Spanish universities to foster learning activities. > *Leadership*

Mobile Learning in Higher Education: Mobilizing Staff to Use Technologies in their Teaching
go.nmc.org/pedagogicalframe
(Sandy Schuck, *eLearn Magazine*, March 2015.) The University of Technology, Sydney formed a professional learning community of faculty and staff to develop and implement a Mobile Pedagogical Framework, which considers the characteristics of mobiles and how they can be used for effective teaching. > *Leadership*

Learning Analytics and Adaptive Learning

Time-to-Adoption Horizon: One Year or Less

Learning analytics is an educational application of web analytics aimed at learner profiling, a process of gathering and analyzing details of individual student interactions in online learning activities. The goal is to build better pedagogies, empower active learning, target at-risk student populations, and assess factors affecting completion and student success. Adaptive learning technologies apply learning analytics through software and online platforms, adjusting to individual students' needs. A paper by Tyton Partners describes adaptive learning as 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."[252] 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 in real time.

Overview

Institutions across the globe have recognized that the one-size-fits-all approach to teaching alienates both students struggling with specific concepts as well as those grasping the material more quickly than their peers.[253] As learning analytics has matured, colleges and universities now have wide access to tools and large sets of data needed to begin personalizing the learning experience.[254] Through data-informed solutions that reduce the time to degree completion, improve student outcomes, and target students for recruitment, learning analytics are benefiting a range of stakeholders beyond learners and instructors, to bodies of governance, researchers, and institutions. Learning analytics has developed in three stages, moving from a focus on hindsight to foresight; the first stage was describing results, the second stage was diagnosing, and the third and current stage is predicting what will happen in the future. Creating actionable data is a hallmark of adaptive learning, which is the latest focus of experiments and pilot programs within various educational settings.[255]

Adaptive learning is best suited to take place in hybrid and online learning environments, where student activities can be monitored by software and tracking applications. Many publishers and digital learning companies are focusing on adaptive learning to reinvent their core services of developing textbooks and course materials.[256] For example, Pearson has partnered with Knewton to develop MyLab & Mastering,[257] McGraw-Hill launched ALEKS,[258] and Macmillan offers access to PrepU's adaptive technology.[259] Initial results are promising; in partnership with Knewton and Pearson, Arizona State University's new adaptive learning platform in developmental math is leading to better student performances than in the traditional course offering.[260] Thought leaders believe that adaptive learning will continue to advance as higher education gains awareness, adopts curricular standards, and systematically tracks learner progress.[261]

There are an increasing number of initiatives bringing together private companies and education providers to shape the future of adaptive learning. The Bill & Melinda Gates Foundation's personalized learning initiatives are some of the most active in this area. Their Adaptive Learning Market Acceleration Grant Program (ALMAP) is one of several programs to drive progress in the field; it provides grants to colleges and universities to study adaptive learning platforms in over 20 courses through different pedagogical approaches.[262] Similarly, the IMS Global Learning Consortium is a group of over 300 vendors and universities working on a shared vocabulary for tracking and reporting learning analytics. Known as Caliper, these metric profiles could become a common standard for how student learning is collected beyond the consortium.[263]

Relevance for Teaching, Learning, or Creative Inquiry

Institutions are increasing accountability efforts to improve graduation rates and identify students at risk of dropping out. The University of Tennessee at Chattanooga is using analytics to determine potential problem areas. Upon investigating the graduation rates of their nursing students, for example, the university made a discovery they had not anticipated; students were being forced to select a different major because they were struggling with a particular English course rather than a core science course.[264] In the UK, Open University is using algorithms in a similar manner to monitor the amount of effort students are applying

to their studies. Through the analysis of a student's history of reading their online textbooks and engaging with learning platforms, instructors discern who needs intervention.[265] Although experiments continue to move from pilot to implementation, many institutions view privacy concerns and the safety of student data as obstacles.[266]

While learning analytics and adaptive learning have the potential to foster more personalized learning for students while providing colleges and universities with key insights about the efficacy of their instruction, development around the world is still uneven. Australia, for example, is still in the nascent stages of adopting learning analytics. A recent study from the Office of Teaching and Learning examining the current state of learning analytics in Australian higher education found that many initiatives were modest in scale and focused narrowly on using tools to boost retention.[267] In Taiwan, Yuan Ze University is the first academic institution in the country to study learning analytics. Focuses of their research include a visualized analytics system to assist students in their progression through core competencies, provide educators with dropout prediction, and evaluate ways to increase engagement in MOOCs.[268]

Although there is growing global interest in using learning analytics and adaptive learning technologies to improve teaching and learning, there are not many studies detailing concrete outcomes. One study, however, is revealing promising results. The third annual survey conducted by McGraw-Hill Education and fielded by Hanover Research, "The Impact of Technology on College Student Study Habits," found that of the 2,600 college students surveyed, 87% report that having access to data analytics concerning their academic performance has a positive impact on their learning. Adaptive learning technology is reported by 75% of students to be very helpful or extremely helpful in aiding their ability to retain new concepts, and 68% of students report that it is most helpful at making them better aware of new concepts.[269]

Learning Analytics and Adaptive Learning in Practice

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

Scaling Up Learning Analytics: Innovating European Education
go.nmc.org/scalingup
The Learning Analytics Community Exchange organized an event in Lisbon and identified and voted on a number of policy propositions to build a roadmap for European policy development and engagement with stakeholders in the field of learning analytics. > *Policy*

iLime
go.nmc.org/iLime
In the e-Learning and Social Networking master's program at Universidad Internacional de La Rioja (UNIR) in Spain, an adaptive learning system called iLime factors in students' interactions in both formal and informal settings. iLime leverages mentoring and evaluation features and was successfully implemented at UNIR to generate personalized guidance for each student.
> *Leadership*

Learning Analytics Teams
go.nmc.org/lfa
Curtin University is building a learning analytics team to provide support to researchers and university operations leaders using big data. The new Curtin Institute for Computation was formed to build teams with specific skills in visualization, and another team is providing support for innovation and operational research into teaching and learning. > *Leadership*

For Further Reading

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

Leveraging Analytics in Community Colleges
go.nmc.org/commcoll
(Treca Stark, *EDUCAUSE Review*, 14 September 2015.) Higher education institutions are leveraging analytics to help both students and administrators make better, more informed decisions. This article highlights three examples. > *Leadership*

Tales From the Frontline of Adaptive Learning
go.nmc.org/frontline
(David Raths, *Campus Technology*, 23 September 2015.) Although implementing it requires much time and energy, adaptive learning is beginning to be incorporated into many institutions' course reconstruction plans, as the benefits recorded often outweigh the costs. > *Practice*

What Do Students Want from a Learning Analytics App?
go.nmc.org/anapp
(Niall Sclater, *Learning Innovation*, 29 April 2015.) University of Lincoln students recently generated ideas on capabilities they would like to see in a learning analytics app, including notifications on grades and progress toward objectives; the ability to give immediate feedback to lecturers and professors in order to improve the course; and reading list functionality that presents metrics on how students engage with the texts.
> *Practice*

Augmented and Virtual Reality

Time-to-Adoption Horizon: Two to Three Years

Augmented reality (AR), the layering of data over 3D spaces to produce a new experience of the world, sometimes referred to as "blended reality," amplifies access to information, bringing new opportunities for learning. Virtual reality (VR) describes computer-generated environments that simulate the physical presence of people and objects to generate realistic sensory experiences. While the most prevalent uses of AR and VR thus far have been in the consumer sector, tools for creating fresh applications are becoming even easier to use and more viable in the education sector. VR constructs provide contextual learning experiences that foster exploration of real world data in virtual surroundings,[270] while AR's responsive interactivity enables students to construct broader understandings based on interactions with virtual objects.[271] These two flexible, immersive technologies spark similar educational outcomes, bringing learners to deeper levels of cognition as they attain new perspectives on underlying data.

Overview

Augmented reality and virtual reality are separate but tightly related technologies. Augmented reality is characterized by the incorporation of digital information including images, video, and audio into real-world spaces. AR aims to blend reality with the virtual environment, allowing users to interact with both physical and digital objects.[272] VR enables users to step into an immersive, computer-simulated alternate world where sensory experiences can occur. Head-mounted devices such as Oculus Rift can deliver both AR and VR experiences.[273] AR can also be used in conjunction with GPS-enabled smartphones or tablets,[274] while VR can take form in a dedicated simulation room.[275] Both AR and VR offer compelling applications for higher education; these technologies are poised to impact learning by transporting students to any imaginable location across the known universe and transforming the delivery of knowledge and empowering students to engage in deep learning.

The museum space has already embraced the use of AR technology to further patrons' learning experiences with enhanced information delivered through their mobile devices.[276] For example, the Chicago History Museum and the School of the Art Institute of Chicago collaborated on the free AR app Chicago "0,0" to create a historical downtown walking tour.[277] A low-cost solution that has facilitated the spread of VR in education is Google Cardboard,[278] a headset made of inexpensive materials that connects to smartphones.[279] Google Cardboard presents students with the opportunity to construct their own VR content, and more educators are using it because of its accessibility and flexibility.[280] Google Glass, the company's first foray into the AR wearable device sector, generated controversy over privacy concerns, and while the company halted sales in early 2015,[281] the product sparked important conversations and stimulated public interest in the possibilities afforded by augmented reality.

While AR has appeared in several previous editions of the *NMC Horizon Report*, recent advancements in VR technology are bringing about fresh perspectives. Major technology companies are investing in this category. In 2014, Facebook acquired Oculus VR (makers of the Oculus Rift head-mounted display),[282] and will release an updated virtual reality platform in early 2016.[283] Facebook CEO Mark Zuckerberg has emphasized the social aspects of VR, promoting a vision of immersive, shared 3D experiences.[284] Microsoft's VR offering, the HoloLens headset, renders holographic 3D image overlay on top of real objects. NASA's Sidekick project will use the HoloLens to provide virtual support to astronauts on the International Space Station.[285]

Relevance for Teaching, Learning, or Creative Inquiry

Given the mounting interest and investment in VR and AR by technology companies, educational exposure to these technologies will benefit students in STEM disciplines or entrepreneurial pathways by preparing them for the future workplace.[286] The growing affordability of the enabling technologies is leading to increased adoption in higher education. Early pilot findings indicate positive impacts on the classroom, including enhanced group dynamics and peer-to-peer learning.[287] Augmented reality can also help students learn by placing course content in rich contextual settings that more closely mirror real-world situations in which new knowledge can be applied. Researchers investigated the effects of incorporating AR elements into an English language

course at Amasya University in Turkey and found that the AR materials helped students learn vocabulary, particularly for words with non-phonetic pronunciation. Students also reported increased motivation, improved confidence in their skills, and higher satisfaction with the language course.[288]

Virtual reality has the potential to significantly impact the delivery and content of online education. Stanford University and MIT have incorporated VR learning environments into their executive education programs, providing their geographically diverse students with a simulated on-campus experience to facilitate group projects, discussions, and networking.[289] At Pennsylvania State University, engineering students tasked with virtually assembling an object completed the objective more efficiently when using the Oculus Rift VR headset and haptic glove, as compared to students who used a mouse-and-keyboard setup within a computer program.[290] This experiment holds promise for incorporation of tactile elements within online courses to improve learning outcomes. Oculus Rift can also promote global student collaboration, enabling students to construct projects within the same virtual space by synchronizing their devices.[291]

Augmented and virtual reality are revolutionizing medical education. The Augmentarium at the University of Maryland develops innovative deployments for surgery training; physicians can utilize AR technology to "see through" patients' bodies before beginning operations[292] and perform surgeries in VR simulations to hone their expertise.[293] Boise State University nursing students are using Oculus Rift headsets to learn proper procedures for catheter insertion in virtual reality. The technology setup is less expensive and requires less space than traditional medical mannequins, as well as enabling real-time feedback.[294] In the UK, Kingston University and St George's, University of London jointly opened the Paramedic Clinical Simulation Center. Within the immersive VR suite, students can practice giving medical care while experiencing the complications and unpredictability of chaotic environments such as nightclub or roadside accidents. Students reported that use of the facilities resulted in increased confidence and better communication skills.[295]

Augmented and Virtual Reality in Practice

The following links provide examples of augmented and virtual reality in use that have direct implications for higher education settings:

GhostHands
go.nmc.org/ghost
The Knowledge Media Institute at The Open University created a tele-tutoring application using AR technology to film what the learner sees and transmit it online to a remote tutor. The tutor then leverages 3D hand-scanning to transmit hand movement back to the learner, manipulating a 3D finger puppet model while also providing audio instruction. **>** *Leadership*

Holographic Medical Anatomy and Beyond
go.nmc.org/crwuholo
Case Western Reserve University, in partnership with Cleveland Clinic, is developing a holographic medical anatomy curriculum for the Microsoft HoloLens. The curriculum will feature a library of 3D holographic human models that provide a systems-level perspective to anatomy that is nearly impossible for students to experience through traditional dissection or with 2D medical illustrations. **>** *Leadership*

Using 360º Spherical Video as a Teaching Tool
go.nmc.org/ncsu-vr
Educators, researchers, and design teams at North Carolina State University are using interactive 360º video capture and virtual reality technologies such as Google Cardboard to better support lab-based and field-based instruction in online learning environments. **>** *Practice*

For Further Reading

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

Augmented Reality: A Technology and Policy Primer
go.nmc.org/uwash
(Tech Policy Lab, University of Washington, September 2015.) This white paper from University of Washington's Tech Policy Lab identifies some of the legal and policy issues AR presents and provides recommendations to help address them. **>** *Policy*

How Virtual Reality Can Close Learning Gaps in Your Classroom
go.nmc.org/howvirt
(Casey Sapp, *EdSurge*, 7 September 2015.) The author argues that virtual reality technology has the potential to keep students engaged through simulations and contribute to pedagogy that encourages discovery and organic exploration. **>** *Practice*

Tiny Mollusc on Beach Could Hold Key to Augmented Reality
go.nmc.org/ardisplay
(Tom Bawden, *The Independent*, 26 February 2015.) Scientists have identified optical structures in a mollusc that filter and absorb light in a manner that could prove useful in the development of augmented reality displays on glass. **>** *Practice*

Makerspaces

Time-to-Adoption Horizon: Two to Three Years

Higher education institutions are repositioning themselves to promote skillsets with applicable value in a rapidly advancing world.[296] 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 applications become accessible to more students. The question of how to renovate or repurpose classrooms and labs to address the needs of the future is being answered through the concept of makerspaces, which offer tools and learning experiences to help people carry out their ideas. The driving force behind makerspaces is rooted in the maker movement, a following comprised of artists, technology enthusiasts, engineers, builders, and people with a passion for making things.[297] The foundation of the maker movement was built on the success of the Maker Faire, which launched in 2006 and has since propagated itself into numerous community-driven events all over the world.[298]

Overview

Makerspaces are informal workshop environments located in community facilities or education institutions where people gather to create prototypes or products in a collaborative, do-it-yourself setting.[299] Offering communal, cooperative access to devices and supplies, makerspaces mirror the sharing economy trend that has disrupted the transportation and hotel industries.[300] Makerspaces can contain equipment including 3D printers, Raspberry Pis, Arduinos, MaKey MaKeys, Adobe Creative Suite software, laser cutters, and sewing machines. Regardless of what they encompass, the general purpose of makerspaces is to provide a place for users to engage in self-directed activities that spark their curiosity, help them identify passions, and build a habit of lifelong learning.[301] By participating in hands-on design and construction in makerspaces, students engage in creative problem-solving and higher-order thinking.[302]

Makerspaces are also contributing to major cultural shifts. After visiting a makerspace located in Shenzhen, China's manufacturing center, the Chinese prime minister introduced a national initiative known as Mass Makerspace that will cultivate entrepreneurship and innovation by funding makerspaces and incubators.[303] In the US, the greater access to equipment afforded by makerspaces is enabling startup companies to manufacture new products domestically. This, in turn, is stimulating local industries, as makers seek out service providers to assist with logistics, legalities, and financial management.[304] In the realm of academia, ALA's Libraries Transform initiative has identified the maker movement as one of the key elements of libraries' evolution, shifting their function from repositories of knowledge to facilities for creation.[305] As libraries increasingly reposition themselves as learning commons that promote discovery and curiosity,[306] many universities are locating their makerspaces there.[307]

A group of US colleges and universities formed the MakeSchools Higher Education Alliance, bringing together institutions to support campus activities that advance the maker movement.[308] Their *2015 State of Making Report* reviewed and analyzed maker education across 40 campuses, noting how makerspaces have fostered the spread of active learning, cross-disciplinary approaches, and creativity in higher education.[309] Many institutions have also witnessed an increase in student-led startups and crowdfunding campaigns. The report's recommendations for member institutions and next steps for the consortium include creating and disseminating success definitions and metrics to help institutions measure campus impact; sharing best practices widely; cultivating partnerships with businesses and schools to facilitate career exploration and expand the maker pipeline; and coordinating Alliance-wide "grand challenges" to build connections among campuses and increase public awareness of maker culture.

Relevance for Teaching, Learning, or Creative Inquiry

Universities are increasingly implementing thoughtful design to foster inventiveness and creative inquiry. One example is Case Western Reserve University's makerspace, think[box], a seven-story building with each level arranged around the evolution of project development. The first floor serves as community space, with subsequent floors for ideation, prototyping, fabrication, open workspace, entrepreneurial resources, and incubator space, respectively.[310] The space has encouraged critical examination of learning

environments: Jaswig, a standing desk for children, was recently prototyped at think[box].[311] Similarly, the University of Southern California houses the Jimmy Iovine and Andre Young Academy for Arts, Technology and the Business of Innovation entirely within a makerspace to promote a flexible culture of making that furthers the program's entrepreneurial focus.[312]

A recent white paper for the American Society of Engineering Education noted that undergraduate engineering curriculum focuses primarily on theory and mathematical modeling, and makerspaces present the opportunity for students to partake in hands-on building while practicing critical thinking.[313] At the University of Texas at Austin, a biomedical engineering student used the Longhorn Maker Studio to 3D print a model of a human heart; doctors at the Seton Heart Institute now use the model in pre-surgery patient consultations.[314] Similarly, the University of Ottawa's makerspace sponsored a prosthetic hand challenge to help a local child. The winning student team 3D printed an Iron Man-inspired design that can be modified and reprinted affordably as the child grows.[315] Another shift is occurring at Tsinghua University in Beijing; after the construction of their makerspace is completed, all degree plans will require open-source hardware experimentation.[316]

On campuses, maker culture is beginning to expand beyond the STEM subjects to encompass multidisciplinary approaches to the teaching of liberal arts. The Challenge Fund for Innovation in Journalism Education will support collaboration among the University of Nebraska-Lincoln, the University of Southern California's Annenberg School for Communication and Journalism, and Texas State University to create a journalism maker curriculum and explore the intersection of journalism with the Internet of Things.[317] Liberal arts colleges have also recognized the pedagogical value of makerspaces. Lawrence University's makerspace aims to help its students develop digital literacies and engage in self-directed learning.[318] Similarly, Elon University established the Maker Hub to aid its students in building resiliency through the maker mindset after noting that their students were conditioned by extensive standardized testing to fear failure.[319] The future could bring institutional changes in admissions standards or degree conferral that recognize the educational significance of students' maker aptitudes.[320]

Makerspaces in Practice

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

3D Printing and Occupational Therapy Prosthetic Hand Project
go.nmc.org/occup
Through a partnership with the Abilene Christian University Maker Lab, graduate students in the Occupational Therapy program printed and assembled 3D prosthetic hands, making modifications as they identified specific needs and patient demographics. > *Practice*

Digital Media Lab
go.nmc.org/digmedia
The Digital Media Lab at Griffith University is an 8,000 square foot multimedia and 3D print production space designed to support students working on video, audio, graphics, interactive, animation, and 3D modeling projects. The lab offers rich opportunities for interdisciplinary work. > *Practice*

Makerbot Innovation Center
go.nmc.org/makerbot
The Digital Media at UMass Amherst added a Makerbot Innovation Center in 2015 that includes 48 3D printers and five digitizers. The Center also provides students access to software for 3D modeling, and support in the use of these technologies. > *Practice*

For Further Reading

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

Making a Makerspace? Guidelines for Accessibility and Universal Design
go.nmc.org/foraccess
(The University of Washington, 2015.) The University of Washington has documented their best practices for universities to apply principles of universal design when planning and developing on-campus makerspaces, along with corresponding policies to ensure the tools are accessible to all. > *Policy*

Making Makerspaces Work on Campus
go.nmc.org/makin
(Melissa Delaney, *EdTech Magazine*, 11 February 2015.) This article explores how universities are in a period of experimentation with building makerspaces on campus, and how they are finding that collaboration between departments is a major key to success. > *Leadership*

Making for All: How to Build an Inclusive Makerspace
go.nmc.org/makingforall
(Sylvia Martinez, *EdSurge*, 10 May 2015.) The author emphasizes the importance of inclusion when it comes to building makerspaces and maker communities and urges educators to look beyond expensive equipment and massive remodeling projects, which are not necessary to create accessible spaces that empower people to create. > *Practice*

Affective Computing

Time-to-Adoption Horizon: Four to Five Years

Affective computing refers to the idea that humans can program machines to recognize, interpret, process, and simulate the range of human emotions.[321] This concept revolves around the development of computers attaining humanlike understanding through activities such as implementing a video camera to capture facial cues and gestures that work in conjunction with an algorithm that detects and interprets these interactions. Not to be confused with facial recognition technologies associated with security, like those that facilitate secure payment transactions,[322] affective computers recognize emotional and behavioral signals that trigger a reactionary process. In higher education, a potential application of affective computing is in online learning situations wherein a computerized tutor reacts to facial indications of boredom from a student in an effort to motivate or boost confidence. With researchers at major institutions including MIT[323] and University of Cambridge[324] working on educational applications, and start-up companies exploring other novel uses,[325] growth in this field has deep implications for the future of human and computer interactions.

Overview

For as long as there have been computers, scientists, philosophers, and filmmakers have envisioned future worlds where machines understand and behave like humans. Some early imaginings presented sophisticated robots as purposely devoid of human emotion, favoring an ideal of flawless logic. Seminal research from MIT in the 1990s, however, revealed the possibilities of more authentic exchanges between people and computers.[326] If a major pursuit of advancing technology is to better accommodate peoples' needs, proponents of affective computing perceive the act of instilling more humanlike behavior in machines to be an important design element that balances emotion and cognition.[327] As technologists and education leaders have increasingly associated emotion with higher learning and connectedness,[328] the move toward machines that pick up on social cues and imitate human behavior reflects the 21st century societal prioritization of emotional intelligence and empathy.

There are two main areas driving higher education research in affective computing: the detection of emotion and the simulation of emotion from machines.[329] Both require the use of technology to interpret human behavior, generally leveraging developments in gesture-based computing and speech recognition. For the former technology, interfaces such as gaming consoles enable the human body to interact with digital resources, controlling what appears on a screen or projection;[330] the latter involves programs that convert spoken words or phrases into machine-readable formats, often in order for the machines to carry out voice commands.[331] The ultimate goal of affective computing is to improve and apply these technologies to create context-aware, emotionally responsive machines that cater to even the most subtly communicated needs. This will be a particularly exciting development for virtual assistants such as Amazon's Alexa and Apple's Siri, which already understand and respond to voice commands; the addition of emotion recognition would take the category to a new level.

While affective computing is still relatively nascent, basic applications are on the rise as interest continues to mount. The Research and Markets firm reports that the field will see rapid growth over the next five years, with companies such as Apple, Intel, IBM, and Microsoft all developing affective computing technologies in some form.[332] Bayer recently contracted the Affective Computing Company[333] for its Human2Human platform and Thrive software, which helps inform management's decisions, monitoring employees' engagement and well-being by becoming increasingly self-aware as they respond to regular prompts on their mobiles and other devices.[334] In the context of higher education, where students' knowledge is increasingly being assessed through analytics, affective computing has the potential to fill in an elusive part of the picture by understanding and catering to learner attitudes and emotions.

Relevance for Teaching, Learning, or Creative Inquiry

As incubators of affective computing innovation, universities are significantly advancing the field. MIT has been deeply involved since the inception through their Affective Computing Group (ACG). Currently, ACG is working on a host of noteworthy studies focused on detecting emotion, including "Automatic Stress Recognition" in which they explore technologies that can automatically recognize stress in everyday situations.

The participating team is modifying the loss function of Support Vector Machines connected to wearable sensors to gauge peoples' tendencies to feel more or less stressed — an important evaluation for students with rigorous schedules and course loads. A similar project leverages wearable sensors and smartphones to diagnose various forms of depression and recommend specific treatments. ACG has also asked the question "What Do Facial Expressions Mean?" and is automating the recognition of positive and negative experiences as they manifest on faces.[335]

Data about how machines detect emotion can inform better design of affective interfaces and the algorithms they apply to respond to users. The University of Michigan Emotional McGurk Effect (UMEME) study is exploring how understanding emotional expressions can be integrated and perceived as information. UMEME's work in this area is unique as the dataset not only encompasses emotionally matched faces and voices, but also mismatched ones, allowing interfaces to better assess individuals in the midst of "emotional noise," or very complex reactions, to make more relevant recommendations. The findings will be particularly helpful in the mental health field.[336] Scientists and researchers at the University of Cambridge's Computer Laboratory have also developed and investigated a computer that interprets nuances in facial expression and infers mental state. Thus far, testing has revealed the computer to be as accurate as the most perceptive people.[337]

While progress has been made through university-led projects, affective computing is still outside mainstream implementation. Thought leaders are just beginning to harness their research to test direct applications for teaching and learning in higher education. In Greece, the University of Macedonia's Computer Networks & Telematics Applications Lab[338] recognizes that effective instructors generally have the ability to intuitively respond to students' emotions, such as boredom or concern, but this skill has not yet translated into online learning environments. In their e-learning studies,[339] Embodied Conversational Agents (ECA) — a kind of avatar — have been used to provide emotional feedback in the form of appropriate facial expressions, tone of voice, and empathetic speech to students they interpret as fearful, sad, or happy. Promising early results indicate when ECAs act in parallel with learners' emotion, students' original emotions persist.

Affective Computing in Practice

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

AttentiveLearner
go.nmc.org/heartra
AttentiveLearner, developed at the University of Pittsburgh, is an intelligent mobile learning system for viewing video content that leverages on-lens finger gestures as an intuitive control channel for video playback, while concurrently monitoring whether students' minds are wandering or engaged. > *Practice*

Exploring the Effect of Confusion in Discussion Forums of Massive Open Online Courses
go.nmc.org/confus
Stanford University researchers have created YouED, a tool that automatically detects and addresses confusion in forum posts and sends short clips from course videos to students in response. > *Practice*

On the Selection of Just-in-time Interventions
go.nmc.org/just
University of South Florida researchers are outfitting smartphones, cloud-based services, and sensors with affective computing capabilities to monitor patient health and provide just-in-time interventions. > *Practice*

For Further Reading

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

Measuring and Understanding Learner Emotions
go.nmc.org/learnemot
(Bart Rienties and Bethany Alden Rivers, LACE, 10 December 2014.) Emotions play a critical role in the teaching and learning process, impacting motivation, self-regulation, and achievement; this paper details data gathering approaches to measure and understand emotions and provides a conceptual framework. > *Policy*

Analyzing Reflective Text for Learning Analytics
go.nmc.org/reflective
(Andrew Gibson and Kirsty Kitto, Queensland University of Technology, 2015.) Anomaly recontextualization software can detect affective dimensions of an author's perspective in writing and communications, which could contribute new data on student interactions in a digital setting. > *Leadership*

Predicting Learning and Affect from Multimodal Data Streams in Task-Oriented Tutorial Dialogue
go.nmc.org/predi
(Po-Ming Lee et al., PLOS One, 2015.) Researchers in Taiwan have found that keystroke duration and latency are influenced by user excitement and are looking into developing technology that detects users' emotions through keystroke dynamics. > *Practice*

Robotics

Time-to-Adoption Horizon: Four to Five Years

Robotics refers to the design and application of robots, which are automated machines that accomplish a range of tasks. The first robots were integrated into factory assembly lines in order to streamline and increase the productivity of manufacturing, most notably for cars. Today, the integration of robots into mining, transportation, and the military has helped improve operations for industries by taking over tasks that are unsafe or tedious for humans.[340] The global robot population is expected to double to four million by 2020 — a shift that will impact business models and economies worldwide.[341] There is a substantial debate on how workers will continue to be affected by the growing dependence on robots, especially now that robots are more autonomous, safer, and cheaper.[342] While robotics is at least four years away from mainstream use in higher education, its potential uses are starting to gain traction, especially in the medical field. New outreach programs are promoting robotics and programming as multi-disciplinary STEM skills that can make students better problem solvers. Emerging studies are also showing that interaction with humanoid robots can help learners with spectrum disorders develop better communication strategies and social skills.

Overview

The notion of working and living amongst robots is becoming less futuristic and more practical than ever.[343] Less clunky and more humanlike than their predecessors, today's robots are increasingly sophisticated and can perform a compelling array of simple, useful, and complex tasks. The Defense Advanced Research Projects Agency (DARPA), an agency of the US Department of Defense, has funded many projects in the field. In 2015, the DARPA Robotics Challenge convened 25 of the world's top robotics organizations to develop and test robots that could perform hazardous rescue missions after nuclear accidents and natural catastrophes. DRC-HUBO from the Republic of Korea won the competition based on its ability to switch from a walking bipedal robot to a wheeled machine, a unique design element that allows it to recover from a fall.[344] The robot was also able to complete the required set of tasks including walking up stairs, drilling a hole into a wall, and opening doors.[345]

Poised on the far-term horizon, robotics has yet to take on a greater role in university-level instruction, but breakthroughs in this field are guaranteed to impact everyday life. Self-driving cars are one emerging development in robotics. The car dispatch startup Uber recently launched the Advanced Technologies Center, which is largely staffed by scientists from the National Robotics Engineering Center at Carnegie Mellon University.[346] Furthermore, increased research and development efforts have produced robots that behave more like humans. UC Berkeley's Department of Electrical Engineering and Computer Sciences programmed a robot based on neural circuitry inspired by the human brain, allowing it to learn new skills with practice. BRETT, the Berkeley Robot for the Elimination of Tedious Tasks, signals major progress in the field, pointing to a future where robots will be able to accomplish complex activities on their own, such as doing laundry or cleaning houses.[347]

From an economic standpoint, empirical evidence is starting to show the long-term effects of increased dependence on robots for labor, an area that has fascinated economists, social scientists, and futurists for some time. A recent analysis from the London School of Economics compared data from the International Federation of Robots on the use of robots across 14 industries in 17 countries between 1993 and 2007. Researchers found that while robots' impact on productivity is significant compared to other technologies,[348] there was no obvious relationship between the use of robots and decreasing employment rates. Robots have replaced low-skilled workers, yet increased productivity for factories has generated new jobs for other workers.[349] A recent paper from the Brookings Institute points to the inevitability of robots becoming a greater part of daily life, and there is a need to create policies that support a society where people can lead fulfilling lives amidst a changing work climate.[350]

Relevance for Teaching, Learning, or Creative Inquiry

As robots take on a greater role in industry, university students are training to engineer innovative designs. In 2015, Georgia Institute of Technology and Emory University partnered to create the first bachelor's, master's, and doctoral degree programs in healthcare

robotics in the US. Funded by the National Science Foundation (NSF), the initiative brings together a diverse body of faculty from both institutions, covering a range of disciplines including engineering, robotics, neuroscience, physiology, rehabilitation, and psychology.[351] Recently, teams of researchers from the University of California San Diego and Clemson University have been leveraging 3D printing technology to build better robots and medical devices. Their collaboration resulted in the discovery that an arm made of overlapping square segments, like that of a seahorse's tail, grips surfaces better than one made of cylindrical segments.[352]

Robots have been used to train medical students and perform clinical procedures in hospital settings for some time now. At the National Autonomous University of Mexico, medical students practice a variety of procedures on 24 robotic patients, which are connected to a software system than can simulate the symptoms of various diseases. The patients are equipped with mechanical organs, simulated respiratory systems, and synthetic blood.[353] Researchers at the STORM Lab of the Engineering Department at Vanderbilt University have been developing the enabling technologies to realize wireless medical capsule robots, which can perform endoscopy procedures. The goal is that these capsules, once swallowed, will be able to perform biopsies, deliver treatments, and interact with the surrounding tissues throughout the gastrointestinal tract without intervention.[354]

Robotics research conducted at higher education institutions is having an impact on the K-12 learning environment. At Penn State University, graduate students and faculty at the GRASP Lab are creating curriculum modules for math and science teachers for middle schools in the School District of Philadelphia. Supported by a grant from the NSF, the program aims to systematically train a new generation of STEM leaders within each school who can continue to generate and support robotics activities.[355] There is also growing interest in the therapeutic benefits of robots, specifically in the treatment of psychosocial disorders. A researcher from Ryerson University in Toronto studied the use of playful robots in language practice for children with autism spectrum disorder (ASD). After recording interactions between the learners and robots, the researcher concluded that robots enable children with ASD to communicate because of their low stimulus levels and predictable behaviors.[356]

Robotics in Practice

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

Pioneering Air Traffic Management System Aims for Safer Drone Air Traffic
go.nmc.org/airtraffic
Researchers at University of Nevada, Reno are working on a new low-altitude traffic management system that will provide safety and governance to autonomous aerial vehicles, helicopters, gliders, and drones as part of the first phase of the NASA Ames Unmanned Aerial Systems Traffic Management project. > *Policy*

We Robot 2015
go.nmc.org/werobo
The University of Washington School of Law hosted the fourth annual robotics law and policy conference to foster conversations between people designing, building, and deploying robots, and those who influence the legal and social structures in which robots will operate. > *Policy*

Robotics Engineering Technology Program
go.nmc.org/calu
The Robotics Engineering Technology program at Cal U blends multiple disciplines to provide an introduction to mechatronic systems with special emphasis on autonomous mobile robots. The program gives students experience in designing, programming, building, and testing autonomous robots in the lab. > *Leadership*

For Further Reading

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

How Humans Respond to Robots: Building Policy through Good Design
go.nmc.org/howhumans
(Heather Knight, The Brookings Institute, July 2014.) This paper describes important decisions people face in the process of developing robots, recognizing that design considerations today have implications for policy decisions down the road. > *Policy*

6 Ways to Get the Most Use Out of Robotics in Higher Education
go.nmc.org/getmost
(Jessica Kennedy, *Higher Ed Tech Decisions*, 14 December 2015.) Institutions are finding that robotics solutions can enable physical presences across distances in a more effective and inexpensive manner than telepresence systems. > *Practice*

Artificial Intelligence and Robotics Slowly Enter College Classrooms
go.nmc.org/slowly
(Calvin Hennick, *EdTech Magazine*, 16 February 2015.) Robotic elements are being used in both face-to-face and online learning environments to assist with instruction as well as providing tutoring support and personalized encouragement to students. > *Practice*

The 2016 Higher Education Expert Panel

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