NMC

Horizon Report > 2017 Higher Education Edition

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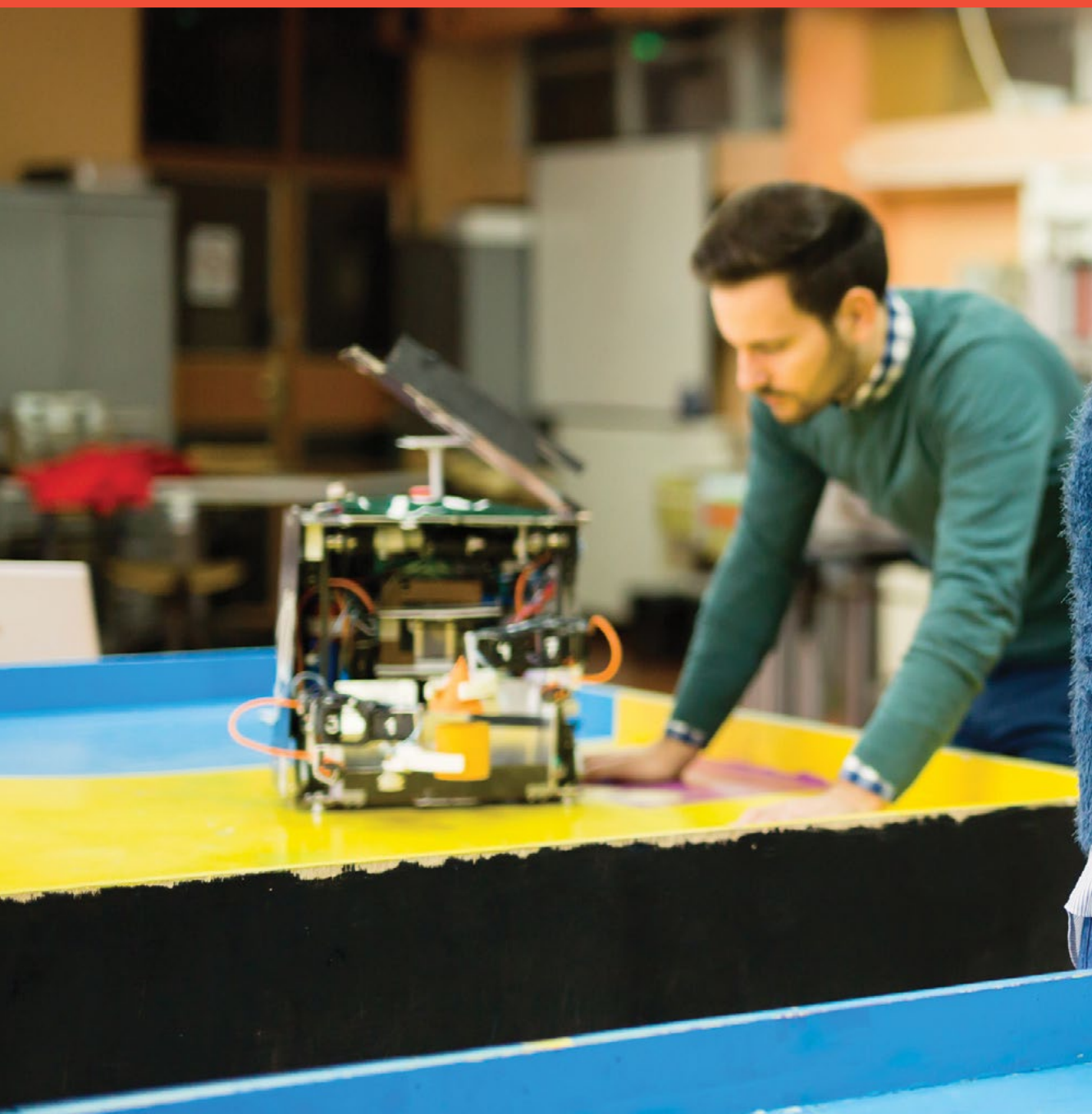

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Front Cover

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Inside and Back Covers

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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 critical challenges and how can we strategize solutions? These questions regarding technology adoption and educational change steered the discussions of 78 experts to produce the *NMC Horizon Report: 2017 Higher Education Edition*, in partnership with the EDUCAUSE Learning Initiative (ELI). This *NMC Horizon Report* series charts the five-year impact of innovative practices and technologies for higher education across the globe. With more than 15 years of research and publications, the NMC Horizon Project can be regarded as education's longest-running exploration of emerging technology trends and uptake.

Six key trends, six significant challenges, and six developments in educational technology profiled in this report are poised to impact teaching, learning, and creative inquiry in higher education. The three sections of this report constitute a reference and technology planning guide for educators, higher education leaders, administrators, policymakers, and technologists. These top 10 highlights capture the big picture themes of educational change that underpin the 18 topics:

1 **Advancing progressive learning approaches requires cultural transformation.** Institutions must be structured in ways that promote the exchange of fresh ideas, identify successful models within and outside of the campus, and reward teaching innovation — with student success at the center.

2 **Real-world skills are needed to bolster employability and workplace development.** Students expect to graduate into gainful employment. Institutions have a responsibility to deliver deeper, active learning experiences and skills-based training that integrate technology in meaningful ways.

3 **Collaboration is key for scaling effective solutions.** Communities of practice, multidisciplinary leadership groups, and open social networks can help spread evidence-based approaches. Institutions and educators can make more progress learning from each other.

4 **Despite the proliferation of technology and online learning materials, access is still unequal.** Gaps persist across the world that are hampering college completion for student groups by socioeconomic status, race, ethnicity, and gender. Further, sufficient internet access remains uneven.

5 **Processes for assessing nuanced skills at a personal level are needed.** Adaptive technologies and a focus on measuring learning are driving institutional decision-making while personalizing student learning experiences; leaders must now consider how to evaluate the acquisition of vocational skills, competencies, creativity, and critical thinking.

6 **Fluency in the digital realm is more than just understanding how to use technology.** Training must go beyond gaining isolated technology skills toward generating a deep understanding of digital environments, enabling intuitive adaptation to new contexts and co-creation of content with others.

7 **Online, mobile, and blended learning are foregone conclusions.** If institutions do not already have robust strategies for integrating these now pervasive approaches, then they simply will not survive. An important step is tracking how these models are actively enriching learning outcomes.

8 **Learning ecosystems must be agile enough to support the practices of the future.** In using tools and platforms like LMS, educators have a desire to unbundle all of the components of a learning experience to remix open content and educational apps in unique and compelling ways.

9 **Higher education is an incubator for developing more intuitive computers.** As artificial intelligence and natural user interfaces tip into mainstream use, universities are designing machine learning algorithms and haptic devices that more authentically respond to human interaction.

10 **Lifelong learning is the lifeblood of higher education.** Institutions must prioritize and recognize ongoing learning — both formal and informal — for their faculty, staff, and students.

It is our hope that this analysis will help to inform the choices that institutions are making about technology to improve, support, or extend teaching, learning, and creative inquiry. Education leaders worldwide look to NMC Horizon Project publications as strategic technology planning references, and it is for that purpose that the *NMC Horizon Report: 2017 Higher Education Edition* is presented.

NMC Horizon Report > 2017 Higher Education Edition at a Glance

Key Trends Accelerating Higher Education Technology Adoption

2017 2018 2019 2020 2021

Short-Term
Driving technology adoption in Higher Education for the next one to two years

Blended Learning Designs
Collaborative Learning

Mid-Term
Driving technology adoption in Higher Education for the next three to five years

Growing Focus on Measuring Learning
Redesigning Learning Spaces

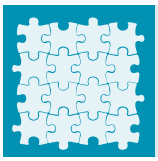
Long-Term
Driving technology adoption in Higher Education for five or more years

Advancing Cultures of Innovation
Deeper Learning Approaches

Significant Challenges Impeding Higher Education Technology Adoption

Solvable
Those that we understand and know how to solve

Improving Digital Literacy
Integrating Formal and Informal Learning



Difficult
Those that we understand but for which solutions are elusive

Achievement Gap
Advancing Digital Equity

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

Managing Knowledge Obsolescence
Rethinking the Roles of Educators

Important Developments in Technology for Higher Education

2017 2018 2019 2020 2021

Time-to-Adoption Horizon: One Year or Less

Adaptive Learning Technologies
Mobile Learning

Time-to-Adoption Horizon: Two to Three Years

The Internet of Things
Next-Generation LMS

Time-to-Adoption Horizon: Four to Five Years

Artificial Intelligence
Natural User Interfaces

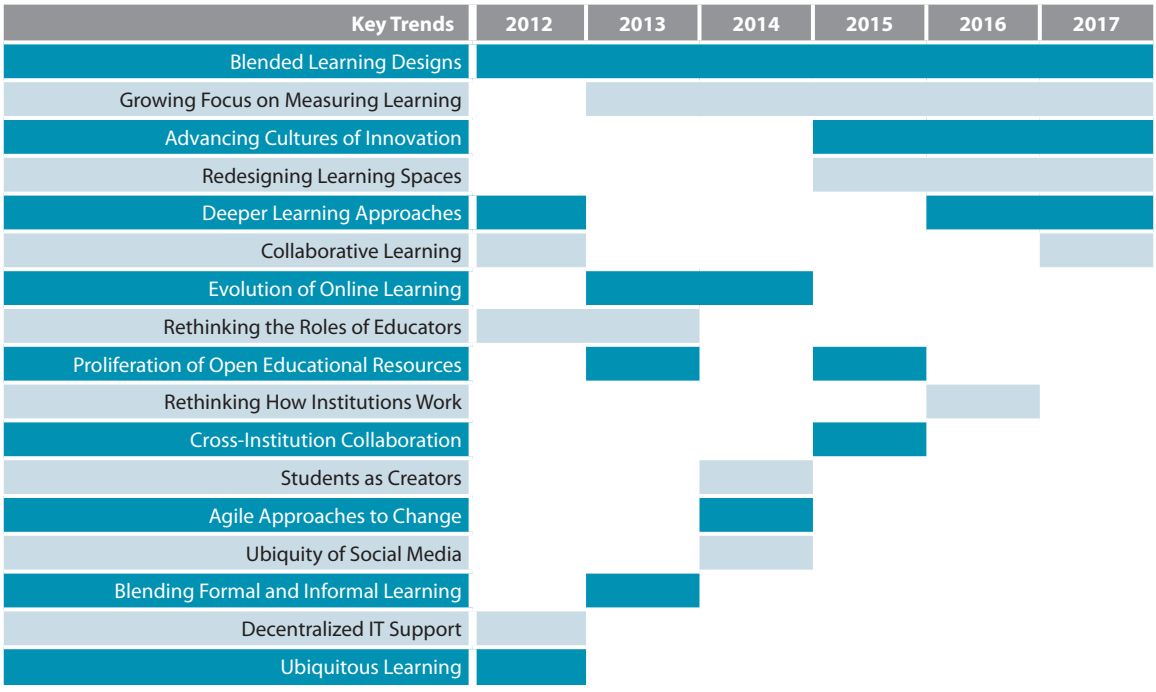
Introduction

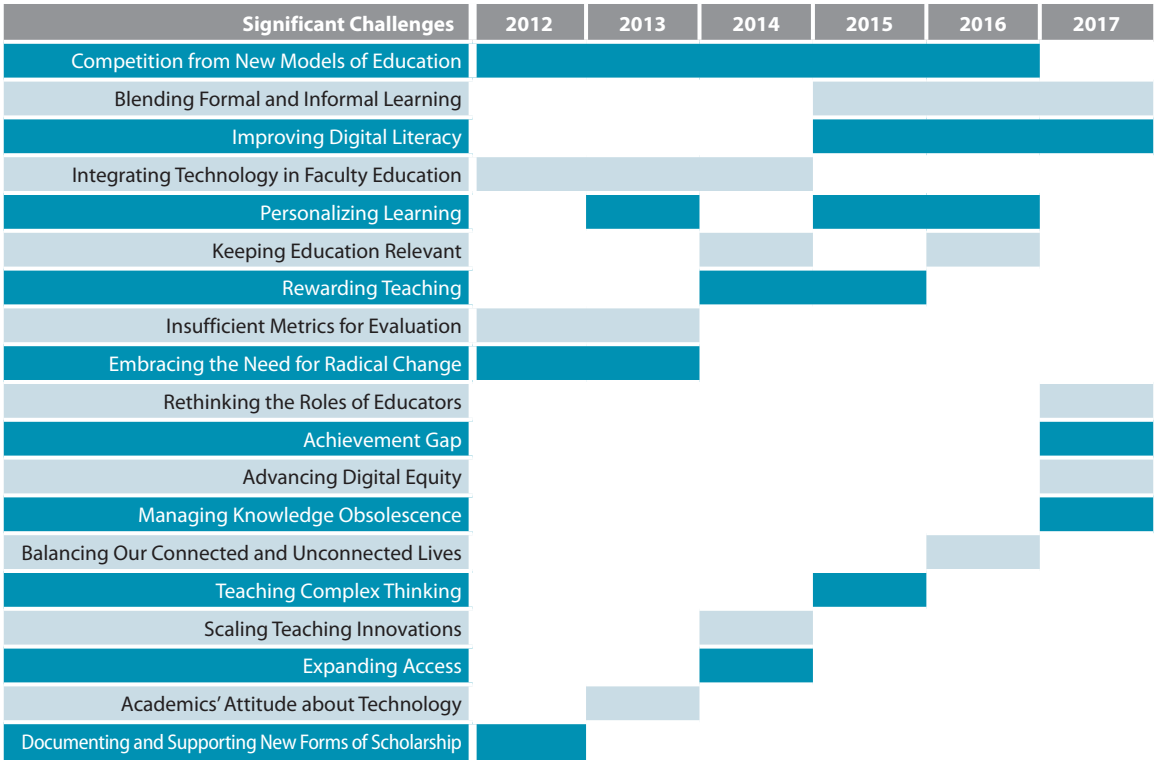
The *NMC Horizon Report: 2017 Higher Education Edition* was produced by the NMC in collaboration with the EDUCAUSE Learning Initiative (ELI). The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlook* series are part of the NMC Horizon Project, a comprehensive effort established in 2002 that identifies and describes important developments in technology poised to have a large impact on technology planning and decision-making 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 trends, six challenges, and six developments in technology or practices that are likely to enter mainstream use within their focus sectors over the next five years (2017-2021).

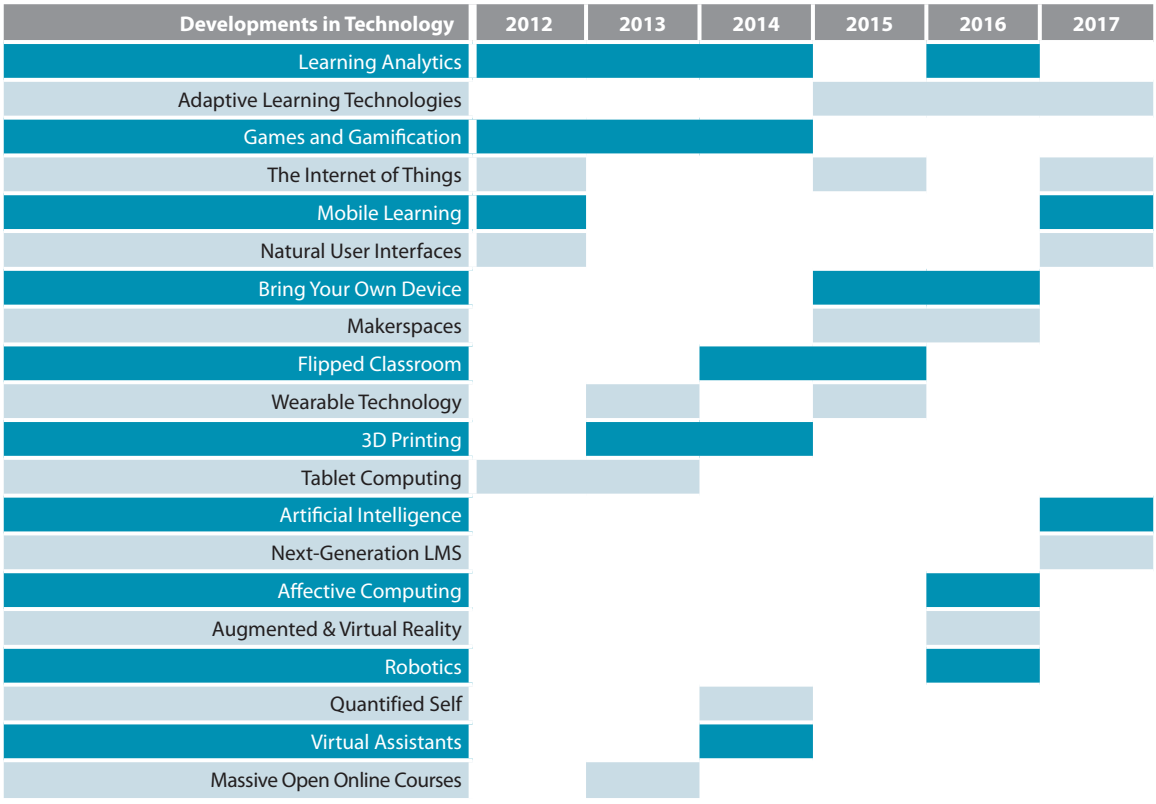
In the pages that follow, 18 topics selected by the 2017 Higher Education Expert Panel related to the educational applications of technology are examined. The topics are placed directly in the context of their likely impact on the core missions of universities and colleges, and detailed in succinct, non-technical, and unbiased presentations. Each has been tied to essential questions of relevance or policy, leadership, and practice.

To plan for the future, it is important to look back. In reflecting on the past 15 years of the NMC Horizon Project, larger themes have emerged. Certain topics such as a focus on measuring learning and competition from new education models reappear, regularly voted into the report by a now vast body of higher education leaders and technologists. The tables below show the findings from the past five higher education editions as well as the 2017 edition. (In some cases, for consistency, the topic names have been slightly modified from the report where they originally appeared.) Also noteworthy is the inclusion of Rethinking the Roles of Educators as well as Blending Formal and Informal Learning as both a trend and challenge; initially categorized as trends,

Six Years of the NMC Horizon Report Higher Education Edition




Significant Challenges
2012
2013
2014
2015
2016
2017
Competition from New Models of Education
Blending Formal and Informal Learning
Improving Digital Literacy
Integrating Technology in Faculty Education
Personalizing Learning
Keeping Education Relevant
Rewarding Teaching
Insufficient Metrics for Evaluation
Embracing the Need for Radical Change
Rethinking the Roles of Educators
Achievement Gap
Advancing Digital Equity
Managing Knowledge Obsolescence
Balancing Our Connected and Unconnected Lives
Teaching Complex Thinking
Scaling Teaching Innovations
Expanding Access
Academics' Attitude about Technology
Documenting and Supporting New Forms of Scholarship


Developments in Technology
2012
2013
2014
2015
2016
2017
Learning Analytics
Adaptive Learning Technologies
Games and Gamification
The Internet of Things
Mobile Learning
Natural User Interfaces
Bring Your Own Device
Makerspaces
Flipped Classroom
Wearable Technology
3D Printing
Tablet Computing
Artificial Intelligence
Next-Generation LMS
Affective Computing
Augmented & Virtual Reality
Robotics
Quantified Self
Virtual Assistants
Massive Open Online Courses

previous expert panels moved to re-categorize them as challenges.

In observing the numerous overlaps from edition to edition, it is important to note that while topics may repeatedly appear, they only represent the broad strokes of educational change; each trend, challenge, and technology development evolves over time, with fresh perspectives and new dimensions revealed every year. For example, both mobile and online learning today are not what they were yesterday. Virtual reality, chatbots, and immersive apps have added more functionality and greater potential for learning.

The *NMC Horizon Report* format was revised in 2014 to more deeply expand on the trends and challenges that frame technology adoption. This change was grounded in the reality that technology alone cannot cultivate education transformation; better pedagogies and more inclusive education models are vital solutions, while digital tools and platforms are enablers and accelerators. Further, the way that society is evolving inherently impacts how technology is used as well as the programming institutions offer. Prior to the 2014 edition, trends and challenges were not placed in horizons; thus the table views do not capture changes over time in length of impact or scope of difficulty, respectively.

Individual topics in the report are published as two-page spreads to make them useful as standalone essays and guides, but generating a more holistic vision of how they all coalesce is becoming increasingly important. In some instances, the challenges represent the obstacles hindering positive trends from scaling and the technologies are accelerators, revealing a convergence between all three sections.

Taken together, the topics featured in the report from year to year tell a larger story about the overarching themes driving progress in — or impeding — teaching, learning, and creative inquiry. Each topic can be placed into one (or more) of six meta-categories that reflect movements in higher education.

Expanding Access and Convenience. People expect to be able to learn and work anywhere, with constant access to learning materials, as well as each other. Colleges and universities have made great strides in generating more methods and platforms for faculty, students, and staff to collaborate and be productive wherever they are. The advent of always-connected devices has provided more flexibility in how, when, and where people learn, and many institutions have updated their IT infrastructures accordingly. While mobile and digital learning strategies have increased over time, disparities in high-speed broadband connectivity and in engagement between different student groups (socioeconomic status, gender, etc.) prompt higher education leaders to continuously evaluate the affordability, access, and quality of their offerings.

Spurring Innovation If education is viewed as a vehicle for advancing the global economy, then it must be the North Star that guides societies to the next big thing, illuminating new ideas that solve pressing challenges and creating opportunities to shape a better future. In this sense, institutions are incubators of high-quality products — actual inventions and developments that progress positive trends, as well as the most important product of all: graduates who not only fulfill evolving job market needs but redefine and improve the workforce they enter. Advancing cultures of entrepreneurial thinking and designing new forms of artificial intelligence are just two of many areas of higher education that are spreading innovation.

Fostering Authentic Learning Project-based learning, challenge-based learning, and competency-based learning — all of these pedagogical trends are in service of creating richer and more hands-on, real-world experiences for students. As higher education institutions prioritize active learning over rote learning, students are being viewed in a new light. Rather than being regarded as mere participants and consumers of knowledge, the embedding of maker culture in higher education has made them active contributors to the knowledge ecosystem. They learn by experiencing, doing, and creating, demonstrating newly acquired skills in more concrete and creative ways. Students do not have to wait until graduation to change the world. However, institutions continue to be challenged to generate these opportunities in spaces and with paradigms that still lean on traditional practices.

Tracking and Evaluating Evidence. What good is a new approach or technology deployment if the results are not carefully measured and analyzed, with the program adjusted based on the results? Institutions are becoming more adept at capturing a bevy of programmatic data. This same principle has been applied to tracking student performance, engagement, and behavior, and leveraging that data to inform

decision-making across departments and campuses. This information is also fueling more personalized learning experiences through adaptive learning tools that analyze areas for improvement and deliver tailored content to each student accordingly. As this data-driven theme proliferates in higher education, leaders must consider how to scale the data in a way that presents a more holistic picture of student success and makes it useful across all disciplines. Embracing a culture of sharing that breaks down silos, while maintaining ethical and privacy standards, will be paramount.

Improving the Teaching Profession

The emphasis on more hands-on, technology-enhanced learning has impacted every facet of campus life, with teaching as a central force. With students inventing, iterating, and collaborating regularly, instructors have been transplanted from their position as "sage on the stage" to "guide on the side." There is a need for mentoring and coaching as students work through complex problems to explore new frontiers and gain concrete skills. As student-led class discussions delve deeper into the material, faculty must balance the student-centered approach with subtle but effective facilitation. However, institutions are often set up in ways that indicate a value on research over teaching. As such, educators are not always sufficiently motivated to improve their teaching craft — or rewarded when they do so successfully. Programs that recognize and scale positive teaching practices are a necessity. Further, just as there is a need to advance digital literacy among students, faculty must also engage in ongoing professional development, with support from institutions.

Spreading Digital Fluency

Technology and digital tools have become ubiquitous, but they can be ineffective or dangerous when they are not integrated into the learning process in meaningful ways. The contemporary workforce calls for digitally-savvy employees who can seamlessly work with different media and new technologies as they emerge. A major element of fostering this fluency is recognizing that simply understanding how to use a device or certain software is not enough; faculty, staff, and students must be able to make connections between the tools and the intended outcomes, leveraging technology in creative ways that allow them to more intuitively adapt from one context to another. Ownership of this movement must be shared and supported among institutional divisions as digital fluency is an important thread that runs through practically every facet of teaching and learning.

In the report that follows, each topic will have icons that appear next to it, indicating the above meta-categories where it belongs, in order to more clearly illuminate the connections between topics. The report's first two sections focus on an analysis of the 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 examples and readings conclude each topic for further elaboration.

The report's third section focuses on important developments in technology — consumer technologies, digital strategies, enabling technologies, internet technologies, learning technologies, social media technologies, and visualization technologies — all positioned to impact higher education over the next five years. Each development contains a discussion of its relevance to teaching, learning, or creative inquiry, and concludes with a set of project examples and further readings.

Taken together, the three sections constitute a straightforward guide for strategic planning and decision-making for postsecondary education leaders across the world.

Key Trends Accelerating Technology Adoption in Higher Education

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories — long-term trends that typically have already been affecting decision-making and will continue to be important for more than five years; mid-term trends that will likely continue to be a factor in decision-making for the next three to five years; and short-term trends that are driving 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 trends have already been the topic of many education leaders' discussions and extensive research, short-term trends often do not have an abundance of concrete evidence pointing to their effectiveness and future directions. All of the trends listed here were explored for their implications for higher education in a series of online discussions that can be viewed at horizon.wiki.nmc.org/Trends.

The NMC Horizon Project model derived three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern 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. Below are summaries of the six key trends that will be explored more in-depth in this section, with citations and resources included.

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

Advancing Cultures of Innovation. As campuses have evolved into hotbeds for entrepreneurship and discovery, higher education has become widely regarded as a vehicle for driving innovation. The focus of this trend has shifted from understanding the value of fostering the exploration of new ideas to finding ways to replicate it across a span of diverse and unique learning institutions. Research has been conducted over the past year to better understand how institutions can nurture the types of culture that promotes experimentation. A significant element for progressing this movement is the call for higher education to alter its status quo to accept failure as an important part of the learning process. The act of integrating entrepreneurship into higher education further acknowledges that every big idea has to start somewhere, and students and faculty can be equipped with the tools needed to spark real progress. In order to keep pace, institutions must critically assess their curriculum and implement changes to their evaluation methods in order to remove barriers that limit the development of new ideas.

Deeper Learning Approaches. There is an ongoing 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. To remain motivated, students need to be able to make clear connections between their coursework and the real world, and how the new knowledge and skills will impact them. Project-based learning, challenge-based learning, inquiry-based learning, and similar methods are fostering more active learning experiences. While deeper learning is proving to be effective for improving graduation rates in schools, its implementation in higher education settings is not as robust, pointing to the need for colleges and universities to make larger investments in quality teaching. As the enabling role of technologies for learning crystalizes, instructors are leveraging these tools to relate materials and assignments to real-life applications.

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

Growing Focus on Measuring Learning. This trend describes an 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. 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 and soft skills such as creativity and collaboration. 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.

Redesigning Learning Spaces. As universities engage with strategies that incorporate digital elements and accommodate more active learning in the physical classroom, they are rearranging physical environments to promote these pedagogical shifts. Educational settings are increasingly designed to support project-based interactions with attention to greater mobility, flexibility, and multiple device usage. To improve remote communication, institutions are upgrading wireless bandwidth and installing large displays that allow for more natural collaboration on digital projects. Further, universities are exploring how mixed reality technologies can blend 3D holographic content into physical spaces for simulations like experiencing Mars by controlling rover vehicles, or to enable multifaceted interaction with objects, such as the human body in anatomy labs, with detailed visuals. As higher education continues to move away from traditional, lecture-based lessons toward more hands-on activities, classrooms are starting to resemble real-world work and social environments that foster organic interactions and cross-disciplinary problem-solving.

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

Blended Learning Designs. Over the past several years, perceptions of online learning have been shifting in its favor as more learners and educators see it as a viable alternative to some forms of face-to-face learning. Drawing from best practices in both online and face-to-face methods, blended learning is on the rise at colleges and universities as the number of digital learning platforms and ways to leverage them for educational purposes continues to expand. The affordances blended learning offers are now well understood, and its flexibility, ease of access, and the integration of sophisticated multimedia and technologies are high among the list of appeals. The current focus of this trend has shifted to understanding how applications of digital modes of teaching are impacting students. Many findings showcase an increase in creative thinking, independent study, and the ability for the student to tailor learning experiences to meet their individual needs.

Collaborative Learning. Collaborative learning, which refers to students or educators working together in peer-to-peer or group activities, is based on the perspective that learning is a social construct. The approach involves activities generally focused around four principles: placing the learner at the center, emphasizing interaction, working in groups, and developing solutions to real challenges. In addition to improving student engagement and achievement, a key benefit of collaborative learning is bolstering openness to diversity, exposing students to people from different demographics. Educators also engage in collaborative learning through online communities of practice where ideas and insights are regularly exchanged. While this trend is rooted in pedagogy, technology plays an important role in the implementation; cloud-based services, apps, and other digital tools promote persistent connectivity, enabling students and educators to access and contribute to shared workspaces, anytime. Further, through adaptive learning and student advising platforms, data can be shared across an institution to illuminate student performance in order to inform improved instructional design and student advising.

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

As campuses have evolved into hotbeds for entrepreneurship and discovery, higher education has become widely regarded as a vehicle for driving innovation. The focus of this trend has shifted from understanding the value of fostering the exploration of new ideas to finding ways to replicate it across a span of diverse and unique learning institutions. Research has been conducted over the past year to better understand how institutions can nurture the types of culture that promotes experimentation. A significant element for progressing this movement is the call for higher education to alter its status quo to accept failure as an important part of the learning process. The act of integrating entrepreneurship into higher education further acknowledges that every big idea has to start somewhere, and students and faculty can be equipped with the tools needed to spark real progress.[1] In order to keep pace, institutions must critically assess their curriculum and implement changes to their evaluation methods in order to remove barriers that limit the development of new ideas.

Overview

Innovation within higher education has been accelerated by institutions that are moving away from traditional methods of learning in which academics and researchers are the main sources of idea generation. New approaches are prompting universities to act as incubators for all students, faculty, and staff to make new discoveries and design solutions to meet the needs of real-world challenges. A study published by the Teachers Insurance and Annuity Association of America (TIAA) Institute highlights three factors for promoting strategic innovation: a diversity of people, who bring along a variety of proficiencies and opinions; a need for dedicated resources to support individuals' intrinsic motivations, rather than using extrinsic incentives, such as the promise of perfect grades; and autonomy, where individuals are encouraged to voice differing opinions based on a variety of experiences instead of making decisions as a single-minded group.[2]

In order to breed innovation, institutions must be structured in ways that allow for flexibility while driving creativity and entrepreneurial thinking. Universities can accomplish this by fostering environments that encourage risk-taking behavior, through experimentation and the testing of ideas. An interview with a professor from Harvard University advocates for institutions to "incubate, then integrate." Successful transformative practices can be identified by piloting proofs of concept, but an important facet of this approach involves the acceptance of the risk of failure.[3] In a study to better understand how to graduate more entrepreneurial thinkers, faculty members from the University of Malaysia investigated the relationship between a university's environment and its effect on student behavior. Using a four-dimensional framework, the report concludes that students' innovation-friendly behaviors, such as curiosity and creativity, stem from the establishment of positive internal and external factors such as teamwork, support, and motivation.[4]

Before this trend can take root at an institution, faculty and staff must be equipped with the proper tools to implement new practices. *The Chronicle of Higher Education's* "Great Colleges to Work For" program interviewed over 1,200 institutions to identify the specific kinds of support needed to advance innovation. The responses were then analyzed and grouped together to form five overarching themes: the need for open communication, collaboration within departments, job security when challenging the status quo, shared responsibility, and top-down support.[5] While student success remains at the core of institutions' initiatives, education leaders must also recognize the need to empower all stakeholders to support the changes needed to advance cultures that promote invention and discovery.

Implications for Policy, Leadership, or Practice

Recent publications underscore the need for policies that help institutions better finance revolutionary practices, calling for US states to be more strategic in their allocation of funds to invest in efforts that increase program completion and degree attainment. For example, HCM Strategists' *Driving Better Outcomes* report series centers on outcome-based funding, which provides incentives for institutions to graduate more students. This structure could open doors for universities to adopt academic models that provide targeted assistance to improve retention and graduation rates for first-generation, minority, and lower-income students.[6] Other organizations are working to evolve traditional higher education paradigms. Information Technology and Innovation Foundation (ITIF) published

a report urging institutions to separate learning from credentialing. The authors champion policy shifts that help students more effectively demonstrate their skills and knowledge to prospective employers. To advance these goals, ITIF proposes that the US Congress enact reforms when reauthorizing the Higher Education Act, including new accrediting agencies, alternative credentials to diplomas, and the use of federal financial aid to support these alternatives.[7]

The *Times Higher Education* Asia Universities Summit 2016 focused on how Asian universities are developing a culture open to the exploration of new ideas in order to create changes with environmental, economic, and social implications. The keynote presenter proposed that higher education is unique in its ability to foster an ecosystem where discovery, intervention, and learning occur without constraint.[8] The president of the University of Hong Kong penned an article prior to his summit session that rallied for "i-words" to form the backbone of his institution's planning for the next decade: internationalism, interdisciplinary, impact, and innovation. He charges university leadership to nurture environments that normalize failure as another facet of learning — an idea that is a major cultural challenge in Asia.[9] Dedicated space is needed to foster this kind of experimentation and iteration. For example, the Maker Commons at Penn State houses the Invention Studio, which is equipped with littleBits, Arduinos, Raspberry Pis, and Phillips HUE lightbulbs to provide students with hands-on experience in using connected technologies to create custom solutions.[10]

For universities that recognize the importance of this trend, programs are well underway to ensure a progressive culture is promoted throughout their campuses. The University of Sydney piloted its Inventing the Future initiative, which aims to cultivate multidisciplinary collaboration skills through product development; students work together to engage in ideation, prototyping, and seeking funding.[11] Nesta, a foundation that fosters new ideas to overcome the world's inequalities, recently published a report that highlights institutional exemplars whose curricula align with their mission. For example, the Norwegian School of Science and Technology forms student groups to create solutions to real-world issues including sustainable energy and social justice. The publication also features prospective developments, like the New Model in Technology and Engineering University, set to launch in Britain in 2018, which will leverage interdisciplinary and problem-based approaches to teaching and learning through collaborations with industry and academic partners.[12]

For Further Reading

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

Embracing an Entrepreneurial Culture on Campus
go.nmc.org/uni
(Tom Corr, *University Affairs*, 4 May 2016.) The Ontario Network of Entrepreneurs is gaining global recognition for its efforts to bolster students' business skills through investing in multiple campus events and programs. For example, the success of Ontario Centres of Excellence has led to the establishment of similar innovation hubs throughout North America, the UK, Australia, and Asia.

Innovation Fest Brings Entrepreneurs to Campus
go.nmc.org/fest
(Amy Weaver, *Auburn University News and Research*, 29 November 2016.) Auburn University teamed up with city leaders to host its first ever Innovation Fest, an opportunity for collaboration and dialogue between the university and local businesses. Students participated in challenges with the potential to win cash prizes.

JMU Drone Challenge Project
go.nmc.org/jmudrones
(JMU Drones Project, accessed 24 January 2017.) At James Madison University, the JMU Drone Challenge project is an interdisciplinary collaborative effort between seven majors, four professors, and a variety of off-campus organizations. Participants will use design thinking and drone technology to determine innovative solutions to complex global problems.

Promoting a Culture of Innovation & Entrepreneurship in Saudi Arabia (PDF)
go.nmc.org/saudiarabia
(Nadia Yusuf and Huda Atassi, *International Journal of Higher Education Management*, February 2016.) In efforts to diversify and strengthen the national economy, Saudi Arabian leaders proposed a framework that includes partnerships between government, industry stakeholders, and universities to bring new ideas to life.

UMUC's Blueprint for Designing a Culture of Constant Innovation
go.nmc.org/blueprint
(Peter Smith, *EdSurge*, 30 July 2016.) The University of Maryland University College has mapped out ways to ensure their campus remains on the cutting edge of discovery. First acknowledging that all change is difficult, the author outlines methods for continuous improvement that help to define what the "new normal" looks like.

Universities are Becoming Like Mechanical Nightingales
go.nmc.org/innovate
(Keith Burnett, *Times Higher Education*, 19 December 2016.) This article cautions academic practitioners of the dangers of complacency within a static system. Rather than viewing higher education as a machine, leaders must continue searching for new models of teaching and learning so that the field can address the needs of an evolving society.

Deeper Learning Approaches

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

There is an ongoing 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.[13] To remain motivated, students need to be able to make clear connections between their coursework and the real world, and how the new knowledge and skills will impact them. Project-based learning,[14] challenge-based learning,[15] inquiry-based learning,[16] and similar methods are fostering more active learning experiences. While deeper learning is proving to be effective for improving graduation rates in schools,[17] its implementation in higher education settings is not as robust, pointing to the need for colleges and universities to make larger investments in quality teaching.[18] As the enabling role of technologies for learning crystalizes, instructors are leveraging these tools to relate materials and assignments to real-life applications.

Overview

Integrating deeper learning pedagogies in higher education has been a growing trend over the past few years and is continuing to see new developments, particularly in STEM disciplines. These active learning approaches fall primarily under two strategies of inquiry-based learning: problem-based learning where students solve real challenges and project-based learning where they create completed products.[19] According to research conducted by Umeå University in Sweden, when technology-enhanced problem-based learning concepts were applied to small group work in advanced chemistry courses, it proved effective in motivating and engaging students in the process of solving authentic challenges, such as sampling and analysis of contaminated sites. Students claimed that social technologies like online logs and group wikis supplemented their learning, helped them articulate their new knowledge, and guided them in addressing problems in new ways.[20]

A 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 at large. This notion is giving rise to the challenge-driven university. Over the past decade, higher education institutions from Chile to China are eschewing traditional lectures and textbooks in favor of project-based learning activities where students work in teams to tackle problems without clear solutions.[21] A fundamentals of strategic management course at the University of Buffalo, for example, worked with a Singapore-based mobile app startup called Carousell. The course gave students the opportunity to learn how a small business operates and apply the knowledge they acquired to navigate real-world business challenges.[22] The University College Dublin has been applying project-based learning to impart design skills in their civil engineering course. Evaluations revealed that the students enjoyed peer-to-peer teaching and interactions with external experts, and the activities fostered skills valued by employers, such as innovation and presentation.[23]

As disciplines including business, communications, psychology, and nursing are seeing the benefits of deeper learning approaches, research indicates that this trend has not yet seen wide penetration in higher education. Indeed, a recent survey conducted by the Buck Institute for Education found that although 77% of the educator respondents use some form of project-based learning, 43% use it less than 25% of the time.[24] New developments in deeper learning may encourage greater adoption; student learning communities, curricular programs designed by faculty, and collaborations between instructional designers and students are becoming increasingly popular. Loyola Marymount University and Ohio University are both leveraging student learning communities to connect humanities with STEM disciplines to improve intercultural competencies and understanding of human rights issues.[25]

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 21st century practices. As part of European Commission program Erasmus+, Knowledge Alliances represent transnational projects intended to bring together postsecondary institutions and businesses to solve common problems. They focus on developing innovative, multidisciplinary approaches to education; stimulating entrepreneurial skills in higher education; and exchanging knowledge. Similarly, in the US, the Improving Career and Technical Education for the 21st

Century Act, passed by the House of Representatives and awaiting Senate approval, is intended to help Americans receive the skills required to compete for in-demand jobs. The legislation will support meaningful student involvement in work-based learning opportunities and promote the use of new types of credentialing.[26]

Partnerships and frameworks are paving the way for advancing deeper learning worldwide. Conceived by the University of Delaware and Pontificia Universidad Católica del Perú, the Pan-American Network for Problem-Based Learning promotes the approach in education throughout the Americas via bilingual training and resource materials, consulting with organizations interested in implementation, and organizing a bi-annual conference.[27] The Buck Institute for Education has created a comprehensive, research-based model to help educators and institutions measure, calibrate, and improve their practice. Known as Gold Standard Project-Based Learning, their framework addresses student learning goals, essential project design elements, and teaching practices.[28] New organizations continue to emerge, signaling increased interest in deeper learning. The Center for Project-Based Learning at Worcester Polytechnic Institute, for example, was recently established at the Association of American Colleges & Universities annual meeting to provide faculty and administrators support in advancing deeper learning approaches on their campuses through an institute, workshops, and online resources.[29]

The impact of this trend continues to grow as deeper learning matures in practice. Since their founding, Maastricht University in the Netherlands has integrated problem-based learning principles into their coursework. Classes of roughly one dozen students are supervised by a tutor, and each class is tasked with solving real-world challenges. An example of an assignment in a "European Public Health" course, for example, involves a case study where an electrician with tuberculosis might have infected patients at a hospital as well as passengers on public transportation. Students have to answer the following questions, "How is tuberculosis spread?", "What are the risk factors?", and "What national and cross-border measures are needed to prevent the further spread of the disease?" At St. Edward's University, faculty from different disciplines collaborated to redesign assignments with more problem-based and real-world elements; the course "Mathematics for the Liberal Arts" aims to prepare students to apply mathematics in daily life, while students enrolled in "American Dilemmas" apply methodologies from social sciences to analyze social problems.[30]

For Further Reading

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

Does Problem-Based Learning Improve Problem Solving Skills?
go.nmc.org/doesp
(Z. Abdul Kadir et al., International Education Studies, 26 April 2016.) A study of business undergraduates at Malaysian Premier Technical University revealed that when students in an experimental group were given four problems to solve, they significantly improved their problem-solving abilities compared to a control group that only received traditional classroom instruction.

IDEAS Academy
go.nmc.org/ideasacademy
(HCC, accessed 24 January 2017.) Houston Community College's West Houston Institute encompasses the IDEAS Academy, which will offer courses in innovation, design thinking, and entrepreneurship. The Academy is being designed as a unique learning experience for the region that teaches students critical skill sets for the 21st century workplace.

Sharing Power to Promote Deeper Learning
go.nmc.org/sharing
(Maura Rosenthal, *Teaching and Learning Together in Higher Education*, *Issue 16*, Fall 2015.) A sociology professor at Bridgewater State University describes using a fishbowl-type discussion to foster deeper engagement. In this approach, groups of students sit in a circle to discuss book chapters based on questions they prepared ahead of class, while students positioned on the outer circle observed and noted discussion themes.

Strengthening Deeper Learning Through Virtual Teams in E-Learning
go.nmc.org/streng
(Joyline Makani et al., *International Journal of E-Learning & Distance Education*, *Vol. 32, No. 2*, 2016.) As online learning becomes more prevalent in universities, there is a need to identify the core skills and knowledge that improve learning in this setting. In this study, researchers concluded that providing plentiful opportunities for collaboration among "virtual teams" are crucial to fostering deeper learning.

UICEE Centre for Problem Based Learning
go.nmc.org/uicee
(*Aalborg University*, accessed 16 December 2016.) Under the auspices of UNESCO, the Aalborg Centre works to reform higher education strategies through combined research involving problem- and project-based learning, engineering education research, and education for sustainable development.

Using Blogs to Foster Deeper Student Learning
go.nmc.org/fosdeep
(Kevin Gannon, *Pearson*, 1 September 2016.) Through blogging, a history professor's students at Grandview University felt more connected to the subject matter while receiving continuous feedback from instructor and peers.

Growing Focus on Measuring Learning

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

This trend describes an 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.[31] 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 and soft skills such as creativity and collaboration. 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

Twenty-first century learning outcomes emphasize academic skill along with interpersonal and intrapersonal competencies for complete learner success. To evaluate these learning gains, next-generation assessment strategies hold the potential to measure a range of cognitive skills, social-emotional development, and deeper learning, giving students and instructors actionable feedback to foster continued growth.[32] The foundation for facilitating this kind of assessment is learning analytics (LA) — the collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs.[33] LA continues to gain traction at institutions as a means to assess and fundamentally improve student learning. Data mining software captures rich datasets that enable learners and instructors alike to monitor learning and generate personalized feedback to ensure continued progress. As the LA industry matures, the emphasis has shifted from data accumulation to garnering nuanced insights on student engagement through data aggregated across multiple sources and courses.[34]

Multimodal data and social network analysis represent a holistic focus that prioritizes the social, cognitive, and affective components of learning. Multimodal learning analytics, a relatively new approach, focuses on gathering data on the biological and mental processes of learning in real-world learning environments.[35] Voice and tonal inflections, facial gestures, and visual attention and inattention are some examples of this kind of data that can be captured via motion sensors, video cameras, and other tracking devices. Wearable technologies that capture biometrics can also serve as data repositories, but present another layer of ethical and privacy concerns.[36] Concurrently, LMS are also experiencing a paradigm shift from course to curricular management that support adaptive learning technologies, offering specialized data analytics and visualization tools for enhanced instructional design and snapshots of student progress.[37]

More sophisticated analytics are aiding retention and college completion. For example, Nottingham Trent University's (NTU) Student Dashboard has facilitated timely interventions from tutors, positively impacting student engagement and behavior. The dashboard presents data collected from online learning environments, card swipes, library access, and assignments as engagement scores. Students use the dashboard to benchmark their progress against those of their peers and modify their behaviors accordingly, while tutors are able to initiate immediate dialogues to ensure the students' continued engagement. NTU leaders assert that it has transformed the university culture into a data-driven business approach.[38] At the University of Wollongong, instructors use SNAPP, a browser extension for LMS, to analyze student interactions in online discussion forums. SNAPP visualizes participant relationships as social network diagrams in real time, enabling instructors to compare and contrast interaction patterns over time and fine tune discussions.

Implications for Policy, Leadership, or Practice

While big data technologies have demonstrated promise in increasing student retention, ethics are a paramount concern. Mount St. Mary's use of predictive analytics to encourage at-risk students to drop out to elevate the retention rate reveals how analytics can be abused without student knowledge and consent.[39] It also speaks to the need for policies at national, local, and institutional levels that frame ethical practices for the collection, security, ownership, access, dissemination, and application of learning data. The UK is at the vanguard of policy efforts with initiatives such as the

DELICATE checklist[40] and Jisc's Code of Practice.[41] Open University's Policy for the Ethical Use of Student Data is learner-centric and uses openness and transparency as guiding principles in the use of learning analytics.[42] At the University of California, Los Angeles, the chief privacy officer along with the Data Governance Task Force developed a governance structure that guides the ethical and appropriate collection and use of data on faculty, staff, and students.[43]

University leaders continue to explore pedagogical innovations that deepen and enhance student learning, especially through data-driven analytics. At the University of Hong Kong, learning analytics is used to gather direct evidence of learner gains, recommend teacher actions, and inform curriculum development through a better understanding of the relationship between learning design, online learning behaviors, and student grades.[44] More recently, the University Innovation Alliance launched a large cross-campus study using 10,000 students to measure the effectiveness of advising programs based on data analytics.[45] At the other end of the spectrum, the Multi-State Collaborative to Advance Learning Outcomes Assessment initiative demonstrated that standardized rubric-based assessments could be reliably scaled across disciplines and institutions to gain actionable insights into student learning.[46]

The transformative impact of learning analytics is most evident in the evolution of adaptive learning, featured in greater detail later in this report. Two professors at the University of New South Wales used the Smart Sparrow platform to develop the first massive open online course in engineering that leverages adaptive learning to provide personalized support. The course aims to enhance learning outcomes in a degree area that is usually marked with high dropout rates, delivering high-quality learning experiences to students of all backgrounds.[47] LA is also informing better instructional design. An assistant professor at Marist College used learner data to identify which content students find the most challenging and create multiple opportunities to interact with it until they achieve mastery.[48] The University of Technology in Sydney uses REVIEW, an online criteria-based assessment tool to monitor student learning across a set of attributes. Students can view the visual dashboard to gain a comprehensive picture of their learning by year, subject, task, and category.[49]

For Further Reading

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

The Colleges Are Watching
go.nmc.org/arewatching
(Mikhail Zinshteyn, *The Atlantic*, 1 November 2016.) With unprecedented access to student data and sophisticated predictive analysis tools, education institutions balance issues of student privacy while fostering academic success.

Learning Analytics in Higher Education (PDF)
go.nmc.org/ecarla
(Pam Arroway, et al., *Learning Analytics in Higher Education*, March 2016.) This EDUCAUSE Center for Analysis and Research (ECAR) report provides a comprehensive overview of learning analytics in higher education and future considerations of its role and application for academic success.

Learning Analytics: Visions of the Future (PDF)
go.nmc.org/lace8
(Rebecca Ferguson, et al., 6th International Learning Analytics and Knowledge Conference, 25-29 April 2016.) The authors present eight visions of the future of learning analytics developed by the LACE project (Learning Analytics Community Exchange) for the LACE Visions of the Future Policy Delphi study.

Measuring Mastery: Best Practices for Assessment in Competency-Based Education (PDF)
go.nmc.org/measmast
(Katie Larsen McClarty and Matthew N. Gaertner, Center on Higher Education Reform, American Enterprise Institute, April 2015.) The potential benefits of competency-based education for student success are numerous, but the same processes for measuring more traditional learning approaches do not apply. This report recommends a framework for determining the acquisition of real-world skills.

Personalization at Scale: Using Analytics for Institutional Improvement
go.nmc.org/atscale
(Elizabeth Mulherrin and Laura Fingerson, *The EvoLLLution*, 2 February 2016.) Capella University and University of Maryland University College are using big data strategically and effectively to shift from operational reporting to prescriptive analytics.

Traversing the Trough of Disillusionment: Where Do Analytics Go from Here?
go.nmc.org/traversing
(Mike Sharkey and Timothy Harfield, Next Generation Learning Challenges, 19 December 2016.) The authors offer practical steps to achieve student success at scale for institutions considering or just undertaking a learning analytics initiative.

Redesigning Learning Spaces

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

As universities engage with strategies that incorporate digital elements and accommodate more active learning in the physical classroom, they are rearranging physical environments to promote these pedagogical shifts. Educational settings are increasingly designed to support project-based interactions with attention to greater mobility, flexibility, and multiple device usage. To improve remote communication, institutions are upgrading wireless bandwidth[50] and installing large displays that allow for more natural collaboration on digital projects. Further, universities are exploring how mixed reality technologies can blend 3D holographic content into physical spaces for simulations like experiencing Mars by controlling rover vehicles, or to enable multifaceted interaction with objects, such as the human body in anatomy labs, with detailed visuals.[51] As higher education continues to move away from traditional, lecture-based lessons toward more hands-on activities, classrooms are starting to resemble real-world work and social environments that foster organic interactions and cross-disciplinary problem-solving.

Overview

To facilitate workplace-style collaboration in the classroom, some universities are forgoing fixed seating and transforming traditional lecture halls into dynamic layouts.[52] Telepresence technologies are allowing geographically dispersed students and professors to more flexibly meet and work together. For example, the University of South Carolina developed telepresence rooms at seven locations, each equipped with cameras, a 72" display screen, and a control room. Instructors can rotate between rooms to work with several classes simultaneously, while students interact across locations using a polling system as well as shared files and notes.[53] Adaptable learning spaces that incorporate features such as movable furniture, adjustable control of display screens, WiFi, and multiple outlets can be modified to suit a variety of learning activities, including group work, hands-on tasks, and student presentations. Designing learning environments with flexibility at the forefront is helping universities maximize their space.[54]

More accessible spaces can further promote lifelong learning principles by providing students around-the-clock access to learning tools. A traditional 50-minute class period that takes place in the same lecture hall two or three times a week can be limiting on its own, so additional opportunities to work in spaces that are open for longer hours give students flexibility during their unstructured time. Further, some institutions are finding that reconfiguring spaces to be more open and favorable for experimentation can break down institutional silos, encouraging students and staff across disciplines to work closely together. The University of Southern California recently developed its "Garage," combining fabrication and workshop areas with informal lounging spaces to encourage cross-disciplinary interaction, hands-on projects, and collaboration; they found students immediately requesting all-hours access, which reinforced the value of such a space.[55]

University makerspaces, a major iteration of learning space redesign, have gained traction in the past few years, especially as extensions of campus libraries. Libraries have traditionally provided access to information resources and technologies that students may not otherwise be able to afford; many are now expanding their offerings to include cutting-edge tools such as virtual reality equipment, advanced digital editing software, and 3D printers. Additionally, spaces that encourage skills like designing and coding are viewed as valuable aspects of a well-rounded university experience.[56] Institutions are also building incubators and innovation hubs that connect learning with real-world opportunities, while helping students to network and secure funding. The University of Nottingham Ningbo China's Incubator Centre is open 24/7; with only a few enclosed meeting rooms, its open design fosters a sense of community and a seamless exchange of ideas. The space also links students and staff to local startups, investors, and government representatives through special programs and events.[57]

Implications for Policy, Leadership, or Practice

Several organizations offer resources to ensure that design plans comply with accessibility policies. Under Section 504 of the Rehabilitation Act and Titles II and III of the Americans with Disabilities Act, US colleges and universities must provide students with disabilities equal and integrated access to higher education; this includes both physical and digital learning spaces. The National Federation of the Blind provides free online resources that institutions can leverage. Additionally,

many universities have developed their own taskforces and policies.[58] For example, California State University Northridge's Universal Design Center works with its campus community to incorporate accessibility considerations into everyday activities, such as using multiple means of representation when developing resources, including audio, text, and video. The university's procurement process also calls for staff to evaluate products for accessibility prior to purchase.[59]

Leading organizations are publishing best practices to help university leaders transform visions for learning spaces into practice. Jisc's Learning Spaces Guide for evaluating and designing environments is accompanied by case studies and a photo library. The guide calls for entrenching the planning process into institutions' overall teaching and learning strategy, along with accessibility and inclusion requirements.[60] FLEXspace is another open educational resource that was initially developed by the SUNY system to aid institutions in discovering and sharing information on learning space design. Users can search for content using three taxonomies: types of activities taking place in the space; technology equipment within the space; and architectural technical requirements. It can be further utilized as a companion tool to the Learning Space Rating System developed by EDUCAUSE. Campuses are finding success with first scoring their spaces' potential and then using FLEXspace to identify examples of effective priorities.[61]

Institutions are analyzing how learning spaces are currently used campus-wide and applying feedback from students and instructors, while offering professional development opportunities that encourage new and refurbished spaces to be aligned with innovative instruction. At the University of New South Wales, the Piloting Active Learning Spaces project convened a cohort of cross-disciplinary faculty to test new learning spaces with configurable furniture and a range of AV equipment to enable information transfer and collaboration. Users of the spaces are evaluating their experiences to allow continual evolution of the project.[62] In the UK, University of Surrey's Active Learning Space project team is implementing designs aimed at providing more flexibility for instructors and enabling more interactivity. For example, Microsoft Surface hubs allow anyone in the room to wirelessly project their laptop or tablet screen. In tandem with the new spaces, the university is providing workshops on flipped classroom teaching and active learning approaches.[63]

For Further Reading

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

Building for Everyone
go.nmc.org/buildfor
(Centre for Excellence in Universal Design, accessed 11 January 2017.) In Ireland, the Centre for Excellence in Universal Design offers recommendations and best practices to ensure the design and composition of an environment allows it to be easily accessed by everyone.

Collaborative Learning Space at BSU
go.nmc.org/bsucollab
(Boise State University, accessed 24 January 2017.) Boise State University's English Department redesigned a traditional computer classroom into a collaborative learning space. By connecting any wireless device to Solstice technology, faculty and students can stream content or share files to any of six monitors. The space has no focal point and furniture can be easily moved and reconfigured.

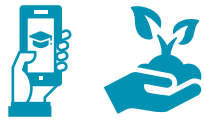
Report of the Ad Hoc Committee on Learning Space Improvement
go.nmc.org/wismad
(Provost, University of Wisconsin-Madison, March 2016.) University of Wisconsin-Madison formed the Ad Hoc Committee on Learning Space Improvement to help transition its spaces to accommodate more active learning techniques enabled by technology. This report describes their improvement plan, providing a window into the entire process.

Research-Informed Principles for (Re)designing Teaching and Learning Spaces
go.nmc.org/mcgill
(Adam Finkelstein, *Journal of Learning Spaces*, 1 November 2016.) McGill University developed a framework for renovating its campus based on institutional goals for active, collaborative teaching and learning. They encourage other institutions to develop their own research-informed pedagogical principles to guide the design and evaluation of learning spaces.

The UK Higher Education Learning Space Toolkit
go.nmc.org/uktool
(Universities and Colleges Information Systems Association, 2 February 2016.) The Universities and Colleges Information Systems Association created a learning space toolkit that can serve as a practical guide for higher education institutions as they build new pedagogies, evaluate their spaces, and implement changes.

University of Western Australia's Reid Library Collaborative Zone
go.nmc.org/refurb
(UWA Library, accessed 24 January 2017.) By offering a variety of group study spaces enabled by technology along with dedicated zones for relaxation, the new Reid Library Ground Floor Collaborative Zone helps students feel more comfortable while engaged in learning for long periods of time.

Blended Learning Designs



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

Over the past several years, perceptions of online learning have been shifting in its favor as more learners and educators see it as a viable alternative to some forms of face-to-face learning. Drawing from best practices in both online and face-to-face methods, blended learning is on the rise at colleges and universities as the number of digital learning platforms and ways to leverage them for educational purposes continues to expand. The affordances blended learning offers are now well understood, and its flexibility, ease of access, and the integration of sophisticated multimedia and technologies are high among the list of appeals. The current focus of this trend has shifted to understanding how applications of digital modes of teaching are impacting students. Many findings showcase an increase in creative thinking, independent study, and the ability for the student to tailor learning experiences to meet their individual needs.

Overview

The growth of blended learning designs acknowledges that students have become more adept at navigating digital environments and engaging with online content — and enjoy the convenience it affords. Over time, this trend has become an umbrella term that encompasses any combination of traditional, face-to-face teaching with modes of technology-facilitated instruction.[64] *Campus Technology* conducted its first-ever "Teaching with Technology" survey in 2016, and 71% of faculty respondents reported using a mix of online and face-to-face environments to teach.[65] From adaptive learning to flipped classrooms to the incorporation of online learning modules, blended learning designs are gaining traction because, when implemented well, they reflect the best of both worlds: they enhance traditional approaches with engaging uses of social technology and rich media. The goal is to foster models that empower faculty with a range of tools to address the varying needs of students from all backgrounds.

The most effective incarnations of this trend incorporate emerging technologies that enable students to learn in ways they would not be able to on a strictly physical campus, or without the tools. For example, architecture students from Ryerson University are using newly released virtual reality headsets to immerse themselves in 360-degree sketches of their designs, allowing for in-depth evaluations.[66] The flipped classroom is another highly recognized form of blended learning, with roots in K-12 education. Many institutions, including Brazil's Singularidades Institute, are finding that this model benefits students by rearranging the time spent in the classroom to promote more active learning and collaboration.[67] While some educators are still hesitant to move a portion of the learning experience online, proponents view blended approaches as a positive disruption that individualizes student-learning activities in ways that build on their strengths and supplement their limitations with personalized resources.[68]

Blended learning designs have topped the list of trends for the past five higher education editions of the *NMC Horizon Report*, in part due to their role in increasing flexibility and convenience for students. Medical students at the Imperial College London recently participated in a mixture of online and face-to-face instruction in a two-course experiment. The study highlights the students' appreciation of being able to combine the physical comfort of interacting on campus with the convenience of completing assignments and watching video lectures online. Students attributed the success of the model to its high-quality design and structure, with easy-to-follow animations and interactive quizzes.[69] Institutions across the US are also recognizing the affordances these designs offer in how time is spent, both in and outside the classroom. Law students liked that the blended approach allowed them to review lectures and reading materials online so they could focus on more difficult topics when they came together face-to-face. Further, it provided them the flexibility to attain a degree while supporting themselves through part- or full-time jobs.[70]

Implications for Policy, Leadership, or Practice

The growing momentum of blended learning designs has led to a number of campuses developing policies to guide faculty in best practices. In 2016, the University of Vermont College of Medicine (UVM) began its six-year journey to flip their courses, replacing the lecture-style platforms with video lectures with the goal of fostering more active learning and experimentation during class. In order to make a successful transition into the blended program, UVM developed new policies, including guidelines for faculty development, strategies for curriculum changes, and new financing structures.[71]

UNESCO recently collaborated with leaders from the Education University of Hong Kong to co-author a report that promotes strategies to drive, sustain, and scale blended learning in higher education. One key takeaway is for institutions to incorporate the designs into their vision and mission statements as a way to ensure the use of a variety of digital learning platforms is a part of the universities' long-term guidance and developmental plan.[72]

The evolution of this trend and its prevalence throughout higher education has led to multiple events centered on advancing its designs. A part of the inaugural Learning Innovation Week held in New South Wales, Australia, the Blended Learning Summit focused on its widespread adoption by addressing three elements fundamental to its success: best practices in implementation methods; ways to promote a culture in which key stakeholders understand and support the need for transition to blended models; and communication strategies to strengthen relationships between educators and technical staff.[73] The Online Learning Consortium (OLC) also initiated a new conference in April 2016 that focused on promoting best practices in online and blended learning.[74] Another effective pathway targets faculty understanding of the designs. In May 2016, EDUCAUSE Learning Initiative (ELI) invited educators interested in adding online learning components to participate in a three-part course that dives into the design, facilitation, and direction of blended courses.[75]

Kiron, a Belgium-based social startup, is modeling an innovative application of this trend, focused on enrolling refugees into higher education courses, free of charge. Their blended program leverages the accessibility and flexibility offered by the combination of online and offline services; to date, the program has 1,500 students, and established four study tracks through partnerships with 22 universities.[76] A music course at the University of Helsinki recently incorporated online learning into its design in hopes of enriching face-to-face time and nurturing more creative thinking in the process of learning music. The overall student feedback on the inclusion of the digital environment was positive; students reported advantages in greater opportunities for independent learning, as well as the ability to apply existing knowledge and experiences to focus on new topics.[77]

For Further Reading

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

Blended Learning Toolkit
go.nmc.org/bltkt
(University of Central Florida, accessed 28 January 2017.) Funded by the Next Generation Learning Challenges program and created in partnership between the American Association of State Colleges and Universities and the University of Central Florida, the Blended Learning Toolkit is a free, open resource for institutions that are developing or expanding their blended learning initiatives.

Business MOOC Maker Udacity Is Embracing Blended Campus/Online Learning
go.nmc.org/uconnect
(Seb Murray, *Business Because*, 20 April 2016.) After evidence pointed to higher success rates for students participating in "clicks and bricks," online learning company Udacity invested in brick-and-mortar buildings with the goal of generating more opportunities for students to connect and network.

Flipping Large Classes: Three Strategies to Engage Students
go.nmc.org/flipped
(Barbi Honeycutt, *Faculty Focus*, 22 August 2016.) Flipped classrooms require educators to advance from dispensing information to guiding students throughout the learning process. This article provides three tips on how teachers can help foster more active learning during class time, transforming into the role of a mentor.

Statement on the Review of Modernization of Higher Education Systems in Europe
go.nmc.org/CESAEER
(*CESAEER*, 8 March 2016.) The Conference of European Schools for Advanced Engineering Education and Research (CESAEER), which spans 50 universities in 24 countries, promotes blended learning in their recommendations by calling for an increase in the use of technology as a means to expand access to institutions.

The Experiences of Lecturers in African, Asian and European Universities in Preparing and Delivering Blended Health Research Methods Courses
go.nmc.org/GH
(Myroslava Protsiv and Salla Atkins, *Global Health Action*, 6 October 2016.) This research paper explores the use of blended learning across four countries — South Africa, Uganda, India and Sweden — to better understand how technology can be used to increase enrollment for lower-income students with the goal of meeting the demand for global health training.

Understanding Blended Learning Through Innovative Professional Development
go.nmc.org/blend
(Stepan Mekhitarian, *EdSurge News*, 19 November 2016.) The author believes current practices for training faculty on how to create a blended learning design are inadequate. This article outlines a step-by-step guide that institutions can adopt for faculty development.

Collaborative Learning

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

Collaborative learning, which refers to students or educators working together in peer-to-peer or group activities, is based on the perspective that learning is a social construct.[78] The approach involves activities generally focused around four principles: placing the learner at the center, emphasizing interaction, working in groups, and developing solutions to real challenges. In addition to improving student engagement and achievement, a key benefit of collaborative learning is bolstering openness to diversity, exposing students to people from different demographics.[79] Educators also engage in collaborative learning through online communities of practice where ideas and insights are regularly exchanged.[80] While this trend is rooted in pedagogy, technology plays an important role in the implementation; cloud-based services, apps, and other digital tools promote persistent connectivity, enabling students and educators to access and contribute to shared workspaces, anytime. Further, through adaptive learning and student advising platforms, data can be shared across an institution to illuminate student performance in order to inform improved instructional design and student advising.[81]

Overview

The now commonplace nature of this trend, also referred to as cooperative learning, acknowledges the social, emotional, and learning gains associated with collaboration. According to the Cornell University Center for Teaching Excellence, effective collaborative activities can lead to higher-order thinking, better self-esteem, and increased leadership skills.[82] Rarely in the workplace do employees operate as silos, independently completing projects without input from others. As such, higher education institutions recognize the need to prepare students for successful careers in which they can adeptly work with a range of personalities and expertise. Students benefit not just from their instructors, but also learn from each other along the way. The University of Queensland views collaborative learning as an integral facet of active learning, fostering a community of inquiry where students feel a sense of belonging.[83] Collaboration is an important undercurrent for many of the other topics in this report, such as Deeper Learning Approaches and Redesigning Learning Spaces.

While the nature of collaborative learning emphasizes group work, there are many more factors that comprise fruitful applications. To guide faculty in designing effective activities, seminal research at Arizona State University pinpoints key areas for consideration, from climate-setting to classroom management. In the former, instructors get student buy-in, helping the class understand how collaboration will build better communication and trust. In the latter, educators carefully formulate heterogeneous teams in terms of achievement, skills, ethnicity, gender, or experience in order to expose students to diverse perspectives. Once in groups, students may require coaching to hone their interpersonal communication skills, especially in terms of giving and receiving feedback to their peers.[84] Similarly, Athabasca University in Canada cites the need for approaches that foster a feeling of community and integrate socially-conscious pedagogy to establish trust, set a proper tone for teamwork, and encourage meaning-making through sustained reflection.[85]

The advent of educational technology is spurring more collaborative learning opportunities; at the most basic level, wikis, Google Docs, social media, and messaging apps enable seamless sharing and communication. In China, educators are leveraging the popularity of social media network WeChat to facilitate student discussions and review assignments.[86] Slack, a real-time messaging platform increasingly used in the workplace, also holds compelling implications for collaborative learning. Marketing guru Seth Godin launched AltMBA, an online leadership workshop hosted in Slack, which consisted of different channels where participants could synchronously trade ideas, post resources, and initiate calls.[87] +Acumen, a nonprofit community of social change leaders, leveraged the success of this model, asking "How can we teach and assess subjects that are nuanced, nonlinear, and deeply human on platforms that are increasingly adaptive and automated?" Their Slack-hosted seminar transcended surface level conversations into dynamic, complex territory suited for deeper learning.[88]

Implications for Policy, Leadership, or Practice

Increasingly, the spirit of collaboration is reflected in initiatives that prioritize global connectivity and leadership training. The US Department of State, in partnership with the Institute of International Education, launched the EducationUSA Leadership Institutes — a program aimed at promoting global collaboration in higher education. With the goal of

cultivating a more globally competent workforce, more than 40 government officials from 24 countries were invited to participate in three academic residencies: US graduate education, industry-private sector linkages, and student mobility. Portland State University, Case Western Reserve University, and GlobalPittsburgh hosted leadership institutes for the exploration of topics including international research collaboration and course accreditation.[89] Recognizing a shortage of work-integrated learning opportunities, the Higher Education Commission in Thailand is looking to adapt Germany's Duale Hochschule Baden-Wuerttemberg institutional model to prepare students for the multidisciplinary, cooperative nature of the workforce.[90]

University leaders are also recognizing the need for campus-wide collaboration around data-sharing, to bolster student success. Georgia State University's (GSU) advising program, Graduation and Progression Success (GPS), identified 800 academic "mistakes," such as registering for the wrong lab sequence or low math scores for students whose major requires calculus. Leveraging this data in a central location, mistakes are flagged whenever they occur for any student, and an advisor contacts them within 48 hours.[91] The GPS initiative has helped drive an increase in the six-year graduation rate from 32% in 2003 to 54% in 2014.[92] GSU has also partnered with the University Innovation Alliance on an $8.9 million grant from the US Department of Education for a multiyear research project to expand their success to 11 universities.[93] Large-scale international collaborations are also taking root with University of Washington, Tsinghua University, and Microsoft partnering to develop the Global Innovation Exchange, a Washington-based program that enables US and Chinese students to attain graduate technology degrees alongside each other. An 100,000 square-foot building will encompass design studios, makerspaces, and designated areas for collaborative projects and presentations.[94]

Students benefit when universities partner on courses that leverage collaborative learning activities. For example, King's College London and Portsmouth University bring together student dentists, students of dental hygiene therapy, and nurses to practice working in real-world teams.[95] Hope College recently received an $800,000 three-year grant from the Andrew W. Mellon Foundation to support collaboration between faculty and students across disciplines. The "Mellon Grand Challenge Initiative" will establish joint research opportunities in which faculty-student teams explore and solve pressing global challenges such as freedom of speech, religious co-existence, and post-conflict reconciliation. The program incorporates Hope College's liberal arts, natural and applied sciences, arts and humanities, and social sciences departments with the aim of developing 50 new linked courses.[96]

For Further Reading

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

Assessing Collaborative Learning
go.nmc.org/assesco
(Peter Williams, *Assessment & Evaluation in Higher Education*, 28 July 2016.) There is an opportunity for more authentic assessments that measure the qualities and dispositions that are key to successful cooperative learning, leveraging the growing wealth of analytics accessible at universities.

Collaborative Learning Spaces
go.nmc.org/cls
(The University of Arizona, accessed 23 November 2016.) As part of the University of Arizona Undergraduate STEM Education Project, the campus-wide Collaborative Learning Spaces Project was developed to foster environments that are better suited for active work with the goal of improving student learning outcomes.

Cooperative Learning
go.nmc.org/coope
(The University of Tennessee Chattanooga, accessed 23 November 2016.) The Walker Center for Teaching and Learning at the University of Tennessee Chattanooga has established definitions and best practices for facilitating small group work. One recommendation includes using a three-step interview as an icebreaker for students who are newly formulated in teams.

How-to Integrate Collaboration Tools to Support Online Learning
go.nmc.org/5stepstr
(Debbie Morrison, *Online Learning Insights*, 2 July 2016.) The author outlines a five-step strategy to cultivate more active learning in online environments. For starters, faculty and staff must consider how the digital tool will improve instruction and motivate learners.

Open Badges Supporting Intercultural Language Learning in a MOOC
go.nmc.org/opebad
(Association for Learning Technology, 26 February 2015.) The Language Centre at the University of Warwick has integrated Mozilla's Open Badge infrastructure for their Online Intercultural Exchange in order to recognize the skill sets required to collaborate effectively online.

Teletandem
go.nmc.org/telet
(Teletandem Brasil, accessed 23 November 2016.) São Paulo State University created Teletandem, an app with text, voice, and webcam features that enable pairs of students who speak different languages to help each other learn their target languages. Students engage in 30-minute conversations that are subsequently mediated by the instructors.

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. Below are summaries of the six significant challenges that will be explored more in-depth in this section, with citations and resources included.

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

Improving Digital Literacy. The productive and innovative use of technology encompasses 21st century practices that are vital for success in the workplace and beyond. Digital literacy transcends gaining isolated technological skills to generating a deeper understanding of the digital environment, enabling intuitive adaptation to new contexts and co-creation of content with others. Institutions are charged with developing students' digital citizenship, ensuring mastery of responsible and appropriate technology use, including online communication etiquette and digital rights and responsibilities in blended and online learning settings and beyond. This new category of competence is affecting curriculum design, professional development, and student-facing services and resources. Due to the multitude of elements comprising digital literacy, higher education leaders are challenged to obtain institution-wide buy-in and to support all stakeholders in developing these competencies. Frameworks are helping institutions assess current staff capabilities, identify growth areas, and develop strategies to implement digital literacy practices.

Integrating Formal and Informal Learning. 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 self-directed, curiosity-based learning. Informal learning encompasses these types of activities, along with life experience and other more serendipitous forms of learning, and serves to enhance student engagement by encouraging them to follow their interests. Many experts believe that blending formal and informal methods of learning can create an environment that fosters experimentation, curiosity, and creativity. An overarching goal is to cultivate the pursuit of lifelong learning in all students and faculty. Institutions are beginning to experiment with flexible programs that provide credit for prior learning and competencies gained through employment, military, or extracurricular experiences. However, there is a lack of scalable methods of formally documenting and assessing skills mastered outside of the classroom and adapting pricing structures and financial aid models to fit new degree options.

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

Achievement Gap. The achievement gap, also referred to as the college completion gap, reflects a disparity in the enrollment and academic performance between student groups, defined by socioeconomic status, race, ethnicity, or gender. While emerging technological developments such as digital courseware and open educational resources (OER) have made it easier to engage with learning resources, significant issues of access and equity persist among students from low-income, minority, single-parent families, and other disadvantaged groups. The one-size-fits-all approach of traditional higher education paradigms, coupled with overwhelming tuition costs, is in stark contrast with an increasingly diverse global student population; more flexible degree plans are needed. The challenge facing higher education is to cater to all learners' needs, aligning postsecondary programs with deeper learning outcomes and the acquisition of 21st century skills, enabled by personalized learning strategies and

data-driven student support systems, that foster goal achievement and gainful employment.

Advancing Digital Equity. Digital equity refers to unequal access to technology, particularly broadband internet. UNESCO reports that while 3.2 billion people across the globe are using the internet, only 41% of those that live in developing countries are online. Further, 200 million fewer women than men are accessing the internet around the world. The United Nations has identified internet access as essential to meeting its sustainable development goals of alleviating poverty and hunger and improving health and education worldwide by 2030. This rampant social justice issue is not just impacting developing nations: more than 30 million Americans lack access to high-speed internet. Efforts to improve these figures are necessary to promote full participation, communication, and learning within society. Technology plays an important role in advancing the availability of higher education for underrepresented student populations and ensuring accessibility of web materials for disabled students. Online learning is enabled by high-speed internet access, while use of open educational resources can provide cost savings to students.

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

Managing Knowledge Obsolescence. Staying organized and current presents a challenge to academics in a world where educational needs, software, and devices advance at a strenuous rate. New developments in technology hold great potential for improving the quality of learning and operations. However, just as faculty and staff are able to master one technology, it seems a new version launches. Institutions must grapple with the longevity of technologies and devise back-up plans before making large investments. There is added pressure to ensure that any tools selected are in service of deepening learning outcomes in ways that are measurable. Processes must be established for both technology and pedagogy discovery so higher education professionals can filter, interpret, organize, and retrieve information in an efficient and insightful manner. Further, the widespread emphasis on research over teaching for promotion and tenure consideration has jeopardized progress in designing high-quality learning experiences, requiring faculty to balance the two and pursue relevant professional development even in the face of inadequate budgets.

Rethinking the Roles of Educators. Educators are increasingly expected to employ a variety of technology-based tools, such as digital learning resources and courseware, and engage in online discussions and collaborative authoring. Further, they are tasked with leveraging active learning methodologies like project- and problem-based learning. This shift to student-centered learning requires them to act as guides and facilitators. Adding to this challenge is the evolution of learning through the rise of competency-based education, which further customizes the academic experience to students' needs. As these technology-enabled approaches gather steam, many institutions across the world are rethinking the primary responsibilities of educators. Related to these growing expectations are the implications of societal changes and evolving faculty models where an increasing percentage of classes are being taught by non-tenure track instructors.

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.

Improving Digital Literacy

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

The productive and innovative use of technology encompasses 21st century practices that are vital for success in the workplace and beyond.[97] Digital literacy transcends gaining isolated technological skills to generating a deeper understanding of the digital environment, enabling intuitive adaptation to new contexts and co-creation of content with others.[98] Institutions are charged with developing students' digital citizenship, ensuring mastery of responsible and appropriate technology use, including online communication etiquette and digital rights and responsibilities in blended and online learning settings and beyond.[99] This new category of competence is affecting curriculum design, professional development, and student-facing services and resources. Due to the multitude of elements comprising digital literacy, higher education leaders are challenged to obtain institution-wide buy-in and to support all stakeholders in developing these competencies. Frameworks are helping institutions assess current staff capabilities, identify growth areas, and develop strategies to implement digital literacy practices.

Overview

Preparing students for the future is the core mission of higher education. Digital literacy is not just about ensuring that students can use the latest technologies, but also developing skills to select the right tools for a particular context to deepen their learning outcomes and engage in creative problem-solving.[100] Jisc, whose work in this area is seminal, has defined digital literacies broadly as "those capabilities which fit an individual for living, learning, and working in a digital society."[101] Digital literacy also encompasses the ability to critically evaluate information encountered on the web. Stanford University researchers have examined "civic online reasoning" skills and found that undergraduate students have trouble judging validity and impartiality of content shared on social media.[102] The proliferation of fake news stories during the recent US presidential election illustrates the importance of cultivating skills for mindful media consumption.[103]

During a recent digital literacy webinar produced by the NMC, panelists agreed that a major obstacle is promoting collective ownership of responsibility and devising comprehensive approaches to developing digital literacy across the curriculum.[104] Embedding digital issues into strategic planning at an institution-wide level is vital, while leadership and vision must incorporate efforts to empower individual growth.[105] Professional development and ongoing support are essential to help faculty contextualize digital literacies within their disciplines. Jisc recommends staff-student partnerships to drive innovation while upskilling the digital prowess of all involved, and has published a guide for planning a collaborative approach.[106] Their digital capability framework also illustrates the spectrum of interrelated skills necessary to meet the challenges of digital environments,[107] including a self-reflection tool to help individuals assess their strengths and access resources to build additional competencies.[108]

In addition to teaching, learning, research, and innovation divisions, academic libraries play an active role in addressing the problem; for example, Western Sydney University Library's digital literacy tutorials and reflection activities help students develop high-order thinking skills.[109] While many digital literacy programs are underway, this challenge remains thorny due to the need for more comprehensive ownership and action. Institutions can prioritize their focus on urgent but achievable actions, and incentivize opportunities for staff at all levels to translate their skills to advance the work of the digital university. Creating and participating in the digital space also surfaces a number of digital literacy issues, including security, privacy, and openness. The Digital Polarization Initiative provides a venue for students to engage in fact-checking and share additional context for news stories. A collaborative wiki reflects a cross-institutional effort overseen by Washington State University Vancouver, with support from the American Association of State Colleges and Universities. Instructors in any course can gain access and create student assignments to improve digital literacies.[110]

Implications for Policy, Leadership, or Practice

Advancing digital literacy has profound implications for global economies; governments are recognizing the intersection of digital strategy with workforce development. The European Commission reports that by 2020, there will be over 750,000 IT jobs without qualified applicants. The Digital Skills and Jobs Coalition initiative directs EC member states to develop policies that address deficiencies in digital skills and increase access to high-quality learning materials.[111]

To support curriculum modernization, policymakers can look to the DigComp framework, which describes digital competencies to aid the assessment of digital knowledge and support the design of targeted educational initiatives.[112] Singapore's government has introduced SkillsFuture, a national initiative to nurture future-ready skills and ensure global competitiveness in the job market. Courses and training modules in the SkillsFuture Credit online portal include IT topics such as digital marketing, data analytics, and social media.[113] In 2016, over two million Singaporeans received $500 credits toward courses available in the portal.[114]

Institutional leaders are working to solve this challenge by creating widely accessible training materials. In the spirit of sharing best practices, Irish universities are collaborating on the Transforming Personal and Professional Digital Capacities in Teaching and Learning Contexts project. Following a survey of social policy educators on their digital proficiencies, instructors and learning technologists will co-design professional training to encourage adoption of technology-enhanced, student-centered teaching and learning approaches. Contributors serve as digital champions, sharing stories to help others overhaul their pedagogies and marking progress with digital badges.[115] Further, the Tech Partnership, an alliance of UK technology employers, is developing a set of standards for digital skills for workplace success. The standards will guide the development of educational programming to best meet these benchmarks. Two categories of competencies have been identified: basic technical skills focus on information management, security, and technology prowess to improve productivity, while behavioral skills include collaboration and critical thinking.

The University of Edinburgh has hired a Wikimedian-in-residence to promote the use of open knowledge resources and improve students' critical assessment skills.[116] The resident will curate events including Wikipedia "edit-a-thons," research and translation workshops, and trainings to foster high-quality digital scholarship.[117] The university also recently offered "23 Things for Digital Knowledge," a self-paced course introducing topics including digital security, Twitter, and augmented and virtual reality. Participating students and staff have linked their blogs to the course site, sharing their learning journeys.[118] Northwestern University is awarding faculty innovation through the Provost's Fellowship for Digital Learning, which provides funding for projects that leverage technology and digital environments to enhance student learning. In one award-winning initiative, students will investigate the experience of Chinese nationals studying in the US, publishing stories in a variety of media formats and languages.[119]

For Further Reading

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

11 Digital Literacy Myths, Debunked
go.nmc.org/digimyth
(Leah Anne Levy, University of Southern California, 2 May 2016.) This article addresses common educator concerns about the role of technology in the classroom, its impact on classroom workflow, and perceived needs to possess expert-level abilities.

Digital Transformation of Industries (PDF)
go.nmc.org/wefdigi
(World Economic Forum, January 2016.) As digital technologies proliferate, this report examines the potential impacts on job creation, automation, environmental sustainability, and more, highlighting the need for large-scale action to address digital skills gaps.

Enhancing Students' Tertiary Blended Learning Experience Through Embedding Digital Information Literacy
go.nmc.org/digimbed
(Bettina Schwenger, *Journal of Perspectives in Applied Academic Practice*, 2016.) By adopting a learner-centered approach and providing continual support throughout the course, blended learning instructors can develop students' critical thinking skills and promote learner independence.

Faculty Development in the Age of Digital, Connected Learning
go.nmc.org/untether
(Jill Leafstedt and Michelle Pacansky-Brock, *EdSurge*, 15 December 2016.) California State University Channel Islands is transforming faculty development through an innovative, "untethered" approach. By increasing availability of online training and encouraging reflection and sharing through contributions to a digital learning blog, the program promotes openness and cultivates connections between educators.

First-Year Experience Project
go.nmc.org/fye
(University of Cape Town, accessed 12 January 2017.) At the University of Cape Town learners complete a digital literacy self-assessment to pinpoint areas for further training, while senior students serve as "tech buddies" to help build technical skills.

A Peer Training Model to Promote Digital Fluency Among University Faculty
go.nmc.org/georgefox
(Linda Samek et al., George Fox University, February 2016.) The Digital Fluency Initiative at George Fox University uses a peer-to-peer model to help faculty discover implementations of education technologies relevant to their interests and goals.

Integrating 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 self-directed, curiosity-based learning.[120] Informal learning encompasses these types of activities, along with life experience and other more serendipitous forms of learning, and serves to enhance student engagement by encouraging them to follow their interests. Many experts believe that blending formal and informal methods of learning can create an environment that fosters experimentation, curiosity, and creativity.[121] An overarching goal is to cultivate the pursuit of lifelong learning in all students and faculty. Institutions are beginning to experiment with flexible programs that provide credit for prior learning and competencies gained through employment, military, or extracurricular experiences. However, there is a lack of scalable methods of formally documenting and assessing skills mastered outside of the classroom and adapting pricing structures and financial aid models to fit new degree options.[122]

Overview

Market forces and the fast pace of technological developments are challenging workers to continually evolve and update their skillsets, making lifelong learning essential. With over 40% of the world's population accessing the internet,[123] recognizing the power and prevalence of online informal learning opportunities is vital to keeping formal education relevant. Online learning resources through platforms such as w3schools, lynda.com, and YouTube have long been leveraged by motivated learners to hone skills, especially in technical fields. The internet has become saturated with learning options on subjects ranging from financial planning to the history of medicine, to hands-on activities like building a bicycle. Currently, incorporating informal knowledge acquisition into formal learning is hindered by a lack of consensus on what constitutes credible informal learning, along with a need for scalable ways to document learning that happens outside the classroom.

Students must be able to recognize what characterizes beneficial learning resources for their specific needs and how to maximize them. Learning institutions are challenged to encourage self-directed learning experiences and to guide students toward the wealth of resources available, such as online courses that reward students with certificates or digital badges, or public assets published by libraries, museums, and cultural centers. Informal experiences can expose students to new areas outside of their academic focuses and allow them to make new connections; learning institutions are in a unique position to connect more students to these opportunities.[124] Humboldt State University Library, for example, promotes international scientific research on the effects of mindfulness, attention, and contemplation through its Library Brain Booth, a drop-in space with hands-on tools and activities. Learners can explore the positive impacts of taking an intentional brain break in a low-key, experiential setting.[125]

A key to integrating informal and formal learning is finding a unified manner to support assessment and certification of knowledge and skills gained through a variety of ventures. With the right infrastructure, students might easily display proof of aptitudes and accomplishments in a more transparent and comprehensive manner than traditional degrees allow.[126] For instance, a student who took online marketing courses through Coursera and developed a product campaign could efficiently display a description of specific skills gained, along with a link to related multimedia materials; this would more accurately portray the student's abilities to student advisors and prospective employers. Creative partnerships between universities, online learning providers, and industry leaders will be vital in advancing recognition of a broader array of competencies. The National Coalition of Certification Centers is connecting community colleges and local industries to develop and implement technical certifications that are portable, stackable, and endorsed by institutions and industry alike.[127]

Implications for Policy, Leadership, or Practice

The European Commission is setting an influential policy precedent by recognizing that informal learning validation increases visibility of learning outcomes and appropriate value of these experiences. Their recently published "European Guidelines for Validating Non-formal and Informal Learning" is aimed at stakeholders, policymakers, and practitioners involved in developing and implementing education validation arrangements.[128] The European Centre for the Development of Vocational Training has, in tandem, developed a database that provides an overview of how

each country is meeting the challenge of validating informal learning.[129] In the US, the Department of Education launched Education Quality through Innovative Partnerships, which allows students to leverage financial aid toward several non-traditional offerings, including management in industries like hospitality and manufacturing or mobile and web development; they are also piloting new assessment mechanisms to support and track the outcomes of these new programs.[130]

Solving this challenge requires leaders to articulate its significance and mobilize institutions to integrate informal learning into their curriculum. The VINCE project encompasses 13 partners from varying sectors, including higher education institutions, vocational education and training providers, NGOs, and an independent Quality Assurance Agency —all working to validate informal learning experiences to increase access into continuing education options as well as the labor market. The project is developing training resources and policy recommendations.[131] Additionally, a coalition of learning stakeholders in Europe has issued the "Bologna Open Recognition Declaration: a Call for a Universal Open Architecture for the Recognition of Lifelong Learning Achievements." The coalition values delivery and recognition of lifelong learning as an enabler for the promotion of social inclusion, employability, and mobility of the world's citizens and global development.[132]

Institutions are also working to move informal learning recognition into practice by implementing campus-wide procedures. In Australia, Macquarie University's Recognition of Prior Learning policy provides a framework for students to gain credit for informal learning through work, social, family, hobby, or leisure activities and experiences as well as other unofficial programs and courses.[133] Trinity College Dublin is another example of an institution that has created a Recognition of Prior Learning strategy as part of a broader effort to facilitate student access and mobility.[134] Texas A&M University–Commerce has developed the competency-based Texas Affordable Baccalaureate (TAB) Program, which includes credit for prior learning that has taken place during previous employment. The TAB option allows students to gain credit for more courses per term, saving them time and money.[135] While pioneering universities continue to take measures to validate a wider variety of learning experiences on their own campuses, broad cross-institution and cross-sector collaborative efforts will be crucial for a large-scale solution.

For Further Reading

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

Digital Badges in Nursing
go.nmc.org/dbnursing
(Digital Badges Nursing at CSUCI, accessed 24 January 2017.) Digital Badges in Nursing at California State University, Channel Islands is a project to recognize and certify nursing students in skills and competencies that are not built into the formal nursing curriculum, ranging from empathy to patient safety to student research.

Integration of Formal and Informal Contexts, for a Better Learning and a Better Teaching
go.nmc.org/contex
(Daniel Burgos et al., UNESCO-UNIR ICT & Education LATAM Congress, 2016.) The UNESCO-UNIR ICT & Education LATAM Congress is focused on combining informal learning with official academic programs and has published this selection of papers to give an overview of related challenges and discussion.

Learning: A Review of the Literature on Informal Learning
go.nmc.org/reconc
(Michelle Van Noy, ACT Foundation, April 2016.) This study analyzes and provides strategies for recognizing informal learning by using a framework in which learning occurs on a continuum of formality based on location, whether learning is instructor- or student-led, content and curriculum, and the motivation of the learner.

Measuring Outcomes in Informal Learning Spaces
go.nmc.org/outcomesin
(Jessica Morley, HASTAC, 22 March 2016.) Informal learning can provide traditionally overlooked students with better educational opportunities. As institutions and educators access more data, they will be able to personalize learning opportunities by adjusting for individual experiences.

Motivational Factors in Self-Directed Informal Learning from Online Learning Resources
go.nmc.org/inself
(Donggil Song and Curtis J. Bonk, Cogent Education, 22 June 2016.) This study of learners using informal learning websites and online learning resources discusses the motivations, obstacles, and learning goals of the self-directed learners interviewed.

Validation of Non-formal and Informal Learning – A Holistic Approach by Scotland
go.nmc.org/Scotlan
(Andrew McCoshan, Electronic Platform for Adult Learning in Europe, 15 August 2016.) Scotland has implemented a robust recognition of prior learning approaches embedded within its Scottish Credit and Qualifications Framework built on values of access, flexibility, and quality assurance.

Achievement Gap

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

The achievement gap, also referred to as the college completion gap, reflects a disparity in the enrollment and academic performance between student groups, defined by socioeconomic status, race, ethnicity, or gender.[136] While emerging technological developments such as digital courseware and open educational resources (OER) have made it easier to engage with learning resources, significant issues of access and equity persist among students from low-income, minority, single-parent families, and other disadvantaged groups. The one-size-fits-all approach of traditional higher education paradigms, coupled with overwhelming tuition costs, is in stark contrast with an increasingly diverse global student population; more flexible degree plans are needed.[137] The challenge facing higher education is to cater to all learners' needs, aligning postsecondary programs with deeper learning outcomes and the acquisition of 21st century skills, enabled by personalized learning strategies and data-driven student support systems, that foster goal achievement and gainful employment.

Overview

Across the world, education has become the most important currency. Attaining some form of a college degree is vital for earning livable wages and building successful long-term careers, with an estimated 85% of current jobs — and 90% of the fastest-growing, best-paying jobs — requiring postsecondary education. Manufacturing jobs, historically attractive for non-graduates, increasingly require postsecondary training and skills.[138] Unfortunately, even the most developed nations are struggling with student achievement. The US, for example, is currently on track to produce at least 11 million fewer certificates and degrees than the national economy will require by 2025.[139] At the same time, nearly half of students who most aspire to filling that need eventually drop out. According to a White House report, half of all people from high-income families earn a bachelor's degree by age 25, as opposed to just one in ten from low-income families.[140] This problem is amplified in Brazil, where only 43% of adults have some postsecondary education.[141]

Additionally, in many of the 40 countries that the OECD routinely researches, a higher percentage of women than men graduate from postsecondary programs. Lithuania sees 66.2% of enrolled women completing postsecondary education compared to 38.6% of men,[142] while women in the US have earned more than half of all bachelor's degrees since the 1980s.[143] Exacerbating the completion challenge is the growth in non-traditional students — defined as financially dependent, single parent, and full-time workers/part-time learners, with a fast-growing number of college students ages 22 to 39.[144] This cohort of students' first-year attrition rate is more than twice as high as traditional students.[145] Online or blended offerings with personalized and adaptive learning strategies are increasingly viewed as a retention solution.[146] Competency-based education, a model exemplified by Western Governors University and Southern New Hampshire University, aims to support completion and job readiness by equipping online students with concrete skills related to their career goals.[147]

Disparities in achievement can also be attributed to socioeconomic factors. The Pell Institute for the Study of Opportunity in Higher Education recently reported that 24-year-olds raised in the top two income brackets account for 77% of bachelor's degrees awarded in the US. The lowest income quarter of less than $35,000 represented just 10%.[148] Further, low-income students eligible to receive federal grants were three times more likely to enroll in for-profit institutions, where the completion rates are significantly lower, than students without financial aid.[149] As a result, the Pell Institute recommends an increase in the maximum Pell grant award from $5,800 to $13,000 as well as expansions in federal programs designed for low-income college students, in which only 10% of eligible students currently participate. Other countries such as Norway, Germany, and Slovenia have circumvented the wealth gap by providing free public postsecondary education.[150]

Implications for Policy, Leadership, or Practice

Governments are launching large-scale initiatives and studies to prioritize college completion. The Obama administration unveiled an agenda to address rising tuition costs as well as spurring student-centered campus innovation;[151] students can now secure financial aid three months earlier to help them make smarter enrollment decisions.[152] The European Commission (EC) published the report *Dropout and Completion in Higher Education in Europe* to investigate factors hampering degree attainment. They found that flexibility in transferring credits to different programs impacts completion; in

Scandinavian countries, students can easily switch from one degree to another, but transfer credit is not widely accepted in the UK, prompting students to drop out after they initially chose a program that was not a good fit. Further, many institutions have poor data collection technology infrastructures, hindering them from developing adequate intervention measures.[153]

Initiatives that promote different routes to enrollment beyond traditional testing and admissions processes are showing promise. Australia is leading this charge, graduating low-income and first-generation students at an increasing rate. Forty percent of residents ages 25-34 whose parents did not attend college earn a degree — compared to just 14% in the US.[154] The Fast Forward program, a partnership between schools, universities, and the Australian government, provides early information to prospective students about alternative pathways to tertiary education, even if they have not performed well in high school.[155] Rather than relying on standardized test scores from the Australian Tertiary Admission Rank, students can enroll in online courses meant to bridge their knowledge from high school to college, demonstrate skills mastered through non-formal learning, or submit personal e-portfolios.[156] In order to qualify for funding and participation in the Fast Forward program, each institution must explicitly detail how its strategies will improve student success.

Institutions are turning to technology solutions to monitor student engagement and predict potential dropouts to inform retention tactics. The Office of Information Technology at the University of Texas at San Antonio (UTSA) is leveraging Ellucian's DegreeWorks platform to aid students in planning their coursework and tracking their progress towards achieving their degree and marketable skills. In fall 2016, UTSA launched the Education Advisory Board's Student Success Collaborative Campus to enable student advisors to provide more personalized support to learners, integrating data from several systems into a single platform designed to target at-risk students.[157] Queensborough Community College has generated a virtual network of student support services, connecting the Academic Literacy Center, the Campus Writing Center, the College Discovery Center, the Math Learning Center, and the Student Learning Center with Starfish Early Alert. Through this infrastructure, learners receive real-time feedback and recommended resources that cater to their unique needs.[158]

For Further Reading

The following resources are recommended for those who wish to learn more about the achievement gap:

Helping Higher Education Faculty Practice (Not Preach) Equity
go.nmc.org/notpreach
(Joseph A. Garcia and Estela Mara Bensimon, *The Denver Post*, 27 May 2016.) Plans to ensure greater college enrollment for African-Americans, Latinos, and Native Americans cannot alone solve degree attainment gaps; the authors posit that rather than focusing on large institutional efforts, individual actions from faculty members must be rethought.

Status and Trends in the Education of Racial and Ethnic Groups 2016 (PDF)
go.nmc.org/iesnces
(Lauren Musu-Gillette et al., Institute of Education Sciences, National Center for Education Statistics, August 2016.) A report commissioned by the US Department of Education details the educational strides and challenges of specific demographics, charting changes over time. While some disadvantaged groups have demonstrated progress in recent years, gaps persist for other groups.

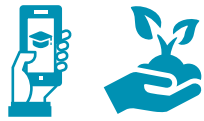
University Degree Remains 'a Remote Dream' for Many in Latin America
go.nmc.org/remotedream
(Carolina Guzmán-Valenzuela, *Times Higher Education*, 7 July 2016.) While increased efforts and investments are positively impacting some Latin American countries, the region remains unequal. The growth of private universities is creating an unmanageable financial burden for low-income families.

What It Takes for a Poor Black Kid from Chicago to Earn a College Degree
go.nmc.org/whatitta
(Rebecca Klein, *The Huffington Post*, 30 September 2016.) The author chronicles the education of Krishaun Branch and Robert Henderson, two students living in notoriously violent Chicago neighborhoods. Against the odds, both earned college degrees — largely due to effective school and institutional support systems.

When College Students Start Behind
go.nmc.org/tcf
(Thomas Bailey and Shanna Smith Jaggars, The Century Foundation, 2 June 2016.) Evidence suggests that investments in helping underprepared students succeed are not greatly impacting their performances at community colleges. This report examines four kinds of reform efforts at various institutions and concludes that the student experience must be redesigned.

Why are South African Students Protesting?
go.nmc.org/whyaresa
(*BBC News*, 4 October 2016.) In recent months, South Africa has experienced the largest student protests since the apartheid ended, due to 10-12% increases in university tuition. Many of the protestors, who are fighting for free tertiary education, come from low-income families and cite the price hike as discriminatory.

Advancing Digital Equity



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

Digital equity refers to unequal access to technology, particularly broadband internet. UNESCO reports that while 3.2 billion people across the globe are using the internet, only 41% of those that live in developing countries are online.[159] Further, 200 million fewer women than men are accessing the internet around the world. The United Nations has identified internet access as essential to meeting its sustainable development goals of alleviating poverty and hunger and improving health and education worldwide by 2030.[160] This rampant social justice issue is not just impacting developing nations: more than 30 million Americans lack access to high-speed internet. Efforts to improve these figures are necessary to promote full participation, communication, and learning within society.[161] Technology plays an important role in advancing the availability of higher education for underrepresented student populations and ensuring accessibility of web materials for disabled students. Online learning is enabled by high-speed internet access, while use of open educational resources can provide cost savings to students.[162]

Overview

Internet access is vital to sustainable economic development; governments must address connectivity challenges alongside efforts to strengthen traditional infrastructure such as roads and electricity. A World Bank study found that developing countries experienced a 1.3% increase in GDP following a 10% increase in broadband access.[163] A white paper by the World Economic Forum, "Internet for All," identifies factors that compound the challenge of bringing more people online, including a lack of electricity for 15% of the world's population, unaffordable broadband access, and illiteracy.[164] Without high-speed internet access, successful scaling of emerging technologies in education is moot. Barriers to equity persist as broadband remains unevenly distributed; the Center for Public Integrity reported that US families in neighborhoods with median incomes in the lowest 20% are five times more likely to lack broadband access than households in areas with median incomes in the top 20%.[165]

Where high-speed internet is available, institutions are challenged to leverage technology-enabled education models to better meet the needs of underserved students. A report funded by Australia's National Centre for Student Equity in Higher Education explored the learning experience for students with disabilities studying at Open Universities Australia, an online institution. Many students advised that the flexibility of online learning allowed them to pursue educational opportunities and that they would be unable to matriculate at traditional institutions.[166] As institutions gather data about student learning via online learning environments, adaptive technologies provide personalized support and targeted feedback to help more students complete courses.[167] In some instances, however, freely available learning resources continue to benefit the most advantaged learners. Researchers from Harvard and MIT examined enrollment data from 68 MOOCs they offered between 2012-2014. They found that participants lived in neighborhoods with median incomes above US averages. Further, teenagers enrolled on the HarvardX platform with a college-educated parent were more than twice as likely to earn a certificate than those whose parents lacked education credentials.[168]

Many institutions have recognized a social responsibility to increase educational access through digital resources. In 2017, Oxford University will provide free online courses through the edX platform founded by Harvard University and MIT.[169] OER, learning materials with free use and remixing rights for educators, offer another alternative to improve equity in higher education.[170] Online repositories including ISKME's OER Commons[171] and the international collaboration Commonwealth of Learning[172] house collections of resources that institutions can use to reduce costs for students. Evidence is mounting that OER can also positively impact student performance. For example, at Northern Virginia Community College, pass rates were 9% higher in courses using OER as compared to courses using traditional texts.[173]

Implications for Policy, Leadership, or Practice

Government initiatives are working to address connectivity gaps and increase use of OER. India's prime minister recently launched the Digital India program, which aims to synchronize implementation of a variety of strategies underway to increase broadband access in rural areas and empower the country through digital technologies. Growth areas include mobile connectivity, public internet access, electronic delivery of services, and IT training for young people.[174] The state of California

has allocated $5 million for the California Community Colleges system to develop Z-degrees — zero-textbook-cost degree pathways. Institutions can design degree plans using existing OER or use funds to create new OER materials; the learning resources will be published in the California Open Online Library for Education (COOL4Ed) to promote cross-institutional collaboration within the state and beyond. Incentive funds are also available to spur faculty adoption of OER through the provision of professional development services.[175]

Industry leaders are developing digital equity strategies to meet this challenge. Comcast is piloting an initiative in Colorado and Illinois in which community college students receiving Pell grants are eligible to purchase computers for less than $150.[176] Programs of this nature recognize the growing importance of access to digital resources and technologies for postsecondary students. Google's Project Link is building metro fiber networks in Uganda that allow internet service providers to offer low-cost broadband access. The company is working with the Research & Education Network of Uganda (RENU) to provide last-mile connectivity that enables research collaborations across higher education institutions.[177] Media Access Australia and the Australian Communications Consumer Action Network have partnered on Affordable Access, a website aggregating resources to improve access to technology for disabled persons and their caregivers. The site provides guidance on selecting affordable smartphones and tablets as well as accessibility features of popular devices.[178]

Institutions are harnessing technologies to meet the needs of more students. The University of Cambridge aims to improve inclusivity for students with disabilities through its Lecture Capture pilot, where faculty will post course content online in a variety of formats including audio and video. Analytics on student use of these materials will also help instructors determine where further instruction is needed. The program is part of the institution's Digital Strategy for Education, which supports activities that enhance teaching and learning through technology and improves equity in the student experience.[179] While the MOOC movement has experienced low completion rates and difficulties in scaling feedback, discussion, and assistance across thousands of students,[180] well-designed courses continue to hold promise for delivering quality education to underserved populations. Stanford University's Lytics Lab found that adding activities that promote social belonging and self-confidence to MOOCs can improve learner perseverance and achievement for participants from developing countries.[181]

For Further Reading

The following resources are recommended for those who wish to learn more about advancing digital equity:

Analysis: Internet Access — An Incomplete Promise
go.nmc.org/incomp
(Frederick L. Pilot, Rural Futures Institute, 1 June 2016.) In the US, access to broadband internet service is often determined by telecommunications companies' ability to seek profits. Lack of infrastructure impacts people's ability to pursue online learning, conduct business from their homes, and receive remote medical services.

Closing the Digital Divide: A Briefing Note
go.nmc.org/wwwbrief
(World Wide Web Foundation, 14 April 2016.) This article provides recommendations on government-industry partnerships, fiscal plans, and policy initiatives that must be prioritized in order to meet the United Nations' sustainable development goals of improving internet access worldwide and reducing gender disparities in technology access.

E-Learning, the Digital Divide, and Student Success at Community Colleges
go.nmc.org/elearncc
(Lisa Young, *EDUCAUSE Review*, 22 August 2016.) Online learning presents opportunities to better meet the needs of diverse students, including the use of OER to reduce educational costs. Institutions must be mindful of persistent inequalities in internet access among those same populations they serve.

Indigenous Internet Increases Inclusion
go.nmc.org/inclus
(Marcus Butler, University of Canberra, 31 May 2016.) Internet connectivity rates are persistently lower among Aboriginal and Torres Strait Islanders as compared to non-indigenous Australian populations. Addressing affordability to bring more people online would increase access to education and employment opportunities, which in turn could improve health outcomes.

Laptop Program Narrows Digital Divide for College-Bound Foster Youth
go.nmc.org/foster
(Eric Lindberg, University of Southern California, 13 September 2016.) A program that provides laptops to foster teens has seen its participants miss fewer school days, improve their mental health and self-esteem, and apply to college and jobs in increasing numbers.

Report of the Special Rapporteur on the Right to Education (PDF)
go.nmc.org/uneduc
(Kishore Singh, United Nations General Assembly, 6 April 2016.) International human rights laws mandate that governments devote public funds to increasing access to education. This report cautions against excess privatization and urges leaders to support the development of free online resources while addressing infrastructure inequalities.

Managing Knowledge Obsolescence

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

Staying organized and current presents a challenge to academics in a world where educational needs, software, and devices advance at a strenuous rate.[182] New developments in technology hold great potential for improving the quality of learning and operations. However, just as faculty and staff are able to master one technology, it seems a new version launches. Institutions must grapple with the longevity of technologies and devise back-up plans before making large investments. There is added pressure to ensure that any tools selected are in service of deepening learning outcomes in ways that are measurable.[183] Processes must be established for both technology and pedagogy discovery so higher education professionals can filter, interpret, organize, and retrieve information in an efficient and insightful manner. Further, the widespread emphasis on research over teaching for promotion and tenure consideration has jeopardized progress in designing high-quality learning experiences, requiring faculty to balance the two and pursue relevant professional development even in the face of inadequate budgets.[184]

Overview

Academics are challenged to understand the educational impact of societal shifts, agilely anticipate sea changes, and continuously generate new ideas that benefit teaching and learning. Additionally, they must make smart decisions around technology adoption, connecting tools with furthering effective pedagogies and research methodologies. However, there is a disparity between the perceived gains of educational technologies and tangible student outcomes. In South Africa, researchers found that technologies are often deployed without sufficiently addressing the needs of both instructors and students.[185] When *Inside Higher Ed* and Gallup surveyed attitudes on technology, they found the topic of online learning to be particularly divisive; 53% of faculty asserted that virtual courses did not match the quality of face-to-face offerings.[186] Although online learning is on the rise as learners expect more flexible degree pathways,[187] institutions are not yet equipped to present the most valuable experiences possible.

With more options than ever for students to acquire new skills, traditional institutions must maintain a competitive edge.[188] Recognizing that rote learning is insufficient for producing workforce-ready graduates, faculty at Asian universities are now expected to incorporate 21st century skills; institutions across the continent are conceptualizing professional development programs that instill more effective learning approaches.[189] For example, Seoul Intensive Course for Medical Educators is a collaborative program for faculty in Cambodia, Laos, Mongolia, Myanmar, and Vietnam to exchange best practices and bolster international health education capacity.[190] In the US, the Tracer Project examined how faculty professional development at Carleton College and Washington State University affected student learning outcomes. Findings revealed that extensive ongoing training, as opposed to one-off topical workshops for single departments, cultivates better teaching practices. Progress is further enhanced by instructors engaging in self-directed learning and communities of practice.[191]

Another dimension of this challenge is the idea that institutions must prepare for the possibility that the technologies they adopt may be rendered obsolete by future incarnations or discontinuations. Higher education can take a cue from other sectors. Museums, for instance, are no stranger to the notion of preservation and conservation as digital objects require special care to ensure the artist's intent is retained during updates to the display technology. The Canadian Heritage Information Network has established a digital preservation template and framework to guide museums in the process.[192] Institutions must similarly build infrastructures that support technology transitions so that changes in products such as smartphones and telepresence systems do not disrupt connectivity and physical spaces on campuses. At Columbia University, Teachers College's Gottesman Library is building the "Learning Theater," an open-plan educational lab that deploys proven techniques from the visual arts to enable staff to experiment with unconventional collaboration and instructional approaches, constructing mock-spaces in the same manner a set designer does a play.[193]

Implications for Policy, Leadership, or Practice

While policies that directly address this wicked challenge are elusive, the European Commission has set a precedent for developing greater capacity for innovation. One aim of their Erasmus+ program, for example, is to modernize higher education offerings by aligning curriculum to labor market needs, fostering more skills in institutional leadership, and generating opportunities for international

exchanges.[194] In 2017, Erasmus+ will award grants of up to 1,000,000 euros for capacity-building projects aimed at helping formulate better institutional policies and practices.[195] Additionally, institutions have established clear policies around faculty and staff professional development. Durham Technical Community College has training and development advisory committees that are responsible for identifying opportunities and maximizing campus resources,[196] while Rochester Institute of Technology allows many tenured faculty to apply for leave to pursue long-term development.[197]

Higher education leadership must continuously seek to fill knowledge gaps among faculty, regardless of tenure status. The Houston Community College system exemplifies best practices for providing adjuncts with technological and pedagogical assistance.[198] Eight Curriculum Innovation Centers work with instructors to integrate the latest technologies into their courses and facilitate engaging learning experiences. Adjuncts receive training on special projects, such as digital storytelling and designing online courses, as well as basic assistance with LMS and grade entry software.[199] The centers are accessible during set hours or by appointment, providing flexibility for adjuncts to visit the location nearest their home, place of employment, or teaching campus. In the UK, Jisc provides both online and face-to-face training to a wide range of educators to encourage timely approaches; a recent virtual workshop covered upcoming changes to Disabled Students' Allowance provisions, helping institutional leaders identify and deploy affordable strategies to support disabled learners.[200]

Penn State University (PSU) employs a three-pronged approach for managing knowledge obsolescence among faculty and staff: providing them with emerging technologies for freeform experimentation, bringing together instructional designers and programmers to reimagine how technology can transform classroom activities, and establishing long-term bonds between leadership and faculty to engage in creative problem-solving. PSU's Faculty Fellows program also awards grants to those interested in piloting new digital tools, such as wearable devices. One such pilot with smart watches has already uncovered compelling student gains, with seamless interactions between participating learners and the content itself.[201] Encouraging faculty and staff to learn through innovation and technology experimentation in this manner is key; effective evidence-based practices cannot exist without support for gathering the evidence in the first place.

For Further Reading

The following resources are recommended for those who wish to learn more about managing knowledge obsolescence:

Communities of Practice in Higher Education
go.nmc.org/usqcop
(University of Southern Queensland, accessed 19 December 2016.) Australia's University of Southern Queensland emphasizes the importance of communities of practice, which provide safe spaces for faculty and staff to collaborate and reflect on teaching and learning practices.

Courseware in Context Framework
go.nmc.org/cwicf
(Courseware in Context Framework, Tyton Partners, accessed 19 December 2016.) This open-access resource enables higher education leaders to view a product taxonomy that categorizes technologies by features. Users can discover peer-reviewed research on how product features impact student learning as well as guides to inform implementation.

Departmental Cultures and Non-Tenure-Track Faculty (PDF)
go.nmc.org/nontenf
(University of Southern California Earl and Pauline Pullias Center for Higher Education, August 2015.) With the Delphi Project on the Changing Faculty and Student Success's self-assessment tool, institutional leadership can use the results to address any gaps in creating a supportive environment that enables adjuncts to best meet student needs.

Female Professors 'Pay Price for Academic Citizenship'
go.nmc.org/femprof
(Jack Grove, *Times Higher Education*, 14 December 2016.) The author makes the case that while male professors concentrate on bolstering their own research and are more likely to receive external recognition, female professors value mentoring and development. Fulfilling more learning and service-oriented roles may be causing them to be overlooked for promotions.

How Colleges Prepare (or Don't Prepare) Their Leaders Is Holding Back Innovation
go.nmc.org/howcol
(Jeffrey J. Selingo, *The Chronicle of Higher Education*, 9 August 2016.) This article examines barriers to effective leadership in higher education, including the steep learning curve before new leaders can be involved in major decision-making.

Learning Technology Commons
go.nmc.org/uncltc
(Marguerite McNeal, *EdSurge*, 8 February 2016.) The University of North Carolina System launched the Learning Technology Commons to make the procurement of specific tools easier for faculty members across 17 campuses. The Commons marketplace allows faculty and staff to contribute product reviews, creating an aggregation of crowdsourced user experiences.

Rethinking the Roles of Educators

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

Educators are increasingly expected to employ a variety of technology-based tools, such as digital learning resources and courseware, and engage in online discussions and collaborative authoring. Further, they are tasked with leveraging active learning methodologies like project- and problem-based learning. This shift to student-centered learning requires them to act as guides and facilitators.[202] Adding to this challenge is the evolution of learning through the rise of competency-based education, which further customizes the academic experience to students' needs. As these technology-enabled approaches gather steam, many institutions across the world are rethinking the primary responsibilities of educators. Related to these growing expectations are the implications of societal changes and evolving faculty models where an increasing percentage of classes are being taught by non-tenure track instructors.

Overview

As detailed in the Deeper Learning Approaches section, higher education institutions are increasingly incorporating activities that foster active learning and promote problem-solving. Educators' duties are changing to curators and facilitators of learning experiences, encouraging students to develop better research habits and formulate deeper questions.[203] With the rise of personalized and contextualized learning, such as competency-based education (CBE), educators are no longer the sole authoritative source of information and are expected to assist students in navigating the mastery of content and skills. An RPK Group study on CBE found that when traditional faculty models are unbundled, it allows for further specialization, with some institutions separating subject-matter experts from mentors, as well as faculty who only work with learning assessments.[205] CBE requires faculty to work in a counter-intuitive way that is challenging for them; experiments at the University of Mary Hardin-Baylor found that CBE curriculum development requires designing assessments before content.[206]

As emerging learning approaches become more commonplace on campuses, an array of societal changes are impacting educator roles. A study by Academic Impressions on faculty professional development highlighted that in addition to keeping pace with disruptions in teaching and learning, faculty must address shifting demographics, changes in enrollment, and pressure from stakeholders to provide graduates with the skills for a globalized 21st century work environment.[207] In Bangladesh, thought leaders note that economic prosperity in developed and developing countries hinges on universities building a skilled workforce, and their traditional education system must evolve to more effectively produce graduates that are creative and adequately prepared to address real-world challenges.[208]

Compounding this wicked challenge is the contradiction between what higher education institutions value and how they prioritize those values. A Gallup survey of college and university presidents found that 64% of presidents place teaching first in importance in faculty roles, and only 1% believe that publishing and research are their most important responsibilities.[209] Yet, pundits note that a growing number of faculty appointments are part-time or non-tenure track positions with lower faculty engagement, higher turnover, and declining instructional quality, and those with tenure are assessed primarily on their scholarly output rather than their ability to engage students.[210] The National Education Association (NEA) supports these claims, stating that only 30% of instructional faculty are tenure-track positions at non-profit universities, while a majority are adjuncts employed on a term-to-term basis. The NEA claims that failing to properly support non-tenure track faculty is detrimental to student outcomes.[211]

Implications for Policy, Leadership, or Practice

Government action will be key to helping educators keep pace with the needs of 21st century learners, especially in the realm of workforce preparedness and entrepreneurship. In spite of criticism of their model,[212] higher education in the state of Arkansas is undergoing a major change with a new funding framework; instead of basing funding on how many students start college, institutions will focus on how many students graduate, requiring shifts in how they operate, with reimagined roles for faculty. The governor's intent is to strengthen the ties between higher education and workforce readiness.[213] The EC's Education and Training 2020 (ET 2020) strategic framework is also designed to help educators address skills deficits in the workforce.[214] HEInnovate is an initiative promoted by ET 2020 to guide institutions in conducting self-assessments on

the innovative nature of their environment. Criteria include organizational capacity, knowledge exchange and collaboration, and entrepreneurial teaching and learning.[215]

Education-focused organizations and agencies are working together to design solutions that help educators understand how to use innovative pedagogies to advance their practice. The National Research Center for Distance Education and Technology Advancements (DETA) was created to help colleges and universities conduct rigorous inquiries on distance education to identify the variables that influence learning and teaching efficacy. They offer the DETA research toolkit that provides faculty and institutions with consistent and accessible ways to conduct research, including research models, survey instruments, and data codebooks.[216] The Competency-Based Education Network (C-BEN) is a US consortium of colleges and universities aimed at designing and scaling CBE degree programs. The network of 17 institutions will undergo research and development to provide an evidence-based approach to advancing CBE.[217] C-BEN recently released eight quality standards for CBE to inform the design and scaling of high-quality programs in this emerging field.

Efforts are under way to help educators transform their teaching practices, enabled by the creative use of technology. The University of Maryland University College is embarking on a three-year initiative to shift their pedagogies from those based on memorizing knowledge to experiential learning and competency — radically changing the teaching culture. This will require faculty to think more like project managers with experience in interpreting data, monitoring team dynamics, and managing IT issues among other skills.[218] In Australia, the University of Melbourne recently established a new academic position with the goal of strengthening connections between the university and industry. The inaugural round of appointments included Enterprise Professors across various disciplines including engineering, economics, and arts.[219]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking the roles of educators:

Faculty Role in Competency Programs Still Evolving
go.nmc.org/facrol
(Dian Schaffhauser, *Campus Technology*, 1 December 2016.) This article examines a study on the roles and responsibilities involved in developing and delivering CBE content. The researchers found that at least 75% of the institutions surveyed noted attracting and retaining students as major challenges.

Issues and Challenges in Open and Distance e-Learning: Perspectives from the Philippines
go.nmc.org/phili
(Patricia Arinto, *International Review of Research in Open and Distributed Learning*, *Volume 17, No. 2*, February 2016.) Distance education has impacted teaching practice at the University of Philippines – Open University. While faculty and administrators in this study are interested in innovative teaching and learning practice, they constitute the minority and believe more faculty development is needed to foster the exploration of new pedagogies.

Rethinking Faculty Models/Roles: An Emerging Consensus about Future Directions of the Professoriate
go.nmc.org/profess
(Adrianna Kezar et al., TIAA Institute, accessed 1 December 2016.) Researchers commissioned by TIAA Institute conducted a study on the rise of non-tenured faculty and the related potential implications and attributes of future faculty models.

Support Scholar-Practitioner in International Higher Education
go.nmc.org/suppscho
(Bernhard Streitwieser and Anthony Ogden, NAFSA: Association of International Educators, 2016.) The authors define two aspects of international higher education: practitioners who work in expanding professional management and scholars who conduct and publish research. They argue the need for the development of scholar-practitioners to bridge both areas, maximizing the connections between the field and profession.

Teaching Presence and Facilitation
go.nmc.org/presence
(Norma Hansen, *Faculty eCommons*, accessed 11 January 2017.) Increasing student satisfaction and outcomes in online courses requires faculty to be mindful of how they engage with students. This post highlights five principles that instructors should achieve in their online offerings including establishing and cultivating online presence, and responsiveness.

The Shift Toward Competency Starts with Faculty
go.nmc.org/shift
(Richard Senese, *EdSurge*, 24 March 2016.) Today's college students are older and more diverse than ever and the author claims that this demographic shift is, in some part, related to the evolution of competency-based learning. This notion changes the role of instructors and enables more opportunities to deeply engage with students.

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 developments that are expected to achieve widespread adoption in one year or less; mid-term developments that will take two to three years; and far-term developments, 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 featured technologies, 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. They also proposed developments in technology that were new to the NMC Horizon Project; a key criterion for the inclusion of a new topic 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 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, making them more capable and useful.

> **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 2017 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 topic 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
> Drones
> Real-Time Communication Tools
> Robotics
> Wearable Technology

Digital Strategies
> Location Intelligence
> Makerspaces
> Preservation & Conservation Technologies

Internet Technologies
> Blockchain
> Digital Scholarship
> Internet of Things
> Syndication Tools

Learning Technologies
> Adaptive Learning Technologies
> Microlearning Technologies
> Mobile Learning
> Next-Generation LMS
> Virtual & Remote Laboratories

Social Media Technologies
> Crowdsourcing
> Online Identity
> Social Networks
> Virtual Worlds

Visualization Technologies
> 3D Printing
> Information Visualization
> Mixed Reality
> Virtual Reality

Enabling Technologies
> Affective Computing
> Artificial Intelligence
> Big Data
> Electrovibration
> Flexible Displays
> Mesh Networks
> Mobile Broadband
> Natural User Interfaces
> Near Field Communication
> Next-Generation Batteries
> Open Hardware
> Speech-to-Speech Translation
> Virtual Assistants
> Wireless Power

Adaptive Learning Technologies

Time-to-Adoption Horizon: One Year or Less

Encompassed by the personalized learning movement and closely linked to learning analytics, adaptive learning refers to the technologies monitoring student progress, using data to modify instruction at any time.[220] Adaptive learning technologies, according to EDUCAUSE, "dynamically adjust to the level or type of course content based on an individual's abilities or skill attainment, in ways that accelerate a learner's performance with both automated and instructor interventions."[221] Enabled by machine learning, these technologies can adapt to a student in real time, providing both instructors and students with actionable data. The goal is to accurately and logically move students through a learning path, empowering active learning, targeting at-risk student populations, and assessing factors affecting completion and student success. Advocates for adaptive learning believe that it can be a solution for the "iron triangle" of educational challenges: cost, access, and quality.[222]

Overview

Previously paired with the topic of learning analytics in the *NMC Horizon Report > 2016 Higher Education Edition*, adaptive learning continues to be poised to see significant growth in 2017. Gartner named it as the top strategic technology for higher education IT leaders to plan for in 2016 because of its potential to help scale personalized learning.[223] Tyton Partners have been mapping the evolution of adaptive learning in higher education since 2012; their most recent analysis has identified several key themes that indicate growth in adaptive learning.[224] The biggest change from the beginning of their study to present lies in the response of vendors to institutional demands for new feature sets, showing that courseware developers are now more in tune with sector needs. This was followed in importance by adaptive learning's viability in some competency-based education cases, highlighting the technology's strength in hybrid and online learning environments.[225]

In spite of the limited research on the empirical impact of this pedagogical approach, early results are promising. Adaptive learning company CogBooks and Arizona State University studied the impact of next-generation adaptive courseware in a flipped introductory biology course and two online history courses. After using CogBooks for one semester, student success rates rose from 76% to 94% and the dropout rate reduced from 15% to 1.5%.[226] SRI's three-year study of the Adaptive Learning Market Acceleration (ALMAP) initiative, a multi-institution effort to use advance adaptive learning to improve access and graduation rates, showed more modest gains, with slightly higher than average course grades in some courseware integrations. Even more significant was how the adaptive courseware varied by use case; student learning was positively impacted both when switching from lecture to adaptive blended instruction, and when moving from non-adaptive to adaptive learning environments in fully online courses.

Supportive attitudes amongst leadership towards adaptive learning are accelerating its adoption. An annual survey conducted in 2016 by the Campus Computing Project found that 96% of higher education CIOs agreed that adaptive learning technology shows great promise for improving learning outcomes.[227] Projects abound in the US, with eight universities, including Oregon State University and Portland State University, recently receiving funding from the APLU for the Accelerating Adoption of Adaptive Courseware initiative.[228] While efforts are not advancing as quickly as in the US, the UK policy group Higher Education Commission sees the driving force behind adaptive learning systems — learning analytics — to have enormous potential. The commission is interested in developing adaptive tools in consultation with students, with ethics and needs of the institution being paramount.[229] Similarly, a proposal for ICT strategy in higher education submitted to the Ministry of Education in Norway highlights adaptive learning as a key area of development.[230]

Relevance for Teaching, Learning, or Creative Inquiry

At Colorado Technical University, adaptive learning is a major component of their long-range academic programming plan. Nearly 82%, or 800 faculty members, use Intellipath, the university's adaptive learning platform. Longitudinal research shows students have increased control over their work by progressing more quickly through known material; are more engaged, stating classes are "more fun;" and demonstrate higher confidence in mastering challenging subject areas. A student in a college algebra course, for example, may be stronger in general fractions but weaker at solving linear equations with fractions. Intellipath assesses each student's strengths and changes how the course is delivered, providing more time to work on problem

areas.[231] While STEM subjects have been in the spotlight for the application of adaptive learning technologies, the University of Georgia is developing tools for English composition courses. Using adaptive tools, students will be guided through foundational concepts such as peer review strategies, argumentation, and designing multimodal compositions, ensuring strong understanding of these concepts before moving on to more sophisticated activities.[232]

In Europe, Jisc has been analyzing the benefit of learning analytics and adaptive learning through 11 case studies in their report *Learning Analytics in Higher Education: A Review of UK and International Practice*.[233] The authors believe that adaptive learning systems help foster a more personalized and self-paced approach to learning and are most appropriate for teaching basic skills. One case study highlights the work of Open University Australia (OUA) and their Personalized Adaptive Study Success (PASS) project intended to help students identify learning pathways. Embedded in OUA's online learning environment and support systems, PASS analyzes data from customer relationship management systems, learning management systems, and curriculum profiles to provide recommendations via customizable dashboard. In addition to tracking student performance, the dashboard recommends activities, predicts course mastery, and provides dynamic content recommendations.[234]

The potential of this technology for teaching and learning continues to grow. The recent report *Clicks and Mortarboards* by Nesta, an innovation foundation based in the UK, examines developments in the use of digital technologies in higher education. While much of the literature on adaptive learning technologies focuses on its relevance for individual learning, new developments show promise in fostering collaboration. In online learning environments, for example, new tools can automatically sort users into groups with shared interests and recommend information sources based on user interests and web browsing habits. Similarly, the report highlights the use of artificial intelligence (AI) in collaborative learning. In adaptive group formation, AI is used to create groups of students best-suited to tackle a specific task; it could suggest pairing learners based on their cognitive abilities or interests or sort them based on complementary knowledge and skills.[235]

Adaptive Learning Technologies in Practice

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

2016 DLIAward Recipient: Tougaloo College
go.nmc.org/tougaloo
Tougaloo College in Mississippi received a Digital Learning Innovation Award (DLIAward) from the Online Learning Consortium (OLC) for its implementation of the Junction Education online platform in its online biology courses. Integrated into the college's LMS, the adaptive learning tool provides differentiated learning materials such as video introductions, online textbooks, and games based on students' learning preferences.

Cellular Transport Virtual Lab
go.nmc.org/central
A lecturer at Central Queensland University worked with edtech startup Smart Sparrow to create an interactive virtual lab for scientific experiments in cellular transport; based on how students perform, adaptive feedback and pathways guide their personalized lab experiences.

PERFORM
go.nmc.org/perform
PERFORM, a joint project of Beijing Normal University and Universidad Internacional de la Rioja, aims to develop software that harnesses learner data to provide personalized recommendations. The initiative not only works to improve outcomes, but allows for researchers to observe the learning patterns of students from different cultures.

For Further Reading

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

Clearing the Hurdles to Adaptive Learning
go.nmc.org/clear
(Barb Freda, *University Business*, 26 August 2016.) Integrating adaptive learning technologies in higher education can be an arduous task, requiring time, expertise, and budgets. The author highlights six challenges to implementation and how early adopters have overcome them, including moving ahead without strong evidence, selecting the right provider, and dealing with extensive data.

Designing Values in an Adaptive Learning Platform
go.nmc.org/deval
(Josine Verhagen et al., *LACE Project*, accessed 9 January 2016.) This paper describes the ethical considerations higher education must undertake when developing adaptive learning technologies. The authors posit that collaboration between ethicists and designers early in the design process may help overcome some obstacles.

How Personalized Learning Unlocks Student Success
go.nmc.org/unlock
(Nazeema Alli et al., *EDUCAUSE Review*, 7 March 2016.) In this post, the authors demonstrate how technology can customize learning experiences, help at-risk students, and develop pathways for success. Adaptive digital courseware, for example, can not only help improve student outcomes, but can also reduce instructional costs by accelerating course completion.

Mobile Learning

Time-to-Adoption Horizon: One Year or Less

The pervasiveness of mobile devices is changing the way people interact with content and their surroundings. As the processing power of smartphones, smartwatches, and tablets continues to increase dramatically, mobile learning, or m-learning, enables learners to access materials anywhere, often across multiple devices. Convenience is driving demand for this strategy, with potential for new mobile-enhanced delivery models that can increase access to education.[236] Instructors are harnessing the capabilities of mobiles to foster deeper learning approaches by creating new opportunities for students to connect with course content. Mobile apps, for example, allow two-way communication in real time, helping educators efficiently respond to student needs. This development is impacting both the delivery and creation of educational content. Surveys of the field have revealed that instructors still need technical and pedagogical support from their institutions in integrating mobiles in their curricula.[237]

Overview

In 2016, StatCounter reported that 51.3% of web browsing worldwide took place via mobiles and tablets, overtaking desktop browsing for the first time.[238] Google has adopted a variety of mobile-first strategies that are driving industry growth, most notably in its recent inclusion of mobile usability as a ranking factor in search results. The company recently announced that it will split its search index into a primary mobile version and a secondary desktop version, which will eventually result in desktop searches returning less updated results as compared to mobile.[239] Higher education is well positioned to leverage the ubiquity of mobiles to enhance teaching and learning. In a study conducted by McGraw-Hill Education and Hanover Research of over 2,600 US college students, nearly two-thirds reported using their smartphones to study.[240] The global market for mobile learning is predicted to grow by 36% annually, increasing from $7.98 billion in 2015 to $37.6 billion by 2020.[241]

Thought leaders have emphasized the potential for mobile learning to boost equity, citing the ability to disseminate content to underserved students.[242] Pew Research Center reports that due to affordability issues, emerging economies continue to lag behind developed nations in smartphone ownership.[243] However, mobile penetration is on the rise in Africa, with 557 million mobile subscribers (46% of the population) at the end of 2015.[244] An innovative mobile learning initiative aims to increase access to higher education across the continent. Kenya's Daystar University has launched Daystar Mobile, a program in which students can earn a bachelor's degree in education primarily through their smartphones. A mobile app will deliver videos and interactive course materials on demand; faculty use the platform to interface with learners and provide additional support.[245]

Mobile devices have become the gateways to personalized working and learning environments that facilitate the exploration of new subjects at each user's pace. A study of a South Korean online university found that learners with full-time jobs were 48% more likely to use a mobile LMS than non-working students. Researchers posited that the flexibility afforded by on-the-go access to lectures and learning materials helped these students better integrate academic pursuits into their schedules.[246] Students can also use mobiles to practice 21st century skills including communication, collaboration, and creating content. Effective deployment of mobile technology entails careful planning built on the foundation of a thorough initial evaluation of the learning context.[247] For example, at RMIT University in Melbourne, Spanish language students produced autobiographical videos on their phones, describing their personalities and neighborhoods. The activity helped learners increase their vocabularies and offered a practical application of course content through the perspective of their own lives.[248]

Relevance for Teaching, Learning, or Creative Inquiry

Mobile devices are providing more opportunities for student-instructor interaction. Hotseat, an app developed at Purdue University, allows students to post questions and comments in real time during class, anonymously or via their social networking accounts. Learners can participate via SMS or the mobile app. Through Hotseat, students answer each other's questions, "like" posts, and respond to polls and quizzes. Faculty cite benefits including increased engagement, the ability to refine their instruction based on student feedback, and helping introverted students find their voices.[249] Educators can also leverage mobiles' capabilities to create rich learning content. A faculty

member in the University of Nebraska-Lincoln's College of Education and Human Sciences produced a series of food science videos using a GoPro camera and an iPad.[250] One video uses 360-degree recording to provide an immersive tour of the department's labs; viewers can witness students and faculty developing solutions.[251]

Field research has indicated that mobile learning can impact student achievement. A study was conducted at Middlesex University in the UK where mobile learning activities were incorporated into certain sections of first-year anatomy courses. Students in the experimental groups used iPads to access Real Bodywork Muscles and Skeletal 3D apps during class, which encompass quiz and game functions to improve learner retention. Feedback indicated that students found the technology "fun" and preferred the hands-on experiences to the lecture format; the iPad cohort also earned better grades.[252] By creating ubiquitous access to educational materials, mobiles also have potential to foster learner independence and build habits for lifelong learning. Jibu, a mobile nursing education app, is helping health workers in Kenya, Uganda, and Tanzania to engage in ongoing training to maintain their professional licenses; institutions can also use the app to support student nurses in the field.[253]

Resources are available to assist educators who are integrating mobiles into their courses. Jisc offers an extensive guide to mobile learning, including a survey of pedagogical frameworks, case studies and examples of higher education mobile initiatives in progress, and technical considerations. In incorporating mobile technologies, instructors are encouraged to consider the SAMR model, moving beyond mere content delivery toward supporting real-time discussions and data-driven assessment.[254] The University of Central Florida's Center for Distributed Learning has created a Critique-at-a-Glance mobile checklist that allows instructors to quickly evaluate a mobile app for adoption into course curriculum based on metrics including price, privacy policy, content rating, and more. Upon completion of the checklist, the user receives feedback and is directed to conduct a deeper assessment of the app's accessibility, FERPA compliance, and opportunity for student feedback.[255]

Mobile Learning in Practice

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

Examining Use of Mobile Device in the Classroom
go.nmc.org/ubit
In the three-part Digital Challenges Series at the University at Buffalo State University of New York, students and faculty were invited to share their experiences of implementing mobile technology into the classroom. The event focused on integrating informal uses of mobile learning into formal practices.

Exploring Mobile Apps for Special Education STEAM Teaching and Learning
go.nmc.org/spedapps
The SpedApps project at Kent State University aims to produce a searchable database of mobile apps for special education teachers and students. The initiative is also building its own apps; a future release called iPD will provide a mobile professional development platform.

Using Mobile Devices in Your Teaching
go.nmc.org/qilt
Western Sydney University has dedicated online resources to help instructors implement mobile devices to manage their teaching activities. This website offers ways to leverage mobiles to enhance established activities and introduce new activities, including streamlining feedback and assessment and encouraging active classrooms.

For Further Reading

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

Mobile Device Usage
go.nmc.org/uwmob
(Tara Coffin et al., University of Washington, accessed 12 January 2017.) Potential challenges impeding adoption of mobile learning include concerns about how to mitigate student distraction, students' lack of clarity on classroom policies, and a lack of support for instructors. The authors recommend development of professional training on evidence-based best practices for improving student success.

Mobile Learning Practice in Higher Education in Nepal
go.nmc.org/nepal
(Krishna Prasad Parajuli, *Open Praxis*, 2016.) Research spanning six universities throughout Nepal has found that the majority of undergraduates use their mobile devices for learning. The author concludes that a continued effort by Nepalese institutions to understand mobiles in the context of pedagogies is essential to ensure that device usage will foster positive learning outcomes.

Student-Driven Mobile App Design: A Case Study
go.nmc.org/ctumobile
(Constance Johnson, *EDUCAUSE Review*, 19 September 2016.) When developing a mobile-learning app for its students, Colorado Technical University had one goal in mind: student-driven design. Tapping the students as stakeholders led to the creation of an app that best aligned with their needs.

The Internet of Things

Time-to-Adoption Horizon: Two to Three Years

The Internet of Things (IoT) consists of objects endowed with computing power through processors or imbedded sensors that are capable of transmitting information across networks. These connections allow remote management, status monitoring, tracking, and alerts.[256] Municipal governments and education institutions are applying the capabilities of IoT, leveraging data to streamline processes and promote sustainability. Connected devices are generating data on student learning and campus activity, informing the direction of content delivery and institutional planning. As more smart devices arrive on campuses, institutions are examining implications for privacy and security.[257] Some technologists predict explosive growth in this area, which will impact the goals of engineering education.[258] Institutions are partnering with industry to provide students with hands-on experiences designing and building IoT devices, equipping them with the skills to meet workforce needs.

Overview

Many people are already familiar with the Internet of Things through their experience with wearables including Apple Watches, Fitbits, and smart home products such as Nest thermostats. Gartner has predicted that by 2020, nearly 21 billion connected things will be in use,[259] while International Data Corporation forecasts that global spending on the IoT will reach $1.29 trillion by 2020.[260] Another growing facet of this field is the smart cities movement, which uses connected devices to capture and analyze data to improve public services and conserve resources. For example, Copenhagen has deployed smart LED street lights that dim according to time of day, and brighten when pedestrians or cyclists pass by.[261] The Dubai Plan 2021 aims to address transportation management through smart traffic sensors, mobile traffic apps, and potentially driverless cars; the city will also install 250,000 smart meters by 2018.[262]

As the number of connected things grows, consumers will be challenged to ensure the security of everyday objects. In 2016, Dyn, a service provider that resolves web addresses into IP addresses to allow browsers to deliver content, was the subject of a distributed denial of service (DDoS) attack; hundreds of thousands of poorly secured, connected devices such as DVRs and routers were hacked and infected with malware that overwhelmed Dyn's data centers with fake traffic requests.[263] Internet users in Europe and the US were temporarily unable to access major websites serviced by Dyn, including Netflix, Twitter, Spotify, and Reddit, as well as major news outlets.[264] This incident has renewed concerns about the impacts of potential future large-scale security breaches. Carnegie Mellon University's CyLab has received a grant from the National Science Foundation to develop a software-based security solution to shield networks from malware on individual devices.[265]

Institutions face uncertainty about the potential deluge of smart devices in coming years. As with the advent of Bring Your Own Device, leaders must consider bandwidth needs and determine which things are authorized to connect to campus networks. Additionally, educational applications of networked objects are surfacing issues around data security and ethical questions surrounding collection and use of student data. Meeting student needs as new technologies proliferate will require concerted efforts across multiple departments to address legal, financial, and technical implications.[266] Beyond infrastructure, the IoT's development will impact curriculum to prepare students for the workforce. Market research firm Cybersecurity Ventures projects a total of six million jobs in global information security by 2019, with a talent pool falling short of this demand by 1.5 million people.[267] Intel Security's report *Hacking the Skills Shortage* recommends that institutions work to increase diversity in STEM education programs.[268]

Relevance for Teaching, Learning, or Creative Inquiry

Applications of IoT have potential to enhance many aspects of campus life, including safety and efficiency. Through their VT Alerts system, students, faculty, and staff at Virginia Tech receive emergency notifications via smartphone or smartwatch.[269] Sensors have been deployed at the University of New South Wales to lower energy consumption and improve connectivity. Further, by tracking student movement and activity, leaders can take action to facilitate group learning opportunities outside of lecture delivery.[270] Institutions can also use data from connected devices and location-tracking to identify students in need of targeted interventions. For example, one expert describes the possibility of monitoring for signs of depression by combining data on skipped meals with data on students staying inside residence halls for extended periods of time.

While these innovations can improve decision-making and delivery of services, administrators must consider ethical implications of student data collection and prioritize security, transparency, and privacy.[271]

By generating awareness of patterns and connecting actions to outcomes, consumer technologies that track movement and sleep can spur change in behaviors.[272] Educational applications are similarly poised to impact student learning and wellbeing. Researchers at the University of Texas Arlington's LINK Lab are studying how emotions affect learning, using wearables to monitor biological factors that correspond to emotional states. At the University of the Pacific, Kinect sensors in classrooms are tracking students' skeletal positions to investigate correlations between postures and learner engagement.[273] Instructors will need support as they harness pedagogical capabilities of IoT. The Tennessee Board of Regents system offers professional development at its institutions through showcases called "Education and Workforce Smart Tools and Gadgets for IoE [Internet of Everything]." Participants apply rubrics to understand new technologies' educational impacts, examining types of data generated and methods to monitor and analyze data to drive classroom change.[274]

As IoT proliferates, institutions are partnering with industry to enable student innovation and developing new programming to equip learners with the latest skills. At Aggies Invent: Internet of Things, a two-day competition at Texas A&M University, representatives from Texas Instruments and Accenture mentored student teams as they conceptualized and prototyped IoT-enabled solutions. Winning inventions included a device for shared laundry facilities that alerts users of machines' cycle status and an LED projector that integrates customer data to optimize timing of advertisements on LED billboards.[275] Undergraduate students can major in IoT at the University of Sydney. The interdisciplinary course of study encompasses electrical and computer engineering, wireless communications, and data analytics. Through exposure to cutting-edge technologies, the program prepares students to develop new products and ideas for fields such as healthcare, utilities, transportation, retail, and resource management.[276]

The Internet of Things in Practice

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

Internet of Things Lab Fosters Student Innovation, Adds Industrial Partners
go.nmc.org/iotwisc
At the University of Wisconsin-Madison's Internet of Things Lab, students gain access to emerging technologies to transform ideas into reality, such as Safe Cycle, a sensing device that alerts cyclists to nearby vehicular traffic. Companies have joined forces with the lab to provide students with business development support.

IOT-OPEN.EU
go.nmc.org/iotopen
The European Commission's Erasmus+ initiative is supporting the creation of an online education module focused on the Internet of Things. Students from multiple European universities connect to a remote lab to learn about IoT hardware, infrastructure, and mobile applications. Open access learning materials can be integrated into courses across various disciplines.

National Internet of Things Innovation Competition for Women in Engineering
go.nmc.org/iotwin
A student at University of Surrey developed a smart garden watering system that utilizes ground-based sensors, taking the top prize in an IoT competition sponsored by Bosch. As part of the company's #BetweenUsWeCan initiative to increase female representation in engineering fields, Bosch engineers will provide mentorship to the student for one year.

For Further Reading

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

Growing Trend: Internet of Things Expands into College and University Curricula
go.nmc.org/iotcurr
(Laura Devaney, *eCampus News*, 8 August 2016.) Growth of IoT is increasing demand for skilled workers in areas including hardware engineering, sensors development, and systems design and integration. Institutions and policymakers must support the development of multidisciplinary curricula to address workforce needs.

How IoT in Education is Changing the Way We Learn
go.nmc.org/learniot
(Andrew Meola, *Business Insider*, 20 December 2016.) Connected devices enable the aggregation of learning data that will help students understand their learning trajectories, helping instructors gain a clearer picture of academic progress to inform the direction of lesson planning.

The Internet of Things: Riding the Wave in Higher Education
go.nmc.org/iotwave
(Itai Asseo et al., *EDUCAUSE Review*, 27 June 2016.) Five experts describe the promise of IoT in higher education. Connected learning environments can generate student profiles with data on attendance, performance, and productivity that provide a holistic view of learner engagement and knowledge advancement. Machine learning capabilities will enable data analysis, helping institutions personalize the student experience.

Next-Generation LMS

Time-to-Adoption Horizon: Two to Three Years

Learning management systems (LMS), also referred to as Virtual Learning Environments, comprise a category of software and web applications that enable the online delivery of course materials as well as the tracking and reporting of student participation.[277] Viewed as a centralized location for the ephemera of learning experiences, LMS have long been adopted by colleges and universities worldwide to manage and administer online and blended courses. It is commonplace for students to access syllabi and readings, submit assignments, check grades, and contact peers and instructors through their institution's LMS, while faculty monitor student engagement and performance at individual and course levels. However, some thought leaders believe current LMS are limited in capacity, too narrowly focused on the administration of learning rather than the learning itself.[278] Next-generation LMS, also called next-generation digital learning environments (NGDLE),[279] refers to the development of more flexible spaces that support personalization, meet universal design standards, and play a larger role in formative learning assessment.[280] Rather than existing as single applications, they are a "confederation of IT systems and application components that adhere to common standards …that would enable diversity while fostering coherence."[281]

Overview

The current higher education LMS space is dominated by several brands, including Canvas, Blackboard, Moodle, Edmodo, Desire2Learn, and Sakai, which are generally deployed at the institution-wide level.[282] Outside of the larger players, only a small percentage of the market share belongs to alternative learning and course development platforms, though the advent of massive open online courses in 2011 sparked new possibilities with open-source platform OpenEdX, while the Helix LMS caters to burgeoning online approaches such as open education[283] and competency-based learning.[284] The path for next-generation LMS is being paved by the desire for enabling educators to unbundle all of the components of a learning experience and allow them to remix open content and educational apps in unique and compelling ways.

Though technological advancements in LMS have enabled sophisticated learning analytics, adaptive learning, and dynamic social exchanges, challenges persist that necessitate the design of new models. The 2017 Higher Education Expert Panel observed that LMS are owned by companies that tightly control their platforms, making it difficult to expand the feature sets and integrate external resources in ways that best align with evolving institutional needs and pedagogies.[285] More faculty and students leverage tools such as Google Apps, WordPress, Slack, and iTunes U, but these apps are generally accessed outside of LMS. Furthermore, gamification, adaptive learning, and OER are just a few examples of technology developments that institutions are adopting to bolster student success and increase affordability — though these elements are not always integrated into LMS. There is a need for ecosystems that not only incorporate emerging learning approaches of today, but are also agile enough to support evidence-based practices of tomorrow.

In 2014, EDUCAUSE was commissioned by the Bill & Melinda Gates Foundation to conduct research on the LMS landscape and gain a clear picture of the ideal platforms for student success in higher education. A collection of three reports document the current LMS ecosystem, report on next-generation needs, and synthesize the complex sea of information into an approachable format.[286] Conversations with 70 community thought leaders surfaced the essential attributes of next-generation digital learning environments: interoperability; personalization; analytics, advising, and learning assessment; collaboration; and accessibility and universal design. Overall, a "Lego" approach to LMS was recommended to empower both institutions and individuals with the flexibility to create bespoke learning environments that accommodate their unique requirements and needs.[287]

Relevance for Teaching, Learning, or Creative Inquiry

The overarching goal of next-generation LMS is to shift the focus of these platforms from enabling administrative tasks to deepening the act of learning. Traditional LMS functions are still a part of the ecosystem, but reimagined incarnations deviate from the one-size-fits-all approach to accommodate the specific needs of all faculty and students. Currently, this type of environment is more aspiration than reality, though a number of organizations and institutions are working to envision and develop next-generation LMS. IMS Global, an organization devoted to advancing

technology in affordable ways that improve education attainment, has developed learning tool interoperability standards and an API for a common architecture that allows institutions to more seamlessly customize their virtual environments, integrating both web-based and externally-hosted content.[288]

As more institutions adopt mastery- and competency-based education (CBE) approaches, learning ecosystems must support the process of skill acquisition and assessment. To carry out their competency-driven mission, Grand Canyon University uses LoudCloud,[289] a tool that leverages a host of open educational resources and learning analytics to personalize learning experiences.[290] Western Governors University, a widely acknowledged leader in delivering CBE online, does not have an LMS; instead, they have designed learning portals specifically for each course where students engage in projects and discussions, access free e-textbooks, and build portfolios.[291] Acrobatiq, a platform developed based on cognitive science from Carnegie Mellon University's Open Learning Initiative, also aims to bolster student achievement in CBE and hybrid models, enabling instructional designers — including those at National Louis University[292] — to author customized courses with adaptive learning functionality.[293]

The growth of adaptive learning technologies, explored earlier in this report, is also expanding the possibilities for a wealth of data LMS are able to collect and analyze. Smart Sparrow, for example, enables educators to customize highly visual content for their classes' needs and then track how students are engaging with the material, flagging common mistakes and misconceptions.[294] The promise of next-generation LMS is that this kind of data will be seamlessly aggregated with student demographic, grades, social presence, and other data points to provide a more holistic picture of learning progress. Another area of interest is platforms that curate a range of resources for self-directed learning. Sandstorm, a company in the British Indian Ocean Territory, aims to make the best open-source web apps such as WordPress, Etherpad, and Wekan[295] integrate more seamlessly within institutions' learning ecosystems.[296] This strategy emphasizes greater personalization and access to a continuously expanding array of digital tools. EdCast uses a similar model, aggregating content from existing LMS and recommending resources based on learners' needs.[297]

Next-Generation LMS in Practice

The following links provide examples of next-generation LMS in use that have direct implications for higher education settings:

Domain of One's Own
go.nmc.org/domain
University of Mary Washington's Division of Teaching and Learning Technologies developed the Domain of One's Own project to enable faculty, staff, and students to register their own domain name and freely associate it with a hosted university webspace. The Division works closely with faculty to ensure the domains are well integrated into course activities.

MyOpenMath
go.nmc.org/mom
Salt Lake City Community College is among the institutions that have adopted Lumen Learning's MyOpenMath, an OER-based learning solution that has significantly increased the affordability of course materials for students and helped bolster student success in developmental and college math courses.

Osmosis at Johns Hopkins University
go.nmc.org/osmosis
Osmosis is an LMS designed to help medical students learn the extensive content needed to navigate medical school. Supported by a mobile app, the collaborative learning framework has led to higher success for users. The project team is also developing Open Osmosis, a crowdsourcing model for anyone to contribute content through open access models.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about next-generation LMS:

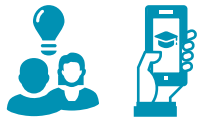
6 Implications of the Next-Generation Digital Learning Environments (NGDLE) Framework
go.nmc.org/6imp
(Malcolm Brown, Next Generation Learning Blog, 6 June 2016.) The EDUCAUSE Learning Initiative Director synthesizes the major themes of the organization's seminal work on the blueprint for NGDLEs, citing the essential role of policy and governance and the need to rethink the way institutions collaborate with each other.

Authoring Tool Accessibility Guidelines (ATAG) 2.0
go.nmc.org/atag
(W3C, W3C Recommendations, 24 September 2015.) Higher education professionals involved in the development of next-generation LMS should look to ATAG 2.0, a set of guidelines for designing web content authoring tools that promote universal design.

Beyond the LMS
go.nmc.org/beyondlms
(Audrey Watters, Hack Education, 5 September 2014.) The author examines the current landscape of LMS with a critical lens, cautioning that other countries may be adopting unworthy models from the US and advocating for systems that foster more open and participatory learning.

Artificial Intelligence

Time-to-Adoption Horizon: Four to Five Years



In the field of artificial intelligence (AI), advances in computer science are being leveraged to create intelligent machines that more closely resemble humans in their functions.[298] The knowledge engineering that allows computers to simulate human perception, learning, and decision-making is based on access to categories, properties, and relationships between various information sets. Machine learning is a subset of AI, providing computers the ability to learn without being explicitly programmed.[299] As another significant area of research, neural networks model the biological function of human brains to interpret and react to specific inputs such as words and tone of voice. Neural networks are proving valuable for more sophisticated natural user interfaces through voice recognition and natural language processing, allowing humans to interact with machines similarly to how they interact with each other.[300] As the underlying technologies continue to develop, AI has the potential to enhance online learning, adaptive learning software, and research processes in ways that more intuitively respond to and engage with students.

Overview

Since the 1950s, the benchmark for machine intelligence has been the Turing Test, which requires that a human be unable to distinguish a machine from another human in conversations and real-world situations.[301] IThe test was finally beaten in 2014[302] and AI is now regularly leveraged in higher education in the form of 24/7 online help desks, including the use of IBM Watson at Deakin University.[303] AI's full potential for education remains untapped, but institutions can look to developments in the consumer sector. Virtual assistants, for example, interpret verbal cues to respond conversationally, mirroring human interaction.[304] Though popular avatars like Siri and Cortana are built into smartphones, Amazon's Alexa is becoming a household name as a standalone, always-listening assistant that uses far-field microphones to retrieve information from the web on command.[305] Indeed, autonomous technology that caters to people's needs is in the spotlight; Uber recently piloted a fleet of self-driving cars, safely transporting customers around San Francisco.[306]

Some fear, however, that the field is advancing faster than people's understanding of it. By nature, AI is complex and opaque in its functioning, so there is a need for interfaces that crystalize how it works to foster greater trust. IBM has been a leader in this area, releasing images and explanatory charts for its medical AI systems.[307] In higher education, the possibilities for virtual tutors and more sophisticated adaptive learning tools are routinely met with concern that the technology, no matter how humanlike, cannot and should not replace educators.[308] The book *Interfaces*, by Cornell University professor Brandon Hookway,[309] envisions a more balanced future for higher education in the vein of "Interface University." In this view, AI-enabled computers are not seen as a tool, but instead as a third hemisphere of the brain that enhances the creative and cognitive learning processes — an equal and symbiotic partnership, or hybrid mind, between humans and their devices.[310]

Machine learning is already spurring progress in both professional life and informal learning. The citizen science project, Smart Flower Recognition System, is a partnership between Microsoft Research Asia and Chinese Academy of Sciences to help botanists in China quickly identify plants with photos taken by smartphones. Through neural networking, algorithms automatically filter out low-quality image submissions and identify the flowers in the photo database with over 90% accuracy.[311] The implications of this kind of project for student and faculty research are compelling, as search queries no longer have to be based on text. To scale the affordances of AI over the next four to five years, higher education can start with open-source codes and open software libraries for numerical computation, as provided by OpenAI[312] and Google's TensorFlow.[313]

Relevance for Teaching, Learning, or Creative Inquiry

An overarching goal of artificial intelligence is to bolster productivity and engagement, better supporting the global workforce and individuals in their daily lives.[314] This makes this technology promising for higher education, especially as teaching and learning increasingly take place online. Adaptive learning, featured earlier in this report, leverages basic AI algorithms to personalize learning, delivering content that best suits students' needs based on performance and engagement with the subject matter.[315] As institutions gather an increasing amount of data on student learning, they also need tools to mine and analyze it at scale; machine learning enterprise software including Jenzabar[316] and IBM

SPSS[317] help colleges and universities interpret the data to support student retention, improve financial aid programs, and predict future enrollment. Emerging approaches like competency-based education will require more sophisticated forms of AI to assess concrete skill acquisition, such as the 3D modeling and prototyping of a car, to provide tailored feedback.

In pursuit of greater personalization in higher education, thought leaders such as Bill Gates champion AI tutors. Providing thorough feedback on writing assignments, for example, is an extensive and time-consuming process for instructors; virtual tutors can transcend checking for surface level errors to analyze meaning, themes, and arguments to provide granular feedback to students. In online classrooms, the tutors can interrupt video lectures to ask questions directly to learners, replaying snippets of the video if it is clear the student is struggling to understand specific subject matter.[318] This kind of omnipresent support and mentoring can fill in gaps, particularly for large introductory courses where it is challenging for instructors to give their pupils one-on-one attention. Researchers at the National School of Engineers of Sousse in Tunisia are investigating an AI tutoring system that recognizes facial expressions as students engage in science experiments in remote and virtual labs.[319]

However, skepticism about the ethics of AI may hamper progress. The World Economic Forum cites learned biases, such as racism, as a major concern, questioning humans' ability to prevent such unintended consequences.[320] As AI proponents wade through these issues, universities are vital incubators for developing new enabling technology. MIT's Computer Science and Artificial Intelligence Laboratory recently created a deep learning algorithm that observes still images and then creates brief videos that simulate likely future events.[321] In Switzerland, the University of Zurich's AI Lab developed Roboy, a humanoid robot with lifelike joints and tendons that prompted many follow-up activities; through the human brain project, for example, scientists and professors are simulating human brains for robots.[322] Progress in embedding AI into everyday life hinges on the advancement of natural-language processing to spark more genuine interactions between machine and man. Researchers at the Free University of Brussels are investigating how robotic agents can self-organize languages, positing that meaning can co-evolve with language.[323]

Artificial Intelligence in Practice

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

Artificial Intelligence Laboratory at UM
go.nmc.org/umail
A key focus of the University of Michigan's AI lab is researching and developing assistive technology for those with physical and cognitive impairments. One such project is the design of a computer interface that automatically adjusts to cater to the needs of the visually-impaired.

SAIL-Toyota Research Center
go.nmc.org/sailtoy
The Stanford Artificial Intelligence Laboratory has partnered with Toyota to conduct research for the next generation of intelligent automobiles. Researchers in fields including machine learning, robotics, and natural language processing are coming together to develop new algorithms.

University of Cambridge Artificial Intelligence Group (AIG)
go.nmc.org/claiuc
The AIG spans multiple disciplines — including genomics, computational learning theory, and informal reasoning — to devise powerful algorithms that address machines' pattern recognition issues and subsequently identify practical applications for those models.

For Further Reading

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

Four Ways that Artificial Intelligence Can Benefit Universities
go.nmc.org/4ways
(Rose Luckin, *Times Higher Education*, 9 August 2016.) In addition to three other affordances, the author notes that higher education is well positioned to train students to work alongside complex intelligent systems; workers who can adeptly discern how and where human intelligence can augment machines have the potential to increase productivity.

The Future of Artificial Intelligence in Education
go.nmc.org/futai
(Barbara Kurshan, *Forbes*, 10 March 2016.) Advancements in AI still lag behind in education. The article cites progress at Cornell University and Brown University in the design of robots that can learn how to perform small tasks.

Higher Education for the AI Age
go.nmc.org/machinesdo
(Joseph E. Aoun, *The Washington Post*, 27 October 2016.) A 2016 survey reveals 80% of AI researchers assert that machines will achieve levels of artificial intelligence that match human intelligence. With AI's increasing applications in professional domains such as medical diagnosis, the author encourages people to view higher education less as a one-stop milestone and more as a vehicle for lifelong learning.

Natural User Interfaces

Time-to-Adoption Horizon: Four to Five Years

A growing list of devices built with natural user interfaces (NUIs) accept input in the form of taps, swipes, and other ways of touching; hand and arm motions; body movement; and increasingly, natural language. Tablets and smartphones were among the first devices to allow computers to recognize and interpret physical gestures as a means of control.[324] These NUIs enable users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively. There is a rising level of interactive fidelity in systems that understand gestures, facial expressions, and their nuances, as well as the convergence of gesture-sensing technology with voice recognition. While there are many applications of gesture and voice recognition already, developments in haptic technology, tactile sensations that convey information to the user, are creating new areas of scientific inquiry and application in education.[325]

Overview

Although natural user interfaces were largely popularized with the launch of the iPhone and its touchscreen in 2007, the concept of the natural user interface was already forming. Discussions around the development of interfaces beyond command line and graphical user interfaces came about in the 1970s and 80s when Steve Mann, widely regarded as the father of wearable computing, began experimenting with human-machine interactions that developed into NUIs.[326] According to a report by Tracxn, over $800 million has been invested in NUIs since 2010 in six major categories: speech recognition, touchscreen interfaces, gesture recognition, eye-tracking, haptics, and brain computer interface. Higher education is playing a major role in these developments as many enabling technologies are being designed at universities and impact how students in the future will engage with learning technologies.[327]

The development of NUIs in the consumer realm is likely to impact higher education as learning organizations need to cater to the evolving expectations of learners. Industry leaders including Amazon, Apple, and Google have all developed voice-enabled products that are gaining traction in the market. The NDP Group's recent research study found that 73% of smartphone owners already use voice commands to interact with their devices. With its virtual assistant Siri, Apple is experimenting with speaker recognition where voice biometrics can be utilized for user authentication.[328] The developers of wearables are also tapping into gesture recognition as their interfaces evolve. The Korea Institute of Science and Technology's third iteration of smart glasses called K-Glass 3 can now detect hand movements and provide virtual text or piano keyboards to make the interfaces more intuitive and convenient.[329]

Haptic technology where users interact with sensors, actuators, and software that, in tandem, simulate physical touch is a NUI category seeing considerable experimentation in the consumer and education sectors.[330] Researchers at the University of Sussex are piloting interfaces that use skin as a touchscreen — a solution to the decreasing size of wearables such as smartwatches. Called SkinHaptics, the tool sends ultrasound waves through the back of the hand to a screen display on the palm.[331] Although higher education is years away from fully unlocking the potential of NUIs to dramatically change how learners use computers, the medical training field is already raising compelling implications. Force feedback haptic technology is augmenting the robotic surgery already taking place by helping surgeons more accurately feel inside a human body as they interact with tissues. This has applications in anatomy studies where medical students train with a limited supply of cadavers. Haptic technology would allow learners to engage with a digital patient in a more realistic manner.[332]

Relevance for Teaching, Learning, or Creative Inquiry

Natural user interfaces are becoming instrumental in the research and training of medical professionals. Rice University's Mechatronics and Haptic Interfaces Lab is experimenting with neurotechnology to help stroke patients regain movement. Researchers there have developed a robotic orthotic device that uses a stroke patient's brain waves to operate an exoskeleton surrounding their arm from elbow to fingertips.[333] Stanford University researchers have created the Wolverine, a mobile, wearable haptic device that simulates grasping a rigid object in virtual reality.[334] At the Hong Kong Polytechnic University, nursing students are using a haptic feedback system for nasogastric tube placement training. Inserting a plastic tube into the stomach for feeding or drainage is important in nursing

training as misplacement could lead to complications or even death; using a computer-simulated virtual environment mitigates risk and allows for greater accuracy.[335]

Developments in NUIs are enabling greater access to education for those with disabilities. Visually-impaired learners will soon be able to benefit from the work of a team of cross-disciplinary researchers from University of Michigan's Engineering, Music, and Theater and Dance Schools. The team is developing a tablet with a full-scale refreshable browser display that uses air or fluid pneumatics to push dots up and down, allowing for many lines of Braille as well as the possibility of reading graphs, spreadsheets, and other spatially distributed mathematic and scientific information.[336] At Deakin University, researchers are developing bespoke haptic-related research for improving appreciation in the arts. Their Haptic-Enabled Art Realization (HEAR) project is a platform that enables the visually-impaired to feel the information within a two-dimensional work of art.[337]

Experiments with NUIs have the potential to unearth new forms of learning and communication in education. Disney Research has developed an electrostatic vibration technology nicknamed the TeslaTouch that enhances smooth glass displays with tactile sensations, enabling users to feel bumps, ridges, and other textures. This technology offers possibilities for more profound interactions with educational content. Applied to mobile devices, the phenomenon of electrically-induced tactile sensation creates the potential for interactive textbooks, allowing students to manipulate 3D objects directly on a page.[338] At the University of Tampere in Finland, current projects are investigating an entirely new form of human-technology interface that adds a fresh dimension to communications that are primarily audio and visual in nature. Their Digital Scents project measures scents through an electronic nose and converts that information into a numbering system, enabling the digital transfer of olfactory perceptions and experience around the world.[339]

Natural User Interfaces in Practice

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

Computer Aided Engineering Design and Virtual Prototyping
go.nmc.org/pvamu
A mechanical research project at Prairie View A&M University is combining freeform shape modeling with virtual reality techniques to improve aerospace, automobile, and model prototyping. The virtual sculpting process uses a PowerWall VR system and a haptic controller.

HoloMed: A Low-Cost Gesture-Based Holographic System to Learn Normal Delivery Process (PDF)
go.nmc.org/arxiv
Photographs are often used to visualize certain elements in medicine studies, but they are insufficient because of their static nature. HoloMed is a holographic system paired with a gesture based interface that helps students more accurately visualize the childbirth process.

Improving Motivation in a Haptic Teaching/Learning Framework
go.nmc.org/improm
Engineering researchers in Spain have developed a framework for building haptic feedback simulators in education. Simulators give students in fields such as civil engineering education, electronic engineering education, and surgery the opportunity to virtually interact with infrastructure, critical devices, and body tissues and organs, respectively.

For Further Reading

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

Augmented Reality and Virtual Reality Go to Work
go.nmc.org/arandvr
(Nelson Kunkel, *Deloitte University Press*, 24 February 2016.) Technologies such as augmented reality and virtual reality have introduced new interfaces that are changing how organizations do business — improving fidelity of intention, increasing efficiency, and fostering innovation.

A Tactile Palette to Translate Graphics for the Visually Impaired
go.nmc.org/tacolor
(Muhammad Usman Raza et al, *National Braille Technology*, accessed 18 January 2017.) Research led by Disney and the National Braille Press investigates the use of electrostatic vibration on friction-enabled displays to convey color information. With a tactile palette of six stimuli corresponding to six specific colors, visually impaired users will be able to perceive color in two-dimensional graphics.

Why Conversational UI is the Next Big Digital Disruption
go.nmc.org/cuiss
(Sarat Pediredla, I*T Pro Portal*, 1 April 2016.) User interfaces are moving from graphical user interfaces to conversational user interfaces where people can use their voices to interact with a device. Machine learning and advancements in big data will increasingly enable computers to understand hypothetical objects and future events.

Methodology

The process used to research and create the *NMC Horizon Report: 2017 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 trends, challenges, and developments in technology, and then explores each of them in progressively more detail, reducing the set until the final listing of topics 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: 2017 Higher Education Edition* can be found at horizon.wiki.nmc.org.

This year, the panel was composed of 78 education and technology experts from 22 countries on five continents; 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 15 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, more than 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. 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.

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: 2017 Higher Education Edition*.

The 2017 Higher Education Expert Panel

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Endnotes

1 https://techcrunch.com/2016/07/21/the-role-of-higher-education-in-entrepreneurship/
2 https://www.tiaainstitute.org/public/pdf/cultivating_strategic_innovation_in_higher_ed.pdf (PDF)
3 http://evolllution.com/managing-institution/higher_ed_business/accepting-risk-and-rejecting-the-status-quo-fostering-an-innovative-higher-ed-culture/
4 http://www.sciencedirect.com/science/article/pii/S1877042816301252
5 http://chroniclegreatcolleges.com/blog/indicators-culture-innovation/
6 http://www.ecampusnews.com/entry/rethinking-state-funding-policies-to-spur-innovation/
7 https://itif.org/publications/2016/08/01/improve-quality-and-reduce-costs-higher-education-itif-calls-policies
8 http://www.washington.edu/president/2016/06/20/universitys-role-innovation-ecosystem-times-higher-education-asia-summit-keynote/
9 https://www.timeshighereducation.com/comment/innovation-nation-hong-kongs-eyes-on-the-future
10 http://makercommons.psu.edu
11 http://sydney.edu.au/news-opinion/news/2016/10/24/a-pilot-program-drives-innovation-across-the-.html
12 https://www.nesta.org.uk/sites/default/files/the_challenge-driven_university.pdf (PDF)
13 http://www.hewlett.org/library/deeper-learning-defined/
14 http://www.shsu.edu/centers/project-based-learning/higher-education.html
15 http://cbl.digitalpromise.org/wp-content/uploads/sites/7/2016/10/CBL_Guide2016.pdf (PDF)
16 http://www.inquirybasedlearning.org/about/#/what-is-ibl/
17 http://www.air.org/sites/default/files/downloads/report/Graduation-Advantage-Persists-Deeper-Learning-Report-March-2016-rev.pdf (PDF)
18 http://acue.org/quality-teaching/
19 http://www.uq.edu.au/teach/flipped-classroom/problem-bl.html
20 http://www.education-inquiry.net/index.php/edui/article/view/27287
21 http://www.economist.com/news/international/21701081-new-crop-hands-universities-transforming-how-students-learn-flying-high
22 https://www.linkedin.com/pulse/project-based-learning-business-education-paul-mcafee
23 https://www.researchgate.net/publication/233224245_Case_study_of_a_project-based_learning_course_in_civil_engineering_design
24 http://www.bie.org/blog/pbl_is_making_headway_in_higher_education
25 http://hechingerreport.org/the-inquiry-based-approach-to-higher-ed-that-could-prevent-college-students-from-dropping-out/
26 http://edworkforce.house.gov/news/documentsingle.aspx?DocumentID=400894
27 http://www1.udel.edu/inst/partners/panpbl.html
28 http://www.bie.org/blog/gold_standard_pbl_essential_project_design_elements
29 http://wp.wpi.edu/projectbasedlearning/
30 http://www.aacu.org/peerreview/2016/winter-spring/Musselman
31 http://edglossary.org/assessment/
32 http://nextgenlearning.org/next-gen-assessment
33 https://tekri.athabascau.ca/analytics/
34 http://er.educause.edu/articles/2016/8/big-data-analysis-in-higher-education-promises-and-pitfalls
35 http://epress.lib.uts.edu.au/journals/index.php/JLA/article/view/5081/5595
36 https://www.weforum.org/agenda/2015/10/wearable-tech-true-health/
37 http://acrobatiq.com/from-course-to-curriculum-an-interview-with-ray-henderson-on-the-coming-lms-paradigm-shift/
38 https://analytics.jiscinvolve.org/wp/files/2016/04/CASE-STUDY-I-Nottingham-Trent-University.pdf (PDF)
39 https://www.datanami.com/2016/11/01/data-analytics-higher-education/
40 http://www.laceproject.eu/ethics-privacy/
41 https://www.jisc.ac.uk/guides/code-of-practice-for-learning-analytics
42 https://analytics.jiscinvolve.org/wp/files/2016/04/CASE-STUDY-H-Open-University-UK.pdf (PDF)
43 https://na-production.s3.amazonaws.com/documents/Promise-and-Peril_4.pdf (PDF)
44 http://www.unescobkk.org/education/ict/online-resources/databases/ict-in-education-database/item/article/scaling-out-teaching-scaling-up-learning-some-thoughts-on-innovation-in-higher-education/
45 http://postsecondary.gatesfoundation.org/areas-of-focus/incentives/policy-advocacy/making-difference/bridget-burns/
46 https://www.aacu.org/press/press-releases/multi-state-collaboration-produces-valuable-new-evidence-about-writing-critical
47 https://www.engineering.unsw.edu.au/news/worlds-first-adaptive-engineering-course-opens-up-engineering-fundamentals-to-all
48 https://sf-asset-manager.s3.amazonaws.com/96945/2/19.pdf (PDF)
49 http://learning-analytics.info/journals/index.php/JLA/article/view/4888/5628
50 http://www.csusm.edu/classrooms/
51 http://case.edu/hololens/
52 http://www.conferenceboard.ca/topics/education/commentaries/16-05-16/innovation_in_learning_spaces_how_we_are_reinventing_the_classroom.aspx
53 http://www.bizedmagazine.com/archives/2017/1/features/business-schools-teach-with-telepresence
54 http://www.edtechmagazine.com/higher/article/2016/08/colleges-transform-campus-sites-high-tech-spaces
55 https://campustechnology.com/articles/2016/06/08/designing-learning-spaces-for-innovation.aspx
56 https://ww2.kqed.org/mindshift/2016/02/05/what-colleges-can-gain-by-adding-makerspaces-to-its-libraries/
57 http://www.nottingham.edu.cn/en/news/2016/unnc-launches-incubator-centre.aspx
58 https://nfb.org/higher-education-accessibility-online-resource-center
59 http://www.edtechmagazine.com/higher/article/2016/10/universal-design-does-your-campus-comply
60 https://www.jisc.ac.uk/guides/learning-spaces
61 https://campustechnology.com/articles/2016/05/17/flexspace-sharing-the-best-of-learning-space-design.aspx
62 https://www.learningenvironments.unsw.edu.au/content/PALS
63 http://www.surrey.ac.uk/tel/news/160634_active_learning_spaces.htm
64 http://acrobatiq.com/what-is-blended-learning-in-higher-ed-six-definitions-from-thought-leaders/
65 https://campustechnology.com/articles/2016/10/12/55-percent-of-faculty-are-flipping-the-classroom.aspx
66 https://nowtoronto.com/lifestyle/class-action/how-virtual-reality-is-changing-post-secondary-education/
67 http://www.eurodl.org/?p=current&sp=brief&article=717
68 http://www.christenseninstitute.org/blog/breaking-cycle-education-fads/
69 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4973547/#CR13
70 http://www.usnews.com/education/best-graduate-schools/top-law-schools/articles/2016-11-07/law-schools-experiment-with-partially-online-learning
71 https://www.insidehighered.com/news/2016/09/26/u-vermont-medical-school-get-rid-all-lecture-courses
72 http://unesdoc.unesco.org/images/0024/002468/246851e.pdf (PDF)
73 http://www.blended-learning.com.au/
74 https://onlinelearningconsortium.org/jaln_full_issue/online-learning-2016-olc-conference-special-issue/
75 https://events.educause.edu/eli/courses/webinar/2016/eli-course-teaching-in-blended-learning-environments
76 https://kiron.ngo/about
77 http://www.sciencedirect.com/science/article/pii/S1877042816000641
78 http://www.cte.cornell.edu/teaching-ideas/engaging-students/collaborative-learning.html
79 http://www.education.umd.edu/Academics/Faculty/Bios/facData/CHSE/cabrera/CollaborativeLearning.pdf (PDF)
80 http://www.connectededucators.org/briefs/online-communities-of-practice-for-educators/
81 http://agb.org/trusteeship/2015/taming-big-data-using-data-analytics-for-student-success-and-institutional
82 https://www.cte.cornell.edu/teaching-ideas/engaging-students/collaborative-learning.html
83 http://www.uq.edu.au/teach/flipped-classroom/collaborative-learning.html
84 Ledlow, Susan. "Cooperative Learning in Higher Education." Arizona State University, 1999.
85 https://coi.athabascau.ca/coi-model/
86 http://www.sixthtone.com/news/how-wechat-changing-online-learning-we-know-it
87 https://altmba.com/about
88 https://www.edsurge.com/news/2016-03-04-could-slack-be-the-next-online-learning-platform
89 http://www.iie.org/Who-We-Are/News-and-Events/Press-Center/Press-Releases/2016/2016-03-01-EducationUSA-Leadership-Institutes-2016#.WDRnCKlrLEY
90 http://www.apjce.org/files/APJCE_17_3_227_247.pdf (PDF)
91 Cook, Lisa. "How Georgia State University Plans to Use Predictive Analytics to Address the National Achievement Gap." Academic Impressions, February 2, 2016. http://www.academicimpressions.com/news/how-georgia-state-university-plans-use-predictive-analytics-address-national-achievement-gap.
92 Kurzweil, Martin, and D. Derek Wu. "Building a Path to Student Success at Georgia State University." Ithaka S+R, April 23, 2015. http://www.sr.ithaka.org/wp-content/uploads/2015/08/SR_Case_Study_Building_Pathway_Student_Success_042315_0.pdf (PDF).
93 Talbot, Jenna Schuette. "US Department of Education Awards UIA $8.9 Million to Evaluate Analytics-Based Advising for Low-Income and First-Generation College Students." University Innovation Alliance, September 21, 2015. http://www.theuia.org/blog/post/us-department-education-awards-uia-89-million-evaluate-analytics-based-advising-low-income.
94 http://www.geekwire.com/2016/gix-groundbreaking/
95 https://www.timeshighereducation.com/blog/office-students-must-promote-collaboration-well-competition
96 http://www.hope.edu/news/2016/academics/grant-to-support-faculty-and-students-in-interdisciplinary-exploration-of-grand-challenges.html
97 http://www.forbes.com/sites/jordanshapiro/2015/10/31/five-technology-fundamentals-that-all-kids-need-to-learnnow/#1a712e397c8c
98 http://blog.core-ed.org/blog/2015/10/what-is-digital-fluency.html
99 http://www.digitalcitizenship.net/Nine_Elements.html
100 http://er.educause.edu/articles/2016/3/from-written-to-digital-the-new-literacy
101 https://www.jisc.ac.uk/guides/developing-digital-literacies
102 https://sheg.stanford.edu/upload/V3LessonPlans/Executive%20Summary%2011.21.16.pdf (PDF)
103 http://www.npr.org/2016/12/14/505547295/fake-news-expert-on-how-false-stories-spread-and-why-people-believe-them
104 https://youtu.be/UnrUTPb-Bfs?list=PLVwavmSEaasH_twUVwJ-zh5o38lewevY9
105 https://ec.europa.eu/jrc/en/digcomporg/framework
106 https://www.jisc.ac.uk/guides/developing-successful-student-staff-partnerships
107 https://www.jisc.ac.uk/rd/projects/building-digital-capability
108 https://discoverytool.jisc.ac.uk/discovery-tool/57f5af9013b67a9a177f2ff1/intro
109 https://www.westernsydney.edu.au/studysmart/home/digital_literacy
110 http://digipo.io/
111 https://ec.europa.eu/digital-single-market/en/news/digital-skills-core-new-skills-agenda-europe
112 https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-20-digital-competence-framework-citizens-update-phase-1-conceptual-reference-model
113 http://www.skillsfuture.sg/
114 http://www.straitstimes.com/singapore/education/starting-jan-1-singaporeans-aged-25-and-above-will-get-500-credit-to-upgrade
115 http://www.teachingandlearning.ie/transforming-personal-professional-digital-capacities-teaching-learning-contexts-collaboration-social-policy-educators-students-learning-technologists/
116 http://www.ed.ac.uk/information-services/about/news/wikimedian-in-residence
117 http://thinking.is.ed.ac.uk/wir/
118 http://www.23things.ed.ac.uk/
119 http://www.northwestern.edu/provost/faculty-honors/digital-learning-fellowships/index.html
120 http://www.sciencedirect.com/science/article/pii/S0747563213003075
121 http://infed.org/mobi/informal-learning-theory-practice-and-experience
122 https://www.academicimpressions.com/news/current-state-competency-based-education-us
123 https://hostingfacts.com/internet-facts-stats-2016/
124 http://etale.org/main/2016/06/29/learning-that-sticks-is-usually-informal-implications-for-school/
125 http://libguides.humboldt.edu/brainbooth
126http://www.forbes.com/sites/gradsoflife/2016/06/13/are-digital-badges-the-new-measure-of-mastery/#c17b9ed23aec
127 https://assets.aspeninstitute.org/content/uploads/files/content/upload/NC3%20Case%20Study.pdf (PDF)
128 http://www.qqi.ie/Publications/European%20guidelines%20for%20validating%20non-formal%20and%20informal%20learning%20-%20CEDEFOP%202015.pdf (PDF)
129 http://www.cedefop.europa.eu/en/publications-and-resources/data-visualisations/european-database-on-validation-of-non-formal-and-informal-learning
130 https://www.whitehouse.gov/blog/2016/08/16/testing-access-low-income-students-new-generation-higher-education-providers
131 http://www.discuss-community.eu/validation-of-informal-learning-3/item/282-vince-validation-for-inclusion-of-refugees-and-migrants-in-european-higher-education.html
132 http://www.openrecognition.org/
133 http://www.mq.edu.au/study/admissions/recognition-of-prior-learning
134 https://www.tcd.ie/teaching-learning/assets/pdf/RPL%20Policy%20Final.pdf (PDF)
135 http://er.educause.edu/articles/2016/12/competency-based-education-saving-students-time-and-money
136 http://www.nea.org/home/20380.htm
137 https://www.eab.com/research-and-insights/continuing-and-online-education-forum/expert-insights/2016/non-traditional-student-success
138 http://www.tonywagner.com/69
139 http://fortune.com/2015/06/03/bill-gates-college-grads/.
140 http://www.ecampusnews.com/technologies/underserved-chicago-adaptive-737/.
141 http://portal.unesco.org/geography/es/files/13662/12960781625TOM_-_Brazil%27s_Ed_System_EN.pdf/TOM%2B-%2BBrazil%27s%2BEd%2BSystem_EN.pdf (PDF)
142 https://data.oecd.org/eduatt/graduation-rate.htm#indicator-chart
143 http://www.nationalreview.com/article/425506/gender-gap-college-fatherless-households
144 http://nces.ed.gov/pubs2015/2015025.pdf (PDF)
145 https://www.eab.com/research-and-insights/continuing-and-online-education-forum/expert-insights/2016/non-traditional-student-success.
146 http://er.educause.edu/articles/2016/3/how-personalized-learning-unlocks-student-success
147 http://www.usnews.com/opinion/knowledge-bank/2016/02/17/the-approaching-revolution-of-competency-based-higher-education
148 http://www.pellinstitute.org/downloads/publications-Indicators_of_Higher_Education_Equity_in_the_US_2016_Historical_Trend_Report.pdf (PDF)
149 http://www.theatlantic.com/education/archive/2016/04/the-growing-wealth-gap-in-who-earns-college-degrees/479688/
150 http://www.investopedia.com/articles/personal-finance/080616/6-countries-virtually-free-college-tuition.asp
151 http://www.ed.gov/college
152 http://blog.ed.gov/2015/10/latinosachieve-when-we-believe-in-them/
153 http://ec.europa.eu/dgs/education_culture/repository/education/library/study/2015/dropout-completion-he_en.pdf (PDF)
154 http://time.com/90399/how-australia-beats-the-u-s-for-graduating-low-income-college-students/

155 https://www.westernsydney.edu.au/fastforward
156 https://myfuture.edu.au/career-insight/alternative-pathways-to-higher-education
157 https://www.utsa.edu/today/2016/08/oitipass.html
158 http://www.qcc.cuny.edu/starfish/
159 http://www.unescobkk.org/education/ict/online-resources/databases/ict-in-education-database/item/article/digital-equity-as-an-imperative-for-the-ict-ecosystem/
160 http://www.un.org/sustainabledevelopment/blog/2015/12/countries-adopt-plan-to-use-internet-in-implementation-of-sustainable-development-goals/
161 https://www.publicintegrity.org/2016/05/12/19659/rich-people-have-access-high-speed-internet-many-poor-people-still-dont
162 https://www.oercommons.org/
163 https://blogs.state.gov/stories/2016/01/25/global-connect-initiative-making-internet-development-priority
164 http://www3.weforum.org/docs/WEF_Internet_for_All_Framework_Accelerating_Internet_Access_Adoption_report_2016.pdf (PDF)
165 https://www.publicintegrity.org/2016/05/12/19659/rich-people-have-access-high-speed-internet-many-poor-people-still-dont
166 https://www.ncsehe.edu.au/wp-content/uploads/2016/05/Access-and-Barriers-to-Online-Education-for-People-with-Disabilities.pdf (PDF)
167 http://er.educause.edu/articles/2016/3/how-personalized-learning-unlocks-student-success
168 https://ww2.kqed.org/mindshift/2015/12/14/what-achieving-digital-equity-using-online-courses-could-look-like/
169 http://www.ox.ac.uk/news/2016-11-15-oxford-announces-its-partnership-edx-and-its-first-mooc
170 http://www.centerdigitaled.com/higher-ed/What-Are-Open-Educational-Resources.html
171 https://www.oercommons.org/
172 https://www.col.org/
173 http://achievingthedream.org/press_release/15982/achieving-the-dream-launches-major-national-initiative-to-help-38-community-colleges-in-13-states-develop-new-degree-programs-using-open-educational-resources
174 http://www.digitalindia.gov.in/
175 http://www.lao.ca.gov/Publications/Report/3392
176 https://internetessentials.com/college
177 https://www.google.com/get/projectlink/
178 http://affordableaccess.com.au/
179 http://www.cam.ac.uk/for-staff/news/harnessing-digital-technology-to-support-teaching-and-learning
180 https://theithacan.org/news/mooc-courses-have-not-gained-as-much-popularity-as-expected/
181 https://odl.mit.edu/news-events/blog/five-things-you-missed-if-you-missed-kizilcecs-talk-closing-achievement-gaps-moocs
182 http://er.educause.edu/articles/2016/5/credentials-reform-how-technology-and-the-changing-needs-of-the-workforce-will-create-the-higher-ed
183 https://www.edsurge.com/news/2015-06-24-before-choosing-edtech-products-ask-yourself-these-three-questions
184 http://josotl.indiana.edu/article/view/13319
185 http://www.palgrave-journals.com/articles/palcomms20152
186 https://www.insidehighered.com/news/survey/partial-credit-2015-survey-faculty-attitudes-technology
187 http://onlinelearningconsortium.org/news_item/babson-study-distance-education-enrollment-growth-continues-2/
188 Jouko Sarvi and Hitendra Pillay, *Innovations in Knowledge and Learning for Competitive Higher Education in Asia and the Pacific*, Asian Development Bank, 1 December 2015.
189 http://www.palgrave-journals.com/articles/palcomms20152
190 http://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-015-0518-8
191 William Condon et al., *Faculty Development and Student Learning: Assessing the Connections*, Indiana University Press, 11 December 2015:
192 http://canada.pch.gc.ca/eng/1443123010060
193 http://nyrej.com/81418
194 https://ec.europa.eu/programmes/erasmus-plus/opportunities-for-organisations/innovation-good-practices/capacity-building-higher-education_en
195 http://eacea.ec.europa.eu/home/erasmus-plus/actions/key-action-2-cooperation-for-innovation-and-exchange-good-practices/capacity-0_en
196 https://www.durhamtech.edu/policiesprocedures/professionaldevelopmentpolicy.htm
197 https://www.rit.edu/academicaffairs/policiesmanual/e180
198 Houston Community College. "Instructional Technology." Accessed October 18, 2016. http://northeast.hccs.edu/about-us/instructional-technology/.
199 Storycenter. "Houston Community College: Embedding Digital Storytelling Across the Higher Education Curriculum." Accessed October 18, 2016. http://www.storycenter.org/case-studies/hcc.
200 https://www.jisc.ac.uk/training/developing-a-strategic-response-to-dsa-changes
201 http://www.centerdigitaled.com/higher-ed/How-to-Help-Faculty-Explore-Wearable-Technology-for-Learning.html
202 http://www.downes.ca/post/65519
203 http://www.facultyfocus.com/articles/online-education/understanding-project-based-learning-in-the-online-classroom/
204 http://blog.blackboard.com/faculty-role-competency-based-education-vs-traditional-education/
205 http://rpkgroup.com/wp-content/uploads/2016/10/rpkgroup_cbe_business_model_report_20161018.pdf (PDF)
206 http://onlinelibrary.wiley.com/doi/10.1002/cbe2.1003/full
207 http://www.academicimpressions.com/sites/default/files/pd-report-2016.pdf (PDF)
208 http://www.thedailystar.net/op-ed/politics/rethinking-higher-education-1285114
209 http://www.gallup.com/services/194783/gallup-college-university-presidents-study-2016.aspx
210 http://www.gallup.com/opinion/gallup/195569/restoring-university-faculty-role-teaching-student-service.aspx
211 http://www.nea.org/home/68481.htm
212 https://tcf.org/content/report/why-performance-based-college-funding-doesnt-work/
213 http://talkbusiness.net/2016/08/higher-education-and-workforce-readiness-need-entrepreneurship-building-blocks/
214 http://ec.europa.eu/education/policy/strategic-framework_en
215 https://heinnovate.eu/about
216 http://www.pearsoned.com/education-blog/studying-the-effectiveness-of-online-learning-needs-to-continue/
217 http://www.cbenetwork.org/about/
218 https://www.edsurge.com/news/2016-07-30-umuc-s-blueprint-for-designing-a-culture-of-constant-innovation
219 http://newsroom.melbourne.edu/enterpriseprofessors
220 https://campustechnology.com/articles/2016/12/20/the-blurry-definitions-of-adaptive-vs-personalized-learning.aspx
221 http://er.educause.edu/articles/2016/10/adaptive-learning-systems-surviving-the-storm
222 http://www.educationdive.com/news/adaptive-learning-holds-promise-for-the-future-of-higher-education/421228/
223 http://www.gartner.com/newsroom/id/3225717
224 http://tytonpartners.com/library/learning-to-adapt-2-0-the-evolution-of-adaptive-learning-in-higher-education/
225 https://campustechnology.com/articles/2016/04/21/research-5-ways-adaptive-learning-has-changed.aspx?admgarea=news
226 https://www.cogbooks.com/2016/02/04/improve-student-success-and-retention-with-adaptive-courseware/
227 http://www.campuscomputing.net/cc2016
228 http://www.aplu.org/projects-and-initiatives/personalized-learning-consortium/plc-projects/Accelerating-Adoption-of-Adaptive-Courseware.html
229 http://www.policyconnect.org.uk/hec/sites/site_hec/files/report/419/fieldreportdownload/frombrickstoclicks-hecreportforweb.pdf (PDF)
230 https://www.ecampus.no/2016/10/26/adaptive-learning-lone-learner-or-community-effort/
231 http://er.educause.edu/articles/2016/3/adaptive-learning-platforms-creating-a-path-for-success
232 https://ovpi.uga.edu/news/english-composition-incorporates-adaptive-learning-into-classroom
233 https://www.jisc.ac.uk/sites/default/files/learning-analytics-in-he-v3.pdf (PDF)
234 https://analytics.jiscinvolve.org/wp/files/2016/04/CASE-STUDY-K-Open-Universities-Australia.pdf (PDF)
235 http://www.nesta.org.uk/sites/default/files/higher_education_and_technology_nov16_.pdf (PDF)
236 https://www.thecommonwealth-educationhub.net/wp-content/uploads/2016/04/eDiscussion-Summary-Increasing-Access-to-Education.pdf (PDF)
237 http://er.educause.edu/articles/2015/6/students-mobile-learning-practices-in-higher-education-a-multiyear-study
238 https://www.theguardian.com/technology/2016/nov/02/mobile-web-browsing-desktop-smartphones-tablets
239 https://www.theguardian.com/technology/2016/oct/14/google-desktop-search-out-of-date-mobile
240 http://www.mheducation.com/news-media/press-releases/learning-analytics-new-likes-college-better-access-personalized-data-new-research.html
241 http://www.emerging-strategy.com/article/learning-on-the-go-the-rise-of-mobile-learning-across-the-globe
242 http://connectedlearning.tv/personal-stories/bryan-alexander-mobile-learning-equity-and-future-education
243 http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/
244 https://www.mobileworldlive.com/featured-content/home-banner/africa-hits-557m-unique-mobile-subs-smartphones-to-dominate-by-2020/
245 http://www.universityworldnews.com/article.php?story=20160819075248597
246 https://www.researchgate.net/publication/305453720_The_use_of_a_mobile_learning_management_system_and_academic_achievement_of_online_students
247 http://www.educause.edu/eli/events/eli-course-mobile-higher-education
248 https://ojsspdc.ulpgc.es/ojs/index.php/LFE/article/viewFile/494/457
249 http://www.purdueexponent.org/features/article_9921c432-223a-508c-b9da-aaf0019fcafa.html
250 http://cehs.unl.edu/cehs/news/engaging-students-mobile-technology/
251 https://www.youtube.com/watch?v=DJ-SFcA0zpk
252 http://eprints.mdx.ac.uk/17589/
253 https://www.elsevier.com/connect/m-learning-gives-kenyan-nurses-scalable-continuing-education
254 https://www.jisc.ac.uk/guides/mobile-learning
255 http://ucfmobile.ucf.edu/cdl/checklist/
256 https://www.theguardian.com/technology/2016/jul/18/what-is-the-internet-of-things-arm-holdings-softbank
257 http://er.educause.edu/articles/2016/6/the-internet-of-things-unprecedented-collaboration-required
258 http://er.educause.edu/articles/2016/8/iot-and-the-campus-of-things
259 http://www.gartner.com/newsroom/id/3165317
260 https://campustechnology.com/articles/2017/01/05/internet-of-things-spending-to-reach-1-29-trillion-by-2020.aspx
261 http://www.cio.com/article/3137047/internet-of-things/internet-of-things-poised-to-transform-cities.html
262 http://www.cbronline.com/news/internet-of-things/5-mega-smart-city-projects-from-around-the-world-4881856/
263 http://www.npr.org/2016/10/22/498954197/internet-outage-update-internet-of-things-hacking-attack-led-to-outage-of-popula
264 https://www.theguardian.com/technology/2016/oct/21/ddos-attack-dyn-internet-denial-service
265 http://www.cmu.edu/news/stories/archives/2016/august/nsf-award-internet-of-things.html
266 https://www.universitybusiness.com/article/higher-prepares-internet-things
267 http://cybersecurityventures.com/jobs/
268 http://www.mcafee.com/us/resources/reports/rp-hacking-skills-shortage.pdf (PDF)
269 http://er.educause.edu/articles/2016/6/the-internet-of-things-is-here
270 https://www.metering.com/news/university-nsw-becomes-testbed-iot-smart-city-tech/
271 http://www.edtechmagazine.com/higher/article/2016/08/internet-things-coming-your-campus-sooner-you-think
272 https://www.edsurge.com/news/2016-01-04-what-higher-education-can-learn-from-fitbit/
273 https://www.edsurge.com/news/2016-11-17-wearable-tech-weaves-its-way-into-learning
274 https://campustechnology.com/Articles/2016/09/20/From-IoT-to-IoE-Institutions-Connect-to-Everything.aspx
275 http://engineering.tamu.edu/news/2016/10/28/students-collaborate-on-innovative-solutions-using-the-internet-of-things
276 http://sydney.edu.au/courses/bachelor-of-engineering-honours-mechanical/major-internet-of-things
277 http://searchcio.techtarget.com/definition/learning-management-system
278 http://er.educause.edu/articles/2015/6/whats-next-for-the-lms
279 https://library.educause.edu/~/media/files/library/2015/12/eli7127-pdf.pdf (PDF)
280 http://www.educause.edu/blogs/mbrown/lms-future-exploring-next-generation-digital-learning-environment
281 https://library.educause.edu/~/media/files/library/2015/12/eli7127-pdf.pdf (PDF)
282 http://mfeldstein.com/state-of-the-us-higher-education-lms-market-2015-edition/
283 https://open.edx.org/
284 http://www.helixeducation.com/
285 http://horizon.wiki.nmc.org/New+Topic
286 https://library.educause.edu/resources/2014/9/next-generation-digital-learning-environment-initiative
287 https://library.educause.edu/~/media/files/library/2015/4/eli3035-pdf.pdf (PDF)
288 https://www.imsglobal.org/activity/learning-tools-interoperability
289 https://support.gcu.edu/hc/en-us/articles/201883674-Accessing-Your-LoudCloud-Classroom
290 http://www.bnedloudcloud.com/
291 http://teachonline.ca/sites/default/files/tools-trends/downloads/wgu.pdf (PDF)
292 http://acrobatiq.com/news/underserved-students-thrive-with-universitys-new-format/#.WD8QtKlrLwc
293 http://acrobatiq.com/
294 https://www.smartsparrow.com/
295 https://apps.sandstorm.io/
296 https://sandstorm.io/go/education
297 https://www.edcast.com/
298 http://www.computerworld.com/article/2906336/emerging-technology/what-is-artificial-intelligence.html
299 http://www.sas.com/en_us/insights/analytics/machine-learning.html
300 http://artint.info/html/ArtInt_183.html
301 http://whatis.techtarget.com/definition/Turing-Test
302 https://www.theguardian.com/technology/2014/jun/08/super-computer-simulates-13-year-old-boy-passes-turing-test
303 http://www.deakin.edu.au/about-deakin/media-releases/articles/ibm-watson-helps-deakin-drive-the-digital-frontier
304 http://www.slate.com/articles/technology/cover_story/2016/04/alexa_cortana_and_siri_aren_t_novelties_anymore_they_re_our_terrifyingly.html
305 http://www.slate.com/articles/technology/cover_story/2016/04/alexa_cortana_and_siri_aren_t_novelties_anymore_they_re_our_terrifyingly.html
306 http://www.nytimes.com/2016/12/14/technology/uber-self-driving-car-san-francisco.html
307 https://www.flickr.com/photos/ibm_research_zurich/albums/72157636361743526/with/10173949393/
308 http://www.recode.net/2016/6/22/11985726/robot-teachers-artificial-intelligence-coursera-daphne-koller
309 https://mitpress.mit.edu/books/interface
310 https://mitpress.mit.edu/books/interface
311 https://www.microsoft.com/en-us/research/blog/researchers-team-up-with-chinese-botanists-on-machine-learning-flower-recognition-project/
312 https://openai.com/about/
313 https://www.tensorflow.org/
314 https://medium.com/@tdietterich/benefits-and-risks-of-artificial-intelligence-460d288cccf3#.4m86dzivv
315 http://er.educause.edu/articles/2016/3/adaptive-learning-platforms-creating-a-path-for-success
316 https://www.jenzabar.com/higher-education-solutions/enterprise-resource-planning-erp/
317 http://www-01.ibm.com/software/analytics/spss/academic/solutions/administrators.html
318 http://www.theverge.com/2016/4/25/11492102/bill-gates-interview-education-software-artificial-intelligence
319 http://www.sciencedirect.com/science/article/pii/S1877050915034912
320 https://www.weforum.org/agenda/2016/10/top-10-ethical-issues-in-artificial-intelligence/
321 https://www.csail.mit.edu/node/2910
322 http://roboy.org/
323 https://ai.vub.ac.be/research/topics/evolutionary-linguistics
324 http://arstechnica.com/gadgets/2013/04/from-touch-displays-to-the-surface-a-brief-history-of-touchscreen-technology/
325 https://www.fastcodesign.com/3049577/wears/the-newest-user-interface-rhythm
326 https://www.interaction-design.org/encyclopedia/wearable_computing.html
327 https://blog.tracxn.com/2016/02/11/tracxn-report-natural-user-interface/
328 http://findbiometrics.com/natural-speech-iot-311-96/
329 https://www.sciencedaily.com/releases/2016/02/160226125315.htm
330 http://www.sigmadzn.com/user-experience-emerging-use-haptics/
331 https://thestack.com/world/2016/04/11/skinhaptics-turns-your-palm-into-a-touchscreen/
332 https://www.vancouver.wsu.edu/haptic-touch
333 https://www.aau.edu/research/article4.aspx?id=17857
334 http://shape.stanford.edu/research/wolverine/
335 https://docs.google.com/document/d/1k4gAtOvO3jMUJeKz4p5YzuBESjBHXqDvBQzclcvEyiw/edit#
336 http://www.engin.umich.edu/college/about/news/stories/2015/december/refreshable-braille-device
337 http://www.deakin.edu.au/iisri/our-research/haptics-research
338 https://blog.somaticlabs.io/electrovibration-electrostatic-vibration-and-touchscreens/
339 http://www2.uta.fi/en/ajankohtaista/uutinen/universities-tampere-develop-digital-scent-technology

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