



The *NMC Horizon Report* is an unbiased source of information that helps education leaders, trustees, policy makers, and others easily understand the impact of key emerging technologies on education, and when they are likely to enter mainstream use.



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## Executive Summary

**W**elcome to the *NMC Horizon Report*, a series of publications designed to help education leaders, policy makers, and faculty understand new and emerging technologies, and their potential impact on teaching, learning, and research. This specific volume, the *NMC Horizon Report: 2013 Higher Education Edition*, is framed specifically around the unique needs and circumstances of higher education institutions, and looks at that landscape with a global lens over the next five years.

The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a comprehensive research venture established in 2002 that identifies and describes emerging technologies likely to have a large impact over the coming five years in education around the globe. Since 2005, this particular edition has been produced via a collaborative effort with the EDUCAUSE Learning Initiative, and examines emerging technologies for their potential impact on teaching, learning, and creative inquiry within the higher education environment.

To create the report, an international body of experts in education, technology, and other fields was convened as an advisory board. The group engaged in discussions around a set of research questions intended to surface significant trends and challenges and to identify a wide array of potential technologies for the report. This dialog was enriched by an extensive range of resources, current research, and practice that drew on the expertise of both the NMC community and the communities of the members of the advisory board. These interactions among the advisory board are the focus of the *NMC Horizon Report* research, and this report details the areas in which these experts were in strong agreement.

The report opens with a discussion of the trends and challenges identified by the advisory board as most important for the next five years. The main section highlights six promising technological areas and their practical, real-world applications in higher education settings. Each section is introduced with an overview

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that defines the topic, followed by a discussion of the particular relevance of the topic to teaching, learning, and creative inquiry in higher education. Next, several concrete examples are provided that demonstrate how the technology is being used. Finally, each section closes with an annotated list of suggested readings that expand on the discussion in the report.

These resources, along with countless other helpful projects and readings, can all be found in the project's open content database — the NMC Horizon Project Navigator ([navigator.nmc.org](http://navigator.nmc.org)). All the ephemera of the *NMC Horizon Report: 2013 Higher Education Edition*, including the research data, the interim results, the topic preview, and this publication, can be downloaded for free on the NMC website ([nmc.org](http://nmc.org)), as well as iTunes U ([go.nmc.org/itunes-u](http://go.nmc.org/itunes-u)).

Each of the three global editions of the *NMC Horizon Report*—higher education, K-12 education, and museum



education — highlights six emerging technologies or practices that are likely to enter mainstream use in their focus sectors within three adoption horizons over the next five years. Key trends and significant challenges that will affect current practice over the same period frame these discussions. Over the course of just a few

## Tablets are proving to be powerful tools for learning inside and outside of the classroom.

weeks in the early winter of 2012, the advisory board came to a consensus about the six topics that appear here in the *NMC Horizon Report: 2013 Higher Education Edition*. The examples and readings under each topic are meant to provide practical models as well as access to more detailed information. The precise research methodology employed is detailed in the closing section of this report.

### Technologies to Watch

The six technologies featured in the *NMC Horizon Report: 2013 Higher Education Edition* are placed along three adoption horizons that indicate likely timeframes for their entrance into mainstream use for teaching, learning, and creative inquiry. The near-term horizon assumes the likelihood of entry into the mainstream for higher education institutions within the next 12 months; the mid-term horizon, within two to three years; and the far-term, within four to five years. It should be noted at the outset that the *NMC Horizon Report* is not a predictive tool. It is meant, rather, to highlight emerging technologies with considerable potential for our focus areas of education and interpretation. Each of the six is already the target of work at a number of innovative organizations around the world, and the projects we showcase here reveal the promise of a wider impact.

#### Near-term horizon

On the near-term horizon — that is, within the next 12 months — *massively open online courses* (MOOCs) and *tablet computing* will see widespread adoption in higher education. MOOCs have become an increasingly popular

option for online learning that often promise free, high quality education, though media attention surrounding this category has prompted critics to examine the most prominent models very closely. Tablets have proven to be a solid fit with today's always-connected university students, and the recent expansion of the tablet market is presenting them with a wide array of affordable options.

- > **Massively open online courses** have received their fair share of hype in 2012, and are expected to grow in number and influence within the next year. Big name providers including Coursera, edX, and Udacity count hundreds of thousands of enrolled students, totals that when added together illustrate their popularity. One of the most appealing promises of MOOCs is that they offer the possibility for continued, advanced learning at zero cost, allowing students, life-long learners, and professionals to acquire new skills and improve their knowledge and employability. MOOCs have enjoyed one of the fastest uptakes ever seen in higher education, with literally hundreds of new entrants in the last year; critics loudly warn that there is a need to examine these new approaches through a critical lens to ensure they are effective and evolve past the traditional lecture-style pedagogies.
- > **Tablet computing** has carved its own niche in education as a portable and always-connected family of devices that can be used in almost any setting. Equipped with WiFi and cellular network connectivity, high-resolution screens, and with a wealth of mobile apps available, tablets are proving to be powerful tools for learning inside and outside of the classroom. Many universities have already designed software for tablets along with best practice guidelines for educators and students. With more major manufacturers producing tablets all the time, the competition in the tablet computing market is a significant driver of innovation. As the market matures, students and institutions can expect a rich and growing array of features from these small devices.

#### Mid-term horizon

The second adoption horizon, two to three years out, is where we expect to see widespread adoptions of two

technologies that are experiencing growing interest within higher education: *games and gamification*, and the further refinement of *learning analytics*. Games in higher education aim to engage students, providing them with digitally enhanced scenarios that challenge their understanding of new concepts in their field. The topic has been expanded this year to include gamification and how elements of game design are informing curricula. Learning analytics is a burgeoning body of work rooted in the study of big data, which aims to use analytic techniques common in businesses to gain insights about student behavior and learning. Information derived from learning analytics can inform instructional practice in real time, as well as aid in the design of course management systems that personalize education.

- > **Games and gamification** are two sides of the same approach. Educational games immerse the student in the game, where content and curricula are delivered or juxtaposed. Gamification aims to incorporate elements of games, such as levels and badges (but also via quests and other strategies) into non-game activities. In gamified curricula, students can accumulate points or other rewards by accepting different challenges, and often have more freedom in choosing what kind of assignments they undertake to earn them. Badging or ranking systems serve to recognize student achievements, and the transparency of student progress inspires competition that can drive more interest in the material among students.
- > **Learning analytics** is the field associated with deciphering trends and patterns from educational big data, or huge sets of student-related data, to further the advancement of a personalized, supportive system of higher education. Preliminary uses of student data were directed toward targeting at-risk learners in order to improve student retention. The widespread adoption of learning and course management systems has refined the outcomes of learning analytics to look at students more precisely. Student-specific data can now be used to customize online course platforms and suggest resources to students in the same way that businesses tailor

advertisements and offers to customers. Universities are already employing analytics software to make the **advising** process more efficient and accurate, while researchers are developing mobile software to coach students toward productive behaviors and habits that will lead to their success.

### Far-term horizon

On the far-term horizon, set at four to five years away from widespread adoption, are *3D printing* and *wearable technology*. 3D printing provides a more accessible, less expensive, desktop alternative to industrial forms of rapid prototyping. Many of the discussions surrounding 3D printers stem from the Maker culture, an enthused community of designers, programmers, and others that bring a do-it-yourself approach to science and engineering. Wearable technology, making its first appearance in the *NMC Horizon Report* series, refers to the integration of devices and related electronics into clothing and accessories. A growing collection of wearable technology has appeared in the marketplace, and collectively hints at the potential for teaching and learning, though there are not yet many concrete education examples.

- > **3D printing** has become much more affordable and accessible in recent years in large part due to the efforts of MakerBot Industries. Founded in 2009, this company has promoted the idea of openness by offering products that can be built by anyone with minimal technical expertise. With MakerBot Replicators selling in the range of \$1,500 to \$3,000, it now only requires a small financial investment to own a 3D printer. Websites including Thingiverse offer source files that anyone can use to print objects without original designs. In an educational context, 3D printing is already implemented in a number of research and lab settings. Over the next four to five years, 3D printers will be increasingly used in the arts, design, manufacturing, and the sciences to create 3D models that illustrate complex concepts or illuminate novel ideas, designs, and even chemical and organic molecules.
- > **Wearable technology** will increase in impact as enabling technologies, such as augmented reality

and thin film displays, gain traction in the consumer market. Bendable OLED displays can wrap around furniture and other curved surfaces, which makes it easy to imagine computing devices and accessories that meld with the human body. Perhaps the most anticipated wearable technology is Google's "Project

and the challenges institutions will need to address if the technologies are to reach their potential, also reflect the advisory board's perspective, and are the focus of the next sections of the *NMC Horizon Report: 2013 Higher Education Edition*, where each is detailed in the context of teaching, learning, and creative inquiry.

## Student-specific data can now be used to customize online course platforms and suggest resources to students in the same way that businesses tailor advertisements and offers to customers.

Glass," augmented reality enabled glasses that operate via voice command, presenting the wearer with an information-laden view of their surroundings. Wearable devices are also proving to be effective tools for research because they use sensors to track data, such as vital signs, in real-time. Although wearable technology is not yet pervasive in higher education, the current highly functional clothing and accessories in the consumer space show great promise.

Each of these technologies is described in detail in the main body of the report, where a discussion of what the technology is and why it is relevant to teaching, learning, or creative inquiry can also be found. Our research indicates that all six of these technologies are already having a clear and immediate impact on practices in higher education, and this report aims to document that in a simple and compelling fashion.

The advisory board of 51 technology experts spanned 13 countries this year, and their names are listed at the end of this report. Despite their diverse backgrounds and experience, they share a consensus view that each of the profiled topics will have a significant impact on higher education around the globe over the next five years. The key trends driving interest in their adoption,





## Key Trends

**T**he technologies featured in each edition of the *NMC Horizon Report* are embedded within a contemporary context that reflects the realities of our time, both in the sphere of higher education and in the world at large. To ensure this context was well understood, the advisory board engaged in an extensive review of current articles, interviews, papers, and new research to identify and rank trends that are currently affecting teaching, learning, and creative inquiry in higher education. Once detailed, the initial list of dozens of trends was then ranked according to how significant each was likely to be for higher education in the next five years. The highest ranked of those trends had significant agreement among the advisory board members, who considered them to be key drivers of educational technology adoptions for the period 2013 through 2018. They are listed here in the order in which the advisory board ranked them.

**1 Openness — concepts like open content, open data, and open resources, along with notions of transparency and easy access to data and information — is becoming a value.** As authoritative sources lose their importance, there is need for more curation and other forms of validation to generate meaning in information and media. “Open” continues its diffusion as a buzzword in education, and it is increasingly important to understand the definition. Often mistakenly equated only with “free,” open education advocates are working towards a common vision that defines “open” as free, copyable, remixable, and without any barriers to access or interaction.

**2 Massively open online courses are being widely explored as alternatives and supplements to traditional university courses.** Led by the successful early experiments of world-class institutions (like MIT and Stanford), MOOCs have captured the imagination

of senior administrators and trustees like few other educational innovations have. High profile offerings are being assembled under the banner of institutional efforts like edX, and large-scale collaborations like Coursera and the Code Academy. As the ideas evolve, MOOCs are increasingly seen as a very intriguing alternative to credit-based instruction. The prospect of a single course achieving enrollments in the tens of thousands is bringing serious conversations on topics like micro-credit to the highest levels of institutional leadership.

**3 The workforce demands skills from college graduates that are more often acquired from informal learning experiences than in universities.**

Informal learning generally refers to any learning that takes place outside of a formal school setting, but a more practical definition may be learning that is self-directed and aligns with the student’s own personal learning goals. Employers have specific expectations for new hires, including communication and critical thinking skills — talents that are often acquired or enhanced through informal learning. Online or other modern environments are trying to leverage both formal and informal learning experiences by giving students traditional assignments, such as textbook readings and paper writing, in addition to allowing for more open-ended, unstructured time where they are encouraged to experiment, play, and explore topics based on their own motivations. This type of learning will become increasingly important in learning environments of all kinds.

**4 There is an increasing interest in using new sources of data for personalizing the learning experience and for performance measurement.** As learners participate in online activities, they leave a clear trail of analytics data that can be mined for insights.

Learning analytics experiments and demonstration projects are currently examining ways to use data for enrichment. Dashboards filter this information so that student progress can be monitored in real time. As the field of learning analytics matures, the hope is that this information will enable continual improvement of learning outcomes.

**5 The role of educators continues to change due to the vast resources that are accessible to students via the Internet.** Institutions are now faced with a critical shift as students engage in more informal learning outside of the classroom, and are using always-

opportunities for increased collaboration while equipping students with stronger digital skills. Hybrid models, when designed and implemented successfully, enable students to travel to campus for some activities, while using the network for others, taking advantage of the best of both environments.

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connected devices to surf the web, download apps, and read articles. Educating learners on how to decipher credible resources and aggregate content has become imperative, and there is a need for university educators to fulfill the position of content guide. The emergence of MOOCs, open content, and free online seminars also raises the question of who is considered the expert. Educators are providing mentorship and connecting students with the most effective forums and tools to navigate their areas of study.

**6 Education paradigms are shifting to include online learning, hybrid learning, and collaborative models.** Students already spend much of their free time on the Internet, learning and exchanging new information — often via their social networks. Institutions that embrace face-to-face/online hybrid learning models have the potential to leverage the online skills learners have already developed independent of academia. Online learning environments can offer different affordances than physical campuses, including



## Significant Challenges

**A**ny discussion of technology adoption must also consider important constraints and challenges. The advisory board drew deeply from a careful analysis of current events, papers, articles, and similar sources, as well as from personal experience, in detailing a long list of challenges higher education institutions face in adopting any new technology. Several important challenges are explained below, but it was clear that behind them all was a pervasive sense that individual organizational constraints are likely the most important factors in any decision to adopt — or not to adopt — a given technology.

Even institutions that are eager to adopt new technologies may be critically constrained by the lack of necessary human resources and the financial wherewithal to realize their ideas. Still others are located within buildings that simply were not designed to provide the radio frequency transparency that wireless technologies require, and thus find themselves shut out of many potential technology options. While acknowledging that local barriers to technology adoptions are many and significant, the advisory board focused its discussions on challenges that are common to the higher education community as a whole. The highest ranked challenges they identified are listed here, in the order in which the advisory board ranked them.

**1 Faculty training still does not acknowledge the fact that digital media literacy continues its rise in importance as a key skill in every discipline and profession.** Despite the widespread agreement on the importance of digital media literacy, training in the supporting skills and techniques is rare in teacher education and non-existent in the preparation of faculty. As lecturers and professors begin to realize that

they are limiting their students by not helping them to develop and use digital media literacy skills across the curriculum, the lack of formal training is being offset through professional development or informal learning, but we are far from seeing digital media literacy as a

**Simply capitalizing on new technology is not enough; the new models must use these tools and services to engage students on a deeper level.**

norm. This challenge is exacerbated by the fact that digital literacy is less about tools and more about thinking, and thus skills and standards based on tools and platforms have proven to be somewhat ephemeral.

**2 The emergence of new scholarly forms of authoring, publishing, and researching outpace sufficient and scalable modes of assessment.** Traditional approaches to scholarly evaluation such as citation-based metrics, for example, are often hard to apply to research that is disseminated or conducted via social media. New forms of peer review and approval, such as reader ratings, inclusion in and mention by influential blogs, tagging, incoming links, and re-tweeting, are arising from the natural actions of the global community of educators with increasingly relevant and interesting results. These forms of scholarly corroboration are not yet well understood by mainstream faculty and academic decision makers, creating a gap between what is possible and what is acceptable.

**3 Too often it is education's own processes and practices that limit broader uptake of new technologies.** Much resistance to change is simply comfort with the status quo, but in other cases, such as in promotion and tenure reviews, experimentation or innovative applications of technologies are often seen as outside the role of researcher or scientist, and thus discouraged. Changing these processes will require major shifts in attitudes as much as they will in policy.

**4 The demand for personalized learning is not adequately supported by current technology or practices.** The increasing demand for education that is customized to each student's unique needs is driving the development of new technologies that provide more learner choice and control and allow for differentiated instruction. It has become clear that one-size-fits-all teaching methods are neither effective nor acceptable for today's diverse students. Technology can and should support individual choices about access to materials and expertise, amount and type of educational content, and methods of teaching. The biggest barrier to personalized learning, however, is that scientific, data-driven approaches to effectively facilitate personalization have only recently begun to emerge; learning analytics, for example, is still in the very nascent stage of implementation and adoption within higher education.

**5 New models of education are bringing unprecedented competition to the traditional models of higher education.** Across the board, institutions are looking for ways to provide a high quality of service and more learning opportunities. MOOCs are at the forefront of these discussions, enabling students to supplement their education and experiences at brick-and-mortar institutions with increasingly rich, and often free, online offerings. As these new platforms emerge, however, there is a need to frankly evaluate the models and determine how to best support collaboration, interaction, and assessment at scale. Simply capitalizing on new technology is not enough; the new models must use these tools and services to engage students on a deeper level.

**6 Most academics are not using new technologies for learning and teaching, nor for organizing their own research.** Many researchers have not had training in basic digitally supported teaching techniques, and most do not participate in the sorts of professional development opportunities that would provide them. This is due to several factors, including a lack of time and a lack of expectations that they should. Many think a cultural shift will be required before we see widespread use of more innovative organizational technology. Some educators are simply apprehensive about working with new technologies, as they fear the tools and devices have become more of a focus than the learning. Adoption of progressive pedagogies, however, is often enabled through the exploration of emerging technologies, and thus a change in attitude among academics is imperative.

These trends and challenges are a reflection of the impact of technology that is occurring in almost every aspect of our lives. They are indicative of the changing nature of the way we communicate, access information, connect with peers and colleagues, learn, and even socialize. Taken together, they provided the advisory board a frame through which to consider the potential impacts of nearly 50 emerging technologies and related practices that were analyzed and discussed for possible inclusion in this edition of the *NMC Horizon Report* series. Six of those were chosen through successive rounds of ranking; they are detailed in the main body of the report.



# Massively Open Online Courses

## Time-to-Adoption Horizon: One Year or Less

**W**hen Stephen Downes and George Siemens coined the term in 2008, massively open online courses (MOOCs) were conceptualized as the next evolution of networked learning. The essence of the original MOOC concept was a web course that people could take from anywhere across the world, with potentially thousands of participants. The basis of this concept is an expansive and diverse set of content, contributed by a variety of experts, educators, and instructors in a specific field, and aggregated into a central repository, such as a web site. What made this content set especially unique is that it could be “remixed” — the materials were not necessarily designed to go together but became associated with each other through the MOOC. A key component of the original vision is that all course materials and the course itself were open source and free — with the door left open for a fee if a participant taking the course wanted university credit to be transcribed for the work. Since those early days, interest in MOOCs has evolved at an unprecedented pace, fueled by the attention given to high profile entrants like Coursera, Udacity, and edX in the popular press. In these new examples, “open” does not necessarily refer to open content or even open access, but only equates to “no charge.” Ultimately, many challenges remain to be resolved in supporting learning at scale. The most compelling aspect of the proliferation of MOOCs is that it is helping frame important discussions about online learning that simply could not have taken place before the advent of actual experiments in learning at scale.

### Overview

The term “massively open online course” was hardly a thought bubble during the discussions for the *NMC Horizon Report: 2012 Higher Education Edition*. Over the

past year, MOOCs have gained public awareness with a ferocity not seen in some time. World-renowned universities, including MIT (edX) and Stanford (Coursera), as well as innovative start-ups such as Udacity jumped into the marketplace with huge splashes, and have garnered a tremendous amount of attention — and imitation. Designed to provide high quality, online learning at scale to people regardless of their location or educational background, MOOCs have been met with enthusiasm because of their potential to reach a previously unimaginable number of learners. The notion of thousands and even tens of thousands of students participating in a single course, working at their own pace, relying on their own style of learning, and assessing each other’s progress has changed the landscape of online learning.

A number of respected thought leaders believe that the current manifestation of MOOCs has significantly deviated from the initial premise outlined by George Siemens and Stephen Downes in 2008, when they pioneered the first courses in Canada. They envisioned MOOCs as ecosystems of connectivism — a pedagogy in which knowledge is not a destination but an ongoing activity, fueled by the relationships people build and the deep discussions catalyzed within the MOOC. That model emphasizes knowledge production over consumption, and new knowledge generated helped to sustain and evolve the MOOC environment.

Despite these philosophical distinctions among MOOC implementations, one aspect that both early and contemporary MOOCs have in common is that they leverage a multitude of emerging pedagogies and tools, including blended learning, open educational resources, and crowd-sourced interaction. The technologies that enable the workflow of MOOCs vary in different models, but the common thread is that

these sorts of tools are readily available and easy to use. MOOCs draw upon cloud-based services such as WikiSpaces, YouTube, and Google Hangouts, among many others, to foster discussions, create and share videos, and engage in all the other activities that have become essential to teaching and learning in a modern online learning environment.

Although there are clear differences among the major MOOC projects, it is important to note that their basic pedagogical approaches are very similar. For Coursera, edX, and Udacity — the three major players in the MOOC space — course materials are located in a hub or central repository and they all use automated software to assess student performance through quizzes and homework assignments. The social structures of the major MOOC projects are also similar, with students participating in online forums, study groups, and in the

## While extremely promising, current MOOC models still largely mirror traditional lecture formats.

case of Coursera and Udacity, organized student meet-ups. Content-wise, Coursera emphasizes video, with students watching recorded lectures from field experts as the main substance of the courses. At the time of publication, Coursera had over two million students enrolled in 200 courses, while edX and Udacity have reached around 500,000 students, across 23 courses and 19 courses, respectively.

While extremely promising, current MOOC models still largely mirror traditional lecture formats. Coursera, for example, is centered around video lectures led by renowned educators from prestigious universities in popular areas such as microeconomics and artificial intelligence. Students watch these videos and demonstrate what they have learned via quizzes and papers. Although the quality of the video and related content provided is high, this delivery model is very much based in traditional models of instruction, and does not include the notions of openness and

connectivism outlined by Siemens and Downes. Indeed, the content on each of the major sites is not “open,” as pervasive copyright notices make clear.

As massively open online courses continue their high-speed trajectory in the near-term horizon, there is a great need for reflection that includes frank discussions about what a sustainable, successful model looks like. Some experts believe that the pace at which MOOCs are developing is too rapid for genuine analysis; others maintain that they are not as disruptive of a technology as initially touted. Time will settle those questions, but there is no doubt that MOOCs have already had a significant influence on the future course of online learning, and deserve close attention, study, and continued experimentation.

### Relevance for Teaching, Learning, or Creative Inquiry

“Free” has played a major role in the rise of massively open online courses, though institutions are brainstorming ways to monetize them, such as charging for special certifications. Last year, the Federal Reserve Bank of New York reported that Americans owe over \$900 billion in student loans, yet 40% of students enrolled at four-year universities do not get their degree in under six years. Furthermore, there is a growing chorus of students expressing frustration about what they are actually getting — and not getting — out of higher education for their money.

In many current models, massively open online courses present opportunities for learners to freely experiment with a variety of subjects and acquire new skills that may not be associated with a degree plan at brick-and-mortar institutions. An English major, for example, could enroll in an edX course on the foundations of computer graphics or circuits and electronics. In other words, learners are not stuck on a single pathway.

Related advances in both classroom and online learning are emphasizing personalized learning, and if massively open online courses could both scale globally and yet cater to individual learning styles, it would be a very exciting combination. In their current forms, MOOCs already allow learners of all ages, incomes, and levels



of education to participate in a wide array of courses without being enrolled at a physical institution. The most effective MOOCs make creative use of a variety of educational strategies and frequently leverage multimedia to demonstrate complex subjects. One recent entrant in Spain, unX, has integrated badges as a way to reward learners for their participation and concept mastery.

As MOOC projects proliferate, the hope is that they will invent new innovative and informal ways for learners to demonstrate their knowledge at scale. Peer review systems, student gurus, badges, and other forms of assessment are currently being explored, but there is no real verdict yet on what is most effective. To continue to gain traction, MOOCs will need to strike a fine balance between automating the assessment process while delivering personalized, authentic learning opportunities.

A sampling of applications of massively open online courses across disciplines includes the following:

- > **Music.** In the spring of 2013, Indiana University-Purdue University Indianapolis and the Purdue University Department of Music and Arts Technology will offer a new MOOC, “Music for the Listener,” that can be converted into credit. The six-week course covers the music of western civilization from 600 AD to the present. The learning environment is being delivered through Course Networking, with full translation features, rich media, and social networking tools: [go.nmc.org/theen](http://go.nmc.org/theen).
- > **Physics.** A MOOC called “Landmarks in Physics” delivered through Udacity was created by an MIT graduate who filmed in Italy, the Netherlands, and England to create a virtual tour that explains the basic concepts of physics at the sites of important discoveries in our history: [go.nmc.org/phy](http://go.nmc.org/phy).
- > **Writing and Composition.** The Gates Foundation awarded a grant to Ohio State University to design a MOOC for Coursera. This course will engage participants as writers, reviewers, and editors in a series of interactive reading, composing, and research activities with assignments designed to help them

become more effective consumers and producers of alphabetic, visual, and multimodal texts. OSU faculty members have developed the Writers Exchange, an idea-networking website to support the course: [go.nmc.org/osu](http://go.nmc.org/osu).

## Massively Open Online Courses in Practice

The following links provide examples of massively open online courses in use in higher education settings:

### Caltech’s Learning from Data

[go.nmc.org/caltech](http://go.nmc.org/caltech)

The California Institute of Technology piloted the “Learning from Data” MOOC in April 2012. The first offering included live streaming and real-time Q&A sessions with the participants, along with automated grading and discussion forums. Since then, it has been offered four times, with over 100,000 enrolled students.

### Games MOOC

[go.nmc.org/gamesmoooc](http://go.nmc.org/gamesmoooc)

The Games MOOC is a community site woven around a series of three courses about the use of games in education, including traditional games, massively multiplayer online role-playing games, game-based learning, and immersive environments. The first courses were piloted in the fall of 2012.

### Google’s Open Course Builder

[go.nmc.org/googco](http://go.nmc.org/googco)

Google created an open course builder and its first massive open online course, “Power Searching with Google.” It drew 150,000 students, and helped sharpen their Internet search skills.

### Open Course for Educators (Career and Technical Education 230: Instructional Technology)

[go.nmc.org/opecoo](http://go.nmc.org/opecoo)

This Maricopa Community Colleges’ course stems from a National Science Foundation-funded project to increase the ability of STEM teachers to collaboratively learn and apply STEM skills using information and communication technology. Participating educators acquire knowledge and skills using Canvas and 3D Game Lab learning management systems, and Google+ Community.

### UMW's Digital Storytelling 106

[go.nmc.org/ds106](http://go.nmc.org/ds106)

Anyone can take this online digital storytelling course at University of Mary Washington (UMW), one of the few that adhere to the original connectivist notion of a massive online course, but only students registered at the university can receive credit. For the past couple years, it has also been taught at several other institutions. UMW is currently exploring how to give credit to other state college students as well as incoming high school students.

### unX

[go.nmc.org/csevunx](http://go.nmc.org/csevunx)

The Centro Superior para la Enseñanza Virtual is encouraging MOOC enrollment to Latin American communities through a Spanish platform called unX. The model includes many interactive features along with a digital badging system.

### For Further Reading

The following articles and resources are recommended for those who wish to learn more about massively open online courses:

#### College Is Dead. Long Live College!

[go.nmc.org/ylazv](http://go.nmc.org/ylazv)

(Amanda Ripley, *TIME*, 18 October 2012.) When the Pakistani government shut down access to YouTube in September 2012, an 11-year old girl connected with U.S. students and found a solution to continue her online studies using Udacity.

#### How 'Open' Are MOOCs?

[go.nmc.org/ope](http://go.nmc.org/ope)

(Steve Kolowich, *Inside Higher Ed*, 8 November 2012.) This article explores several misunderstandings in the way many chief academic officers view massively open online courses and their potential to supplement traditional university classes.

#### Jump Off the Coursera Bandwagon

[go.nmc.org/cou](http://go.nmc.org/cou)

(Doug Guthrie, *The Chronicle of Higher Education*, 17 December 2012.) This author observes that as universities rush to deliver online education, they may

be too quick to launch insufficient models. As a result, many MOOCs are not addressing critical pedagogical issues, in addition to interactivity and customization.

### MOOCs and Money

[go.nmc.org/money](http://go.nmc.org/money)

(Matt Greenfield, *Education Week*, 1 October 2012.) MOOCs have some possible monetizing strategies that can work as long as they continue to attract millions of students. The author argues that many current students are attracted to MOOCs out of curiosity, and ponders whether enrollment numbers will continue to be high over the next few years.

### The Single Most Important Experiment in Higher Education

[go.nmc.org/single](http://go.nmc.org/single)

(Jordan Weissmann, *The Atlantic*, 18 July 2012.) This article discusses Coursera's new partnerships with several other universities. One school, the University of Washington, is giving credit for its Coursera courses. The funding from all these new universities will allow the company to blossom as a market for learning.

### xED Book

[go.nmc.org/xed](http://go.nmc.org/xed)

(Dave Cormier, George Siemens, and Bonnie Stewart, Accessed 2 January 2013.) George Siemens and two education researchers are writing a book that will discuss how the Internet is restructuring knowledge and the implications for MOOCs. They are currently chronicling their ideas on this site.

### The Year of the MOOC

[go.nmc.org/moo](http://go.nmc.org/moo)

(Laura Pappano, *The New York Times*, 2 November 2012.) Over the past year, MOOC development has become a major trend. This article examines the current higher education institutions and organizations offering MOOCs, discussing their strategies and the challenges each are facing.



# Tablet Computing

## Time-to-Adoption Horizon: One Year or Less

*In the past two years, advances in tablets have captured the imagination of educators around the world. This category is led by the incredible success of the iPad, which at the time of publication had sold more than 85 million units and is predicted by GigaOM to sell over 377 million units by 2016. Other similar devices such as the Samsung Galaxy Nexus, Kindle Fire, the Nook, Sony's Tablet S, and the Microsoft Surface have also entered this rapidly growing market. In the process, the tablet (a device that does not require a mouse or keyboard) has come to be viewed as a new technology in its own right, one that blends features of laptops, smartphones, and earlier tablet computers with always-connected Internet and thousands of apps with which to personalize the experience. As these new devices have become more used and understood, it has become even clearer that they are independent and distinct from other mobile devices such as smartphones, e-readers, or tablet PCs. With significantly larger screens and richer gesture-based interfaces than their smartphone predecessors — and a growing and ever more competitive market — they are ideal tools for sharing content, videos, images, and presentations because they are easy for anyone to use, visually compelling, and highly portable. Tablets have gained traction in education because users can seamlessly load sets of apps and content of their choosing, making the tablet itself a portable personalized learning environment.*

### Overview

When the Apple iPad was released in 2010, a new category of mobile device was born, distinct from smartphones, ultra-small laptops, e-readers, and other kinds of portable devices. Suddenly people had the ability to download and read books, watch videos, learn foreign languages, and much more — all through a large, high-resolution touchscreen that made the

experience convenient, vibrant, and shareable. On these always-connected devices, several people could sit down together and easily watch the same movie and study the same images.

Tablet computing continues to capture the immediate focus of technology adopters, as it has for the past year. In the early months of 2012, the category was new, and the focus was on the early entrant, the iPad, as there were no viable competitors in the marketplace yet. Now

**Tablets have gained traction in education because users can seamlessly load sets of apps and content of their choosing, making the tablet itself a portable personalized learning environment.**

the tablet market is very different, with a wide range of solid alternatives, operating systems, and form factors, and there is real competition in the market for the first time.

According to a recent report from the web analytics firm, Chitika, Internet traffic from the iPad dropped over 7% in late December 2012 ([go.nmc.org/chiki](http://go.nmc.org/chiki)) from its share of 86% of all tablet traffic. This decline is the result of emergent new competitors in the tablet scene, including the Kindle Fire, Samsung Galaxy, Google Nexus, and the Microsoft Surface — all of which enjoyed increased web traffic shares at the end of the year. Nexus traffic saw a 135% increase in July 2012

alone. Consumers now have a growing array of choices in the tablet market, though the iPad still sets the pace for the category, and continues to hold its solid position at the top.

Mobile apps continue to push the capabilities of these devices, and hundreds of thousands of specialized apps are available to extend the functionality of tablets, integrating features including location awareness, network connections, and other built-in sensors, such as accelerometers. The larger screen real estate allows for more detailed interfaces or viewing area than smartphones. Apps range from games to banking services that allow users to check their credit card balances to science and art apps that enable users to

## It is increasingly clear that tablets are not a new kind of lightweight laptop, but rather a completely new technology.

explore outer space, the Louvre, and many other places that they may not ever get to see in person in their lifetimes. It is this transformative nature of apps that has helped tablets become popular and powerful tools in higher education.

Extremely portable, tablets have become significant distribution points for magazines and e-books, with major retailers including Amazon revealing that their e-books outperform their print books. In December 2012, *Newsweek* ended 80 years as a print publication, and went completely digital, largely as a result of the compelling experience that tablet devices bring to the magazine and periodical market.

Screen resolution in tablets improved significantly in the last year, and ultra-high resolution displays such as Apple's Retina Display and Nexus' high-resolution display are more common. As a result, any app using rich media has benefited. High-definition video is the norm, and video providers have stepped up with myriad

ways to access live and archived video content. Real-time two-way video calls, pioneered with FaceTime, are now common. Cameras have added capabilities, sharper images, and higher resolution — and social media enhancements have made sharing video and pictures very simple. Fast, easy email, web browsers, and rich, full-featured game platforms are all everyday tools on the new devices. It is increasingly clear that tablets are not a new kind of lightweight laptop, but rather a completely new technology.

### Relevance for Teaching, Learning, or Creative Inquiry

The rising popularity of tablets in higher education is partly the product of campuses across the world embracing the BYOD (bring your own device) movement. It is so easy for students to carry tablets from class to class, using them to seamlessly access their textbooks and other course materials as needed, that schools and universities are rethinking the need for computer labs, or even personal laptops. A student's choice of apps for his or her tablet makes it easy to build a personalized learning environment, with all the resources, tools, and other materials they need on a single device, and with most tablets, the Internet is woven into almost every aspect of it.

Productivity apps, including Cheddar, TagMyDoc, Dropbox and many more ([go.nmc.org/wiwip](http://go.nmc.org/wiwip)) enable learners to take and share notes, create to-do lists, store all of their files, and organize their academic schedules. The advent of services such as iBooks Author is also helping universities formulate strategies for textbooks and reading assignments. The Learning Studio at Abilene Christian University, for example, worked with key faculty to develop prototypes of learning resources in iBooks Author. The process helped identify strategic opportunities in multi-touch books as next-generation textbooks ([go.nmc.org/aculs](http://go.nmc.org/aculs)).

In higher education, it is now a bit of an anomaly for a university to be without its own branded tablet app that integrates features like campus maps, access to grades, university news, and more. Having an app in the iTunes and Android marketplace has become essential to the recruiting process, to better orient students

to their surroundings, and alert them to campus opportunities. Some universities, such as Missouri State, have incorporated their iTunes U catalogs in the app, making it easy to download video lectures and other course materials on-the-go. As tablets face imminent widespread adoption, higher education institutions are equipping students with the skills to develop content for them. Carnegie Mellon University, for example, now offers a course on the art of iPad programming ([go.nmc.org/icmu](http://go.nmc.org/icmu)).

Mobile apps are also tightly integrated with social networks, making tablets effective tools for collaborating and sharing. Many note-taking and annotation apps enable users to immediately email content to peers or post insights to their social networks. Students who use Evernote, for example, can share digital notebooks and see each other's text, picture, or video updates in real-time ([go.nmc.org/ever](http://go.nmc.org/ever)). An increasing number of educators are also turning to Edmodo's app ([go.nmc.org/edmodo](http://go.nmc.org/edmodo)) to communicate with students about assignments and schedule updates.

Because of their portability, large display, and touchscreen, tablets are also ideal devices for fieldwork. Many institutions are relying on handheld computers in place of cumbersome laboratory equipment, video equipment, and various other expensive tools that are not nearly as portable or as inexpensive to replace. At the College of Wooster in Ohio, geology students are using iPads to take and annotate photos of Icelandic terrain ([go.nmc.org/woost](http://go.nmc.org/woost)), and similarly, earth science students at Redlands College in Australia are using them to collect and share data on indigenous rocks ([go.nmc.org/redla](http://go.nmc.org/redla)). In these scenarios, the immediate access to recording and analytical tools enables direct and active learning in the field.

In the past two years, more colleges and universities have launched one-to-one pilot programs in which they have provided every student on campus (or those enrolled in a specific program) with their own tablet. Each tablet comes pre-loaded with course materials, digital textbooks, and other helpful resources. The Geisel School of Medicine at Dartmouth College, for example, has adopted this type of program with iPads

and is sharing their findings and resources as they go, via a special website ([go.nmc.org/geisel](http://go.nmc.org/geisel)).

Where one-to-one learning is not yet possible, many institutions, including the Community College of Aurora in Colorado, the University of Richmond, and the University of South Carolina, have also made tablets available via check-out systems to students who may not have one, in which students can borrow tablets to do coursework that is specifically designed to be completed with the devices.

With their growing number of features, tablets give traction to other educational technologies — from facilitating the real-time data mining needed to support learning analytics to offering a plethora of game-based learning apps. Transitioning to tablets is relatively painless for students as they already use them or very similar devices outside of the classroom to download apps, connect to their social networks, and surf the web. To maximize the potential of tablets in higher education, faculty members are also exploring creative ways to incorporate them into coursework.

A sampling of tablet computing applications across disciplines includes the following:

- > **Art.** At Plymouth University in the UK, students working toward their Illustration degree are using the iPad and an illustration app called Brushes to produce drawings that can be played back as video. This activity is encouraging reflection and discussion on the drawing process and enabling students to contrast technique and highlight and correct any bad habits: [go.nmc.org/ipa](http://go.nmc.org/ipa).
- > **Biology.** In a pilot program at Yale University's Department of Molecular, Cellular, and Developmental Biology, instructors are sharing images from their digital microscopes with students' iPads through a mobile app. By connecting microscope with tablet, students are able to annotate images and capture them for future use: [go.nmc.org/yavis](http://go.nmc.org/yavis).
- > **Journalism and Mass Communications.** Professor Messner at Virginia Commonwealth University

secured iPads for his students so they could create multimedia news stories from happenings on the campus and surrounding community. The students learned the importance of social media in journalism and found the iPad useful for gathering news and sources: [go.nmc.org/jou](http://go.nmc.org/jou).

- > **Special Needs.** Vanderbilt University graduate students are designing an Android app that enables visually impaired students to learn math. Using haptic technology integrated into new touchscreen devices, the vibrations and audio feedback help students feel and hear shapes and diagrams: [go.nmc.org/hapt](http://go.nmc.org/hapt).

## Tablet Computing in Practice

The following links provide examples of tablet computing in use in higher education settings:

### Chinese Language Classes Experiment with iPads

[go.nmc.org/chilang](http://go.nmc.org/chilang)

Students studying introductory Chinese at Northwestern University are supplementing their course material with iPad apps, which are enabling them to look up word definitions and hear their own pronunciations juxtaposed with those of native speakers, as well as help them learn how to correctly write characters by tracing the order of strokes directly on the device.

### MobiLearn

[go.nmc.org/mobilearn](http://go.nmc.org/mobilearn)

At HAMK University of Applied Sciences in Finland educators initiated the MobiLearn project to develop creative ways for integrating mobile devices into the curriculum. They are currently piloting Samsung Galaxy tablets and have cited that the devices work well for creating and sharing documents.

### Samsung Galaxy Tablets at Lavington Primary School

[go.nmc.org/lavington](http://go.nmc.org/lavington)

Samsung is piloting a program called “Smart School” at Lavington Primary School in Africa in which classrooms are equipped with Galaxy Tablets. So far, teachers have noted that the devices have made learning experiences more personalized and interactive.

### Seton Hall University and Samsung Windows 8 Tablet

[go.nmc.org/epir](http://go.nmc.org/epir)

Seton Hall University recently became the first university in the US to adopt Windows 8 PC tablets. By having a combination of tablet mobility with the functionality of a computer, the university believes they are enabling quicker access to information, deeper engagement, and greater flexibility.

### Stanford University's iPad Implementation

[go.nmc.org/suin](http://go.nmc.org/suin)

The Stanford University School of Medicine distributed iPads to incoming students and studied their use in classrooms and laboratories. They found the tablets were favored over laptops for note taking and especially effective in quickly accessing reference materials and educating patients in clinical settings.

### Tablets at Amrita University

[go.nmc.org/amrita](http://go.nmc.org/amrita)

Amrita University students and teachers are using a \$35 tablet called Aakash — a low-cost alternative to other mobile devices. Their ongoing research is focused on developing responsive UI-based content for tablets that integrates with their formative assessment process and e-learning environments.

### UWS Deploys iPads to Support IT-Enhanced Learning

[go.nmc.org/uwsip](http://go.nmc.org/uwsip)

The University of Western Sydney (UWS) announced that 11,000 incoming students and staff members would be receiving iPads as part of a comprehensive curriculum renewal strategy. UWS is moving to a blended learning environment for all degrees beginning in 2013 and believes tablets are an important tool to support this new learning and teaching model.

## For Further Reading

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

### Given Tablets but No Teachers, Ethiopian Children Teach Themselves

[go.nmc.org/eth](http://go.nmc.org/eth)

(David Talbot, *Forbes*, 29 October 2012.) Kids in two remote Ethiopian villages responded with surprising



aptitude when tablet computers were dropped off, all boxed up, with no instruction as to how they worked. The children quickly taught themselves to use the devices and were soon even hacking settings to personalize the devices.

### **Google Wages War with Apple and the Rest of the Tablet Industry, Unleashes Impressive Nexus 7+ Mobile**

[go.nmc.org/warapp](http://go.nmc.org/warapp)

(Drew Olanoff, *TechCrunch*, 13 November 2012.) The author of this article reviews the recent mobile upgrade of the Google tablet line from Nexus and claims that Apple now has serious competition in the tablet market. Notable differences are the device's voice command feature, Google Now, and advanced mapping technology of Google Maps.

### **How a Classroom of iPads Changed My Approach to Learning**

[go.nmc.org/redu](http://go.nmc.org/redu)

(Chris Blundell, *Edudemic*, 3 October 2012.) One-to-one deployment of iPads at Redlands College has abandoned the computing model of labs and laptop trolleys, creating a paradigm shift where students can learn anywhere and at anytime. The college's IT staff reported that this new approach has been saving them time and effort managing software because of the ease of installation and maintenance.

### **Tablets are Changing the Tech You Use, Whether You Own One or Not**

[go.nmc.org/tabchan](http://go.nmc.org/tabchan)

(Louie Herr, *Digital Trends*, 9 September 2012.) The author of this article argues that the release of tablets into the market has disrupted software and hardware trends. He explains the decline of netbooks and flash and the subsequent rise of HTML5 and cloud storage as the indicators of how tablets are shaping the way we engage with computer technology.

### **Teaching with Tablets**

[go.nmc.org/teachw](http://go.nmc.org/teachw)

(Staff Writers, *Online Universities*, 21 August 2012.) This infographic shows the distribution of tablet ownership across multiple platforms, each device's specific

features, and owners' opinions of their effectiveness in educational settings. It further explains the tablet's relevance for college students and quantifies Apple's current impact on education.

### **Why Tablets are the Future of Electronic Medical Records**

[go.nmc.org/emr](http://go.nmc.org/emr)

(Richard MacManus, *readwrite*, 27 September 2012.) Tablets equipped with Electronic Medical Records (EMR) mobile applications are enabling more efficient interactions between physicians and patients. The study of small to medium size practices, conducted by EMR vendor drchrono, found that over 60 minutes per day were saved using iPad-equipped EMRs.



## Games and Gamification

### Time-to-Adoption Horizon: Two to Three Years

**T**he gamer culture is growing to include a substantial sector of the world's population, with the age of the average gamer lowering each passing year. A 2012 survey conducted by the Entertainment Software Association showed that the age demographic of game players in the U.S. is split in almost equal thirds with people ages 18-35 representing 31% of gamers. As tablets and smartphones have proliferated, desktop and laptop computers, television sets, and game consoles are no longer the only way to connect with competitors online, making game-play a portable activity that can happen in a diverse array of settings. Game play has traversed the realm of recreation and has infiltrated the worlds of commerce, productivity, and education, proving to be a useful training and motivation tool. While a growing number of educational institutions and programs are experimenting with game-play, there has also been increased attention surrounding gamification — the integration of game elements, mechanics, and frameworks into non-game situations and scenarios. Businesses have largely embraced gamification to design work incentive programs and mobile apps that engage employees through rewards, leader boards, and badges. Although still in its nascent stages, the gamification of education is gaining further support among researchers and educators who recognize that games stimulate productivity and creative inquiry among learners.

#### Overview

The popularity of digital games has led to rapid development in the video game industry, facilitating innovations that have broadened the definition of games and how they are played. In the past, game-play could only be conducted via game consoles and desktop computers, while the number of competitors depended on the number of controllers or people

physically present. When the games industry began to incorporate network connectivity into game design, they revolutionized game-play by creating a vast virtual arena, where users from all over the world could connect, interact, and compete.

The Internet offers gamers the opportunity to join massively multiplayer online (MMO) role-player games, such as “World of Warcraft,” and to build online reputations based on the skills, accomplishments, and abilities of their virtual avatars. Whatever the scenario, online games enables strangers to build camaraderie and social networks in mere minutes, and to compete in a public forum where recognition is highly desirable.

Advancements in mobile technology further expand opportunities for game-play, allowing participants to engage any time from any place. Anyone who owns a smartphone or tablet can become a gamer. Free mobile games abound, and the most popular have become widely used outlets for social interaction and connecting family and friends, such as “Words with Friends” — a modern take on Scrabble. Social networking features of mobile games support the prevalence of game play in a culture that is increasingly concerned with staying in touch and being connected all of the time; in this sense, the appeal of online games is not just about who is playing, but who in one's personal network is playing — and winning.

Gamification, or the notion that game mechanics can be applied to all manner of productive activities, has been employed successfully by a number of mobile app and social media companies; one of the most well known is Foursquare — its reward system encourages people to check into locations and accumulate points. Ultimately the goal is to collect enough points to be recognized through badges like “Super User,” “Local,” and “Mayor,”

which are public-facing distinctions that can be posted on social networking sites, such as Facebook. Users of Foursquare also benefit from tangible rewards, including free goods and perks from frequented establishments. The notion of incentivizing users is nothing new; reward programs were initially implemented by the airline and hospitality industries, and continue to be huge draws that attract and retain consumers.

It is not uncommon now for major corporations and organizations, including the World Bank and IBM, to consult with game experts to inform the development and design of large-scale programs that motivate workers through systems that incorporate challenges, level-ups, and rewards. While some thought leaders argue that the increasing use of game design in the workplace is a short-lived trend that yields short-term bursts of productivity, companies of all sizes in all sectors are finding that workers respond positively to gamified processes. Game-like environments transform tasks into challenges, reward people for dedication and efficiency, and offer a space for leaders to naturally emerge, which lends itself to myriad applications in higher education.

### **Relevance for Teaching, Learning, or Creative Inquiry**

This year, game play in the sphere of education is being viewed through a new lens. Referred to as Game-Based Learning in previous editions of the *NMC Horizon Report*, this field of practice has expanded far beyond integrating digital and online games into the curriculum. The updated reference, *Games and Gamification*, reflects the perspective that while games are effective tools for scaffolding concepts and simulating real world experiences, it should also include the larger canvas of gamer culture and game design.

Research has long indicated that video games help stimulate the production of dopamine, a chemical that provokes learning by reinforcing neuronal connections and communications. Furthermore, educational game-play has proven to increase soft skills in learners, such as critical thinking, creative problem-solving, and teamwork. This idea is the basis of the relationship between games and education. By exploring the way people engage with games — their behaviors,

mindsets, and motivations — researchers are getting better at designing adaptive games and effective game frameworks that transform learning experiences.

In the context of higher education, when students are expected to think critically in order to solve problems, game-like simulations can be leveraged in any discipline to reinforce the real world applications of concepts. At the IE Business School in Madrid, for example, students are learning the complexities of global economic policy through a game called “10 Downing Street” ([go.nmc.org/street](http://go.nmc.org/street)). In this simulation, students take on the role of the British prime minister and work with key figures including Paul Krugman, Margaret Thatcher, and Milton Friedman to come to an agreement that will affect the

## **Game play has traversed the realm of recreation and has infiltrated the worlds of commerce, productivity, and education, proving to be a useful training and motivation tool.**

well being of the national economy. In teams of six, students engage in debates to determine the most viable policy option, which is then put into practice after a general election. Scenarios like this one demonstrate the power of games to mimic pressing issues, requiring students to do higher-level thinking and exercise skills pertinent to their area of study.

Another feature of games universities are experimenting with is badging, a system of recognition that allows students to accumulate documentation of their skills, achievements, qualities, and interests in a visual public-facing format. Launched in September 2011, Mozilla Foundation's Open Badges project ([go.nmc.org/badges](http://go.nmc.org/badges)) is a free online platform for designing and collecting badges in portfolios that can be viewed by peers, professors, and potential employers. Mozilla's Open Badges has sparked considerable discussion about how to recognize informal learning experiences, especially

those that cannot typically be conveyed through credit hours or grade point average.

Advocates of open badging systems point to the egalitarian quality of a system where the rules are clear and the platform's ability to explain much more in the way of accomplishments and goals than a college transcript. Purdue University has developed two mobile apps, Passport and Passport Profile ([go.nmc.org/passport](http://go.nmc.org/passport)), that integrate the Mozilla Open Infrastructure software ([go.nmc.org/zonbp](http://go.nmc.org/zonbp)). The badging system was adopted by Purdue in order to identify skills that are not represented by a student's degree, and to provide educators with another outlet to recognize student accomplishment and concept mastery.

As game play continues to be a major focal point of discussions among educators, some believe that gamified learning is merely a trend, and carries the danger of immediately disenchanting students if executed poorly. To negate this challenge, more universities are partnering with organizations and companies skilled in game design to develop and integrate games that are relevant to the curriculum and to students' lives. Games and gamification in education include a broad set of approaches to teaching and learning, and when implemented effectively, can help with new skill acquisition while boosting motivation to learn.

A sampling of applications of games and gamification across disciplines includes the following:

- > **Architecture.** SimArchitect is a simulation game and social connection site for architects, developed by IBM Center For Advanced Learning. Players are issued a request for proposal by a fictitious client and must respond, conducting meetings with the client and team and then proposing a solution. IBM created a performance scorecard that evaluates the player's communication with the client, architectural methods, and more: [go.nmc.org/ibm](http://go.nmc.org/ibm).
- > **History.** The Historical Williamsburg Living Narrative project at the University of Florida is an effort to create an interactive fictional game in which the geography, culture, and characters of early Williamsburg, Virginia

will be brought to life. Functional maps show the early architecture of historic buildings, and interactive scenarios with characters like George Washington and Patrick Henry allow students to participate in discussions of the times: [go.nmc.org/wil](http://go.nmc.org/wil).

- > **Nursing.** The University of Minnesota's School of Nursing has partnered with the Minnesota Hospital Association and a technology company, VitalSims, to develop web-based interactive games that engage nursing students with real-life scenarios. With initial versions of the game already completed, health care educators are looking forward to implementing these digital learning tools in 2013: [go.nmc.org/serious](http://go.nmc.org/serious).

## Games and Gamification in Practice

The following links provide examples of games and gamification in use in higher education settings:

### Global Social Problems

[go.nmc.org/cjqog](http://go.nmc.org/cjqog)

The Global Social Problems, Local Action & Social Networks for Change project at St. Edward's University positioned learners in the role of superheroes to tackle large-scale global social problems at local levels.

### HML-IQ

[go.nmc.org/fre](http://go.nmc.org/fre)

At the Henry Madden Library at California State University, Fresno, students play a game that is built into Blackboard called HML-IQ to orient themselves with the available library resources and how to use them. Top scorers are awarded gift cards to the library's coffee shop upon completing each level. The games were created with open source tools including Snagit.

### Open Orchestra

[go.nmc.org/canar](http://go.nmc.org/canar)

McGill University's Open Orchestra simulation game uses high definition panoramic video and surround sound to provide musicians with the experience of playing in an orchestra or singing in an opera.

### Queen’s University “Exergames”

[go.nmc.org/exergame](http://go.nmc.org/exergame)

A professor at Queen’s University in Ontario, Canada is involved in a collaborative study that explores how “exergames” — or video games that require physical activity — improve the well being of teenagers afflicted with cerebral palsy.

### Social Media Innovation Quest

[go.nmc.org/sljsmi](http://go.nmc.org/sljsmi)

At the Fox School of Business at Temple University, a professor designed his social media innovation course as a quest in which students earn points for blogging and engaging in social media activities. They are awarded badges, and those that excel earn a place on the leader board.

### The University of Bahia’s Games and Education

[go.nmc.org/gamesa](http://go.nmc.org/gamesa)

The University of Bahia’s Games and Education initiative, based in the Brazilian state of Bahia, supports collaborative, scholarly research along with publications about educational games. One of their missions is to aid in developing games that simulate teaching scenarios.

### University of Washington Business Simulations

[go.nmc.org/fsb](http://go.nmc.org/fsb)

The Foster School of Business at the University of Washington partnered with game developer Novel Inc. to take real, complex scenarios from major companies, including Starbucks and Nike, and turn them into enterprise simulation games.

## For Further Reading

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

### Game Based vs. Traditional Learning — What’s the Difference?

[go.nmc.org/xwidb](http://go.nmc.org/xwidb)

(Justin Marquis, *Online Universities*, 16 August 2012.) Taking a deeper look at gamification and its potential outcomes raises concerns for some. Authenticity,

student engagement, creativity, and innovation are all areas that are addressed in this article.

### Gamification in Education: What, How, Why Bother?

[go.nmc.org/ykgum](http://go.nmc.org/ykgum)

(Joey J. Lee and Jessica Hammer, *Academic Exchange Quarterly*, 2011.) Educators at the Teachers College at Columbia University outline the fundamentals of gamification and explain how game mechanics and frameworks can increase the motivation to learn. They also point out the challenges and risks that may arise when implementing a gamified model.

### Motivating Students and the Gamification of Learning

[go.nmc.org/gamhie](http://go.nmc.org/gamhie)

(Shantanu Sinha, *The Huffington Post*, 14 February 2012.) The president of the Khan Academy explores effective ways to integrate game mechanics into education, and makes the case that games help learners by providing them with real-time feedback that they may otherwise not receive.

### Taking a Cue from Video Games, a New Idea for Therapy

[go.nmc.org/taking](http://go.nmc.org/taking)

(Hayley Tsukayama, *The Washington Post*, 17 October 2012.) Games could play a positive role in supporting war veterans by providing positive, practical goals. This has implications for many higher education areas of study, including psychology.

### Where Does Gamification Fit in Higher Education?

[go.nmc.org/uvedg](http://go.nmc.org/uvedg)

(Jimmy Daly, *EdTech Magazine*, 30 November 2012.) This article covers the foundational ideas of gamification and outlines the elements of games that have been leveraged to engage students. It also includes a detailed infographic based on research conducted by the MIT Education Arcade.



# Learning Analytics

## Time-to-Adoption Horizon: Two to Three Years

**L**earning analytics, in many ways, is “big data,” applied to education. The term owes its beginnings to data mining efforts in the commercial sector that used analysis of consumer activities to identify consumer trends. The rise of the Internet triggered a huge transformation in the field of market research and metrics as web tracking tools (web analytics) enabled companies to keep track of customers and their purchases. With the avalanche of data derived from consumers, businesses began to seek out analysts who could decipher meaning from gigantic sets of data and develop models and predictions about consumer behavior to support marketing strategies. Similarly, educational institutions are embarking on their own explorations of the science of large data sets, with the aim of improving student retention and providing a higher quality, personalized experience for learners.

### Overview

Learning analytics is an emergent field of research that aspires to use data analysis to inform decisions made on every tier of the educational system. Whereas analysts in business use consumer-related data to target potential customers and thus personalize advertising, learning analytics leverages student-related data to build better pedagogies, target at-risk student populations, and to assess whether programs designed to improve retention have been effective and should be sustained — important outcomes for administrators, policy makers, and legislators. For educators and researchers, learning analytics has been crucial to gaining insights about student interaction with online texts and courseware. Students are also benefitting from the deliverables of learning analytics, through the development of mobile software and online platforms that use student-specific data to tailor support systems that suit their learning needs.

Positioned in the same two-to-three year adoption timeframe as it was last year, learning analytics continues to be an emerging field, one that is growing quickly, but is still just out of reach for most educators. This year, the rise of big data was the subject of discussions across many campuses, and educational data scientists all over the world are beginning to look at vast sets of data through analytical methods pioneered by businesses to predict consumer behaviors. In the same way that Amazon, Netflix, and Google use these metrics to tailor recommendations and advertisements to individuals, educators and researchers involved in learning analytics envision being able to tailor learning to students’ personal needs and interests — relying on data to make carefully calculated adjustments and suggestions to keep learners motivated as they master concepts or encounter stumbling blocks.

The promise of learning analytics is actionable data relevant to every tier of the educational system. Conclusions based on analyses of these data sets will have meaningful implications for administrative and governing bodies as they indicate areas for improvement, allocate resources to targeted issues, and finally, as they assess the effectiveness of their programs in order to support ongoing efforts.

A key outcome of learning analytics pertains to the student on an individual level, and his or her path in higher education. Administrative databases and online course systems are beginning to offer academic advisors a window into the experience of students, identifying both their strengths and areas of improvement. At Austin Peay State University in Tennessee, university advisors use the Degree Compass, software that employs predictive analytic techniques, to help students decide which courses they will need to complete their degree along with courses in which they



are likely to be successful ([go.nmc.org/apsu](http://go.nmc.org/apsu)). With these insights, advisors and counselors hope to illuminate a student's best learning path.

Learning analytics is envisioned as an effective, efficient way to assess student responses, provide immediate feedback, and make adjustments in content delivery and format. Those invested in the field of learning analytics see its potential to foster personalized learning environments that adapt to the learning behaviors of students.

### **Relevance for Teaching, Learning, or Creative Inquiry**

As higher education institutions adopt hybrid approaches to teaching, learning is happening more and more within online environments and platforms. Sophisticated web tracking tools within these settings already can track precise student behaviors, recording variables such as number of clicks and time spent on a page, and increasingly more nuanced information such as resilience and retention of concepts. Inclusion of behavior-specific data adds to an ever-growing repository of student-related information, making the analysis of educational data increasingly complex. One of the most promising payoffs of this data is its potential to inform the design of instructional software and adaptive learning environments that respond to a student's progress in real-time, fostering more engagement in course material.

One of the earlier applications of learning analytics by a university was Purdue University's Signals project, which was launched in 2007. Project Signals incorporates data from student information systems, course management systems, and course grade books to generate risk levels so that at-risk students can be targeted for outreach. Efforts to use student data to personalize education have been made by Saddleback Community College in Orange County with their Service-Oriented Higher Education Recommendation Personalization Assistant, or SHERPA, system. This software compiles detailed profiles of each student, recording information about work schedules, experiences with professors, and other personal information, throughout their time at the university. The information is then analyzed to

create recommendations about time management, course selection, and other factors that contribute to a student's success in higher education.

Advancements in learning analytics have uncovered interesting applications that get to the heart of student retention and achievement by interacting with the student directly and continuously. Persistence Plus, a mobile app designed by Kauffman Labs Education Ventures ([go.nmc.org/plus](http://go.nmc.org/plus)), is rooted in behavioral science, and addresses the lack of proactive support of students on their way to graduation through a mobile platform called Small Nudges. This system leverages

## **Advancements in big data and learning analytics are furthering the development of visually explicit streams of information about any group of students or individuals, in real-time.**

mobile technology and student data to customize insights regarding a student's progress, their progress in relation to their team, and references to external resources and strategies that encourage success.

In late 2012, CourseSmart, a digital textbook provider with five partners in the textbook publishing industry, announced the launch of its analytics package, CourseSmart Analytics, which closely tracks a student's activity as they interact with online texts, and interprets that data for professors, providing them with an engagement score for a particular text. At this level, professors can use the results of CourseSmart Analytics to assess student efforts, as well as their own decisions in the selection of effective and engaging texts.

Advancements in big data and learning analytics are furthering the development of visually explicit streams of information about any group of students or individuals,

in real-time. Ideally, these digital dashboards will better inform participants on every tier of the learning system — policy makers, educators, and students. Using these dashboards, stakeholders of the institution can assess progress and develop strategies for meeting achievement goals. The United States Department of Education, for example, has its collection of data and statistics in a public-facing dashboard ([go.nmc.org/usdash](http://go.nmc.org/usdash)). There, a visitor can find charts and other visual indicators that demonstrate how far the nation has progressed toward its goal of having the highest proportion of college graduates in the world by 2020.

Although the practice of analyzing student-related data is not new, the field of learning analytics has only recently gained wide support among data scientists and education professionals. In the coming years, outcomes of learning analytics will have significant impact on the evolution and refinement of higher education, especially in the design of personalized and online learning environments.

A sampling of applications of big data and learning analytics across disciplines includes the following:

- > **Reading.** Kno, an e-textbook company, launched the “Kno Me” tool, which provides students with insights into their study habits and behaviors while using e-textbooks. Students can also better pace themselves by looking at data that shows them how much time has been spent working through specific texts, and where they are in relation to their goals: [go.nmc.org/kno](http://go.nmc.org/kno).
- > **Science and Engineering.** The University of Washington’s eScience Institute is involved in a number of projects to develop processes and tools for analyzing massive-scale datasets. They recently received crucial funding from the National Science Foundation and the National Institutes of Health to use big data to advance science and engineering research and innovation: [go.nmc.org/uwescience](http://go.nmc.org/uwescience).
- > **Writing and Composition.** In writing intensive courses, Mobius Social Learning Information Platform is used at University of North Carolina Greensboro

to facilitate anonymous peer-to-peer feedback and grading. When students submit an essay, it is automatically distributed to the rest of their randomly chosen peer group, and an algorithm turns their feedback into statistics and performance reports: [go.nmc.org/mob](http://go.nmc.org/mob).

## Learning Analytics in Practice

The following links provide examples of learning analytics in use in higher education settings:

### The Glass Classroom

[go.nmc.org/gclass](http://go.nmc.org/gclass)

Santa Monica College’s Glass Classroom initiative strives to enhance student and teacher performance through the collection and analysis of large amounts of data. Using real-time feedback, adaptive courseware adjusts based on an individual’s performance in the classroom in order to meet educational objectives.

### jPoll at Griffith University

[go.nmc.org/jpoll](http://go.nmc.org/jpoll)

jPoll is an enterprise-wide tool developed by Griffith University in Australia, directed at capturing, maintaining, and engaging students in a range of interactive teaching situations. Originally developed as a replacement for clicker-type technologies, jPoll is helping educators identify problem areas for students via learning analytics.

### Learning Analytics Seminars

[go.nmc.org/latf](http://go.nmc.org/latf)

At the University of Michigan, Provost Phil Hanlon launched the Learning Analytics Task Force (LATF), to help faculty better leverage instructional data. As part of the LATF, a series of seminars was developed to help train the faculty on current learning analytics tools and strategies for managing the growing amount of student data.

### Predictive Learning Analytics Framework

[go.nmc.org/apus](http://go.nmc.org/apus)

The American Public University System is working with Western Interstate Commission for Higher Education’s Cooperative for Educational Technologies to share a large data pool of student records across ten universities.

Their goal is for this data to inform strategies for improving student learning outcomes.

### **Stanford University's Multimodal Learning Analytics**

[go.nmc.org/multimo](http://go.nmc.org/multimo)

In partnership with the AT&T Foundation, Lemann Foundation, and National Science Foundation, Stanford is exploring new ways to assess project-based learning activities through students' gestures, words, and other expressions.

### **For Further Reading**

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

#### **Best Practices for Big Data: Learning from the Past While Looking to the Future**

[go.nmc.org/jfgio](http://go.nmc.org/jfgio)

(Tonya Balan, *Subconscious Musings*, 19 October 2012.)

The author discusses different ways to interpret big data and how to guide decisions on applications and usage based on best practices, including four core principles.

#### **Big Data on Campus**

[go.nmc.org/ifmkx](http://go.nmc.org/ifmkx)

(Marc Parry, *The New York Times*, 18 July 2012.)

Universities across the globe are increasingly using data mining software, especially for online education. This software is providing students with access to personalized courses based on their current learning need and academic record while helping professors determine which students need extra assistance.

#### **Expanding Evidence Approaches for Learning in a Digital World**

[go.nmc.org/evi](http://go.nmc.org/evi)

(U.S. Department of Education Office of Educational Technology, 21 December 2012.) A report from the U.S. Department of Education Office of Educational Technology focuses on using big data to discover how people learn, and creating learning systems that support the findings.

#### **Learning and Knowledge Analytics (PDF)**

[go.nmc.org/laknow](http://go.nmc.org/laknow)

(George Siemens and Dragan Gasevic, *Journal of Educational Technology & Society*, Vol. 15, No. 3, October 2012.) Seminal learning analytics experts George Siemens and Dragan Gasevic edited a special edition of the journal that discusses the maturation of learning analytics and its impact on teaching and learning. They also wrote a special introduction that explores the long-term trajectory of the field.

#### **The State of Learning Analytics in 2012: A Review and Future Challenges**

[go.nmc.org/kmi](http://go.nmc.org/kmi)

(Rebecca Ferguson, SocialLearn, *KMi*, March 2012) A combination of technological, educational, and political factors is impacting the state of learning analytics in education. This report discusses the challenges currently faced in educational data mining and making use of analytics.

#### **Top Ed-Tech Trends of 2012: Education Data and Learning Analytics**

[go.nmc.org/dat](http://go.nmc.org/dat)

(Audrey Watters, *Hack Education*, 9 December 2012.) In this overview of learning analytics in 2012, the author discusses the correlation of data and testing, along with the issues that arise from the current practices of learning analytics. Many of the current initiatives and analytics tools are listed, with special attention placed on models that allow students to personally construct and take ownership of their own learning data.



## 3D Printing

### Time-to-Adoption Horizon: Four to Five Years

**K**nown in industrial circles as rapid prototyping, 3D printing refers to technologies that construct physical objects from three-dimensional (3D) digital content such as computer-aided design (CAD), computer aided tomography (CAT), and X-ray crystallography. A 3D printer builds a tangible model or prototype from the electronic file, one layer at a time, using an inkjet-like process to spray a bonding agent onto a very thin layer of fixable powder, or an extrusion-like process using plastics and other flexible materials. The deposits created by the machine can be applied very accurately to build an object from the bottom up, layer by layer, with resolutions that, even in the least expensive machines, are more than sufficient to express a large amount of detail. The process even accommodates moving parts within the object. Using different powders and bonding agents, color can be applied, and prototype parts can be rendered in plastic, resin, or metal. This technology is commonly used in manufacturing to build prototypes of almost any object (scaled to fit the printer, of course) that can be conveyed in three dimensions.

### Overview

3D printing is already pervasive in a number of fields, including architecture, industrial design, jewelry design, and civil engineering. The earliest known examples were seen in the mid-1980s at the University of Texas at Austin, where the Selective Laser Sintering was developed, though the equipment was cumbersome and expensive. The term 3D printing itself was coined a decade later at the Massachusetts Institute of Technology, when graduate students were experimenting with unconventional substances in inkjet printers. 3D printing appeared in the very first *NMC Horizon Report*, published in 2004, and since then, it has helped the U.S. Department of Defense to

inexpensively create aerospace parts, architects create models of buildings, medical professionals develop body parts for transplants, and much more.

During the process of 3D printing, the user will start by designing a model of the desired object through software such as CAD. Once the design is sent to the printer, the materials — either plastics or metals — are dispensed through a nozzle, gradually deposited to eventually form the entire object. Additive manufacturing technologies change the way the layers are deposited as some objects call for the material to be softened or melted. Selective heat and laser sintering, for example, require thermoplastics, while electron beam melting calls for titanium alloys. In the case of laminated object manufacturing, thin layers must be cut to shape and then joined together.

In the past several years, there has been a lot of experimentation in the consumer space — namely within the Maker culture, a technologically-savvy, do-it-yourself community dedicated to advancing science, engineering, and other disciplines through the exploration of 3D printing and robotics. Those involved in the many Maker communities around the world emphasize invention and prototyping. The MakerBot ([go.nmc.org/maker](http://go.nmc.org/maker)) is a 3D desktop printer that allows users to build everything from toys to robots, to household furniture and accessories, to models of dinosaur skeletons. In 2012, MakerBot Industries released the Replicator 2, with a higher resolution compatibility and build volume. Relatively affordable at under \$2,500, the MakerBot has brought 3D printing to the masses; the technology had previously only been found in specialized labs.

The resurgence of 3D printing has also been aided by online applications such as Thingiverse ([go.nmc.org/](http://go.nmc.org/))

thingv), a repository of digital designs for physical objects where users can download the digital design information and create that object themselves, instead of starting from scratch. The museum community in particular has capitalized on this service, creating and sharing replicas of artwork, sculptures, and fossils.

In early 2013, the world's first 3D printing photo booth will open in Japan ([go.nmc.org/omote](http://go.nmc.org/omote)), and reservations can be made online by anyone. Making 3D printing accessible to all is a trend that is also emerging in higher education. The University of Nevada, Reno's DeLaMare Science and Engineering Library recently became one of the first academic libraries in the U.S. to allow students, faculty, and the public to use 3D printing and scanning tools ([go.nmc.org/delamare](http://go.nmc.org/delamare)). As the technology becomes cheaper and more prevalent in public buildings at universities, access will no longer be an obstacle for the widespread adoption of 3D printing. Currently, however, the machines and tools are limited to participants in specialized projects and students enrolled in specific courses.

### **Relevance for Teaching, Learning, or Creative Inquiry**

One of the most significant aspects of 3D printing for education is that it enables more authentic exploration of objects that may not be readily available to universities. While 3D printing is four to five years away from widespread adoption in higher education, it is easy to pinpoint the practical applications that will take hold. Geology and anthropology students, for example, can make and interact with models of fragile objects such as fossils and artifacts. Through rapid prototyping and production tools, organic chemistry students and those studying x-ray crystallography can print out models of complex proteins and other molecules, similar to what can be seen in 3D Molecular Design's Model Gallery ([go.nmc.org/molec](http://go.nmc.org/molec)).

While it has become easier for faculty and students to work with these models, some of the most compelling progress of 3D printing in higher education comes from institutions that are using the technology to invent brand new tools. Researchers at the University of Warwick recently created an inexpensive, 3D printable,

electrically conductive plastic that enables electronic tracks and sensors as part of the 3D printed model ([go.nmc.org/3dp](http://go.nmc.org/3dp)). The goal is for engineering students to be able to design and print products with the circuitry system already built into the model.

As 3D printing gains traction in higher education, universities are designing dedicated laboratories and initiatives to explore creative uses of the technology. The Fab Lab program ([go.nmc.org/fablab](http://go.nmc.org/fablab)), for example, was started in the Media Lab at MIT as a learning and maker space for digitally-enabled fabrication, equipped with laser cutters, 3D printers, circuit boards, and

## **The exploration of the 3D printing process from design to production, as well as demonstrations and participatory access, can open up new possibilities for learning activities.**

more, and the project has now scaled to create similar laboratories all over the world.

The exploration of the 3D printing process from design to production, as well as demonstrations and participatory access, can open up new possibilities for learning activities. In medical schools, rapid prototyping has been helping participants produce anatomical models based on the images from MRIs and CAT scans. Doctors are able to better strategize surgeries when exploring these models. Medical schools and programs are also in the process of building artificial body parts. Scientists at Heriot-Watt University in Edinburgh, for example, are using human cells to 3D print artificial liver tissue for laboratory use, which could ultimately make the testing of new drugs more efficient and reliable than traditional methods by using human organ models instead of live animals ([go.nmc.org/artili](http://go.nmc.org/artili)).

Similarly, a young girl afflicted with a rare neuromuscular condition was given 3D-printed appendages that enabled her to move her arms with greater ease ([go.nmc.org/magica](http://go.nmc.org/magica)). While this type of product development has already taken root in specialized schools and research labs, it is beginning to appear at a broader number of universities across the world, justifying the placement of 3D printing on the far-term horizon.

A sampling of applications of 3D printing across disciplines includes the following:

- > **Archaeology.** Harvard University's Semitic Museum is using 3D printing technology to restore a damaged ancient artifact from their collection. By 3D scanning existing fragments of the Egyptian lion's legs, researchers are able to create computer models that will be used to print a scale foam replica of the complete sculpture, though it initially was missing its body and head: [go.nmc.org/semit](http://go.nmc.org/semit).
- > **Art and Design.** The Emily Carr University of Art and Design is exploring ways to speed up design and production in textiles, foundry, and ceramic construction with a built-from-scratch 3D printer that only cost them \$500: [go.nmc.org/mat](http://go.nmc.org/mat).
- > **Mechanical Engineering.** Two mechanical engineering students from the University of Virginia fabricated and assembled one of the first 3D printed planes ever flown. As part of their internship with the MITRE Corporation, they learned how to rapidly prototype and test scale models of aerial vehicles in a fraction of the time and cost it would have taken before the availability of 3D printing: [go.nmc.org/fly](http://go.nmc.org/fly).

## 3D Printing in Practice

The following links provide examples of 3D printing in use in higher education settings:

### 3D Model Workshops

[go.nmc.org/vic](http://go.nmc.org/vic)

At Victoria University of Wellington, the Schools of Architecture and Design held a 3D model workshop with metalwork and woodwork machinery areas and a range of 3D digital fabrication and other modeling equipment.

### 3D Printing at Purdue University

[go.nmc.org/strong](http://go.nmc.org/strong)

Purdue University researchers are working with Adobe's Advantage Technology Labs to develop a software application that creates more durable 3D printed objects. Through structural analysis the program identifies problematic areas and offers solutions to create stronger objects using a minimal amount of raw material.

### Adding a "3D Print" Button to Animation Software

[go.nmc.org/beast](http://go.nmc.org/beast)

Computer scientists at Harvard University are developing an add-on software tool that makes it possible to print 3D action figures from computer animation files. The research, conducted in collaboration with graphics experts, enables animators to create replicas of otherworldly creatures by finding the location of joints and gauging the correct size and friction to make them move and pose.

### Think[box]

[go.nmc.org/thinkbox](http://go.nmc.org/thinkbox)

Case Western Reserve University's new invention center, Think[box], is a space for anyone to creatively tinker, complete with 3D printers, laser cutters, and tools for students to create their own printed circuit board or computerized embroidery.

### ThinkLab

[go.nmc.org/thinklab](http://go.nmc.org/thinklab)

The ThinkLab is a Makerspace at the University of Mary Washington for hands-on creative inquiry and learning with a variety of high-tech tools, including a 3D printer. In one project students used the 3D printer for prototyping, designing, and creating makeshift solutions to business problems.

## For Further Reading

The following articles and resources are recommended for those who wish to learn more about 3D printing:

### 3D Printing: The Desktop Drugstore

[go.nmc.org/dedru](http://go.nmc.org/dedru)

(Katharine Sanderson, *BBC News*, 26 September 2012.)

This article explores how 3D printing can revolutionize



the medical industry through the printing of body organs, pharmaceuticals, and custom prosthetics. Although many projects are still in the research stage, this emerging technology provides hope for lower cost medical solutions for remote areas of the world.

### **7 Educational Uses for 3D Printing**

[go.nmc.org/7ed3d](http://go.nmc.org/7ed3d)

(Nancy Parker, *Getting Smart*, 14 November 2012.) There is a vast array of uses for 3D printers in education, including drafting in architecture courses, creating 3D art in graphic design, developing body part models for biology, and more.

### **The Future of Higher Education: Reshaping Universities through 3D Printing**

[go.nmc.org/reshap](http://go.nmc.org/reshap)

(Jason Hidalgo, *Engadget*, 19 October 2012.) From libraries to laboratories, 3D printing is becoming more ubiquitous across college campuses. The University of Nevada, MIT, and Columbia are just a few universities utilizing 3D printers to engage their students in how to rapidly prototype designs, understand molecular shapes, and more.

### **Making It Real With 3D printing**

[go.nmc.org/making](http://go.nmc.org/making)

(Drew Nelson, *InfoWorld*, 11 December 2012.) This article highlights the emergence of open source 3D printers which got their start in 2007 and have now developed into lower cost, more efficient models as users share, copy, and improve upon the model designs.

### **NASA Turns to 3D Printing for Self-Building Spacecraft**

[go.nmc.org/nasa](http://go.nmc.org/nasa)

(Jeremy Hsu, *Technews Daily*, 13 September 2012.) NASA's SpiderFab project is studying the feasibility of 3D printing in space. The author of this post describes how this type of research could lead to the era of rockets equipped with 3D printers and raw materials, manufacturing massive telescopes, satellites, and space antennas while in orbit.

### **The New MakerBot Replicator Might Just Change Your World**

[go.nmc.org/mbot](http://go.nmc.org/mbot)

(Chris Anderson, *Wired*, 19 September 2012.) MakerBot's Replicator 2 was released in September 2012, signaling the maturation of the desktop 3D printing market because of its accessible price, simplified software, and improved resolution. This article profiles the MakerBot company, their development, and the ecosystem they have helped create.

### **Science in Three Dimensions: The Print Revolution**

[go.nmc.org/kurz](http://go.nmc.org/kurz)

(Kurzweil, 5 July 2012.) This article brings to light the capabilities of 3D printers for scientific research, and the way they are democratizing the ability to create custom models. Examples include models of complex molecular systems and 3D printed collagen to construct scaffolds for growing cells.

### **What Can be Made with 3-D Printers?**

[go.nmc.org/whacan](http://go.nmc.org/whacan)

(*The Washington Post*, 4 January, 2013.) A photo slideshow reveals a series of objects that were created from 3D printers, including an iPhone case, a shoe, a model of a Les Paul guitar, and more. People of all ages created these items — even a high school student — demonstrating how 3D printing has become more accessible and easier to manage.



# Wearable Technology

## Time-to-Adoption Horizon: Four to Five Years

**W**earable technology refers to devices that can be worn by users, taking the form of an accessory such as jewelry, sunglasses, a backpack, or even actual items of clothing such as shoes or a jacket.

*The benefit of wearable technology is that it can conveniently integrate tools, devices, power needs, and connectivity within a user's everyday life and movements. Google's "Project Glass" features one of the most talked about current examples — the device resembles a pair of glasses, but with a single lens. A user can see information about their surroundings displayed in front of them, such as the names of friends who are in close proximity, or nearby places to access data that would be relevant to a research project. Wearable technology is still very new, but one can easily imagine accessories such as gloves that enhance the user's ability to feel or control something they are not directly touching. Wearable technology already in the market includes clothing that charges batteries via decorative solar cells, allows interactions with a user's devices via sewn-in controls or touch pads, or collects data on a person's exercise regimen from sensors embedded in the heels of their shoes.*

### Overview

Wearable technology is not a new category, but this edition marks its debut appearance in the *NMC Horizon Report* series. One of the most popular incarnations of the technology was the calculator watch, which was introduced in the 1980s. Since then, the field has advanced significantly, but the overarching theme behind the technology remains the same — convenience. These tools are portable, lightweight, and often take the place of an accessory the user already wears, such as a t-shirt, glasses, or wristwatch, making them easy to take anywhere. Effective wearable devices become an extension of the person wearing them,

allowing them to comfortably engage in everyday activities or to help them accomplish a specific task.

The consumer space is brimming with new wearable devices for both productivity and recreation, from Bluetooth necklaces designed to replace unsightly headsets ([go.nmc.org/ahalife](http://go.nmc.org/ahalife)) to vests that enable gamers to feel the impact of their actions in video games ([go.nmc.org/3dvest](http://go.nmc.org/3dvest)). In a number of cases, wearable technology is used to communicate on behalf of the user. Italian denim brand Replay produced a Bluetooth-enabled pair of jeans that can update the wearer's Facebook status ([go.nmc.org/replay](http://go.nmc.org/replay)).

One of the latest turns in this category of devices are tiny cameras that clip to a user's shirt collar or pocket, and take hundreds — even thousands — of photographs of their surroundings. Memoto, funded via Kickstarter, is a tiny, GPS-enabled camera that clips to a user's shirt collar or button and takes two five-megapixel photographs per minute and uploads them to social media platforms ([go.nmc.org/enzht](http://go.nmc.org/enzht)). The Contour Video Camera is another such device, favored by extreme athletes, that records and streams HD video ([go.nmc.org/contour](http://go.nmc.org/contour)). There is an increasing demand from users for all of their special moments to be seamlessly captured, but it is becoming less desirable to have to lug around cumbersome devices. As technologies are continuously designed to be smaller and more mobile, wearable devices are a natural progression in the evolution of technology.

Wearable technology that communicates with a user's surroundings often has the ability to convey important observations. A team from the Centre for Sensor Web Technologies at Dublin City University is building a wearable sensor that detects hazardous gases and will immediately alert the user of these conditions ([go.nmc.org/clarity](http://go.nmc.org/clarity)). While there are a number of seminal efforts,

like this one, to build new wearable technologies in higher education, most of the work is currently transpiring in the consumer space.

## Relevance for Teaching, Learning, or Creative Inquiry

Currently, the number of new wearable devices in the consumer sector seems to be increasing daily, greatly outpacing the implementation of this technology at universities. The education sector is just beginning to experiment with, develop, and implement wearable technologies, though the potential applications are significant and vast. Smart jewelry or other accessories could alert students working in chemical laboratories to hazardous conditions, while wearable cameras can instantly capture hundreds of photographs or data about a user's surroundings on an offsite geology dig that can be later accessed via email or other online application.

One of the most compelling potential outcomes of wearable technology in higher education is productivity. Wearable technologies that could automatically send information via text, email, and social networks on behalf of the user, based on voice commands, gestures, or other indicators, would help students and educators communicate with each other, keep track of updates, and better organize notifications. Thinkgeek's InPulse Smart Notification watch ([go.nmc.org/thinkgeek](http://go.nmc.org/thinkgeek)) is relatively affordable at \$150 and works with Android devices to enable users to view and organize emails, texts, phone calls, and other notifications.

In Google's "Project Glass," augmented-reality-enabled glasses — slated for release in early 2013 — display relevant information for users as they go about their daily routines ([go.nmc.org/googleglass](http://go.nmc.org/googleglass)). Users can access the Internet via voice command, communicate email replies, and more. The glasses will also have the ability to alert the user of pertinent information as it arises; if their regular train to campus is running late, for example, the goggles could let them know and propose an alternative route.

Some current research and development efforts at the university level are related to sensory improvement,

such as gloves that enhance responsive feeling when performing surgery or interacting with scientific equipment. The MIT Media Lab is taking this notion a step further by allowing users to turn any surface into

**As technologies are continuously designed to be smaller and more mobile, wearable devices are a natural progression in the evolution of technology.**

an interface with SixthSense ([go.nmc.org/six](http://go.nmc.org/six)), a tool consisting of a pocket projector, a mirror, and a camera. The hardware components inside this pendant-like wearable device project information onto any surface, while the camera recognizes and tracks a user's hand gestures.

Another significant area of interest for education is wearable flexible displays. Samsung, LG, Sony, and a number of other technology companies have already created light-emitting diode (LED) displays that can wrap around furniture and other curved surfaces, and Erogear has developed a display that can be integrated into different types of clothing ([go.nmc.org/erogear](http://go.nmc.org/erogear)). Advancements in this area could eventually make smartphones, tablets, and other computing devices obsolete. Researchers at Arizona State University's Flexible Display Center are developing a lightweight display for soldiers that could reveal important location data, including maps ([go.nmc.org/flex](http://go.nmc.org/flex)), and soon that same technology could be configured into wearable combinations.

A sampling of applications for wearable technology across disciplines includes the following:

- > **Fashion Design.** The recent international exhibition, "Technosensual," showcased futuristic creations inspired by the marriage of fashion and technology. The event brought together an eclectic mix of artists

and engineers who showed off interactive garments and smart clothing, offering a peek into the future of tech-based fashion design and aesthetic: [go.nmc.org/cnnjs](http://go.nmc.org/cnnjs).

- > **Medicine.** A flexible circuit designed by John Rogers at the University of Illinois at Urbana-Champaign is worn over a person's fingertip, allowing its sensors to measure pressure, temperature, or other electrical properties. This could enhance surgical gloves to be able to sense the thickness or composition of tissue: [go.nmc.org/tingl](http://go.nmc.org/tingl).
- > **Programming.** Federico Parietti and Harry Asada of MIT created a prototype for robotic arms that could potentially be used by factory workers. The algorithms in charge of the limbs will be first trained to perform specific tasks, but the goal is to program them so that they can anticipate what the wearer wants them to do: [go.nmc.org/han](http://go.nmc.org/han).

## Wearable Technology in Practice

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

### Autographer

[go.nmc.org/autog](http://go.nmc.org/autog)

The Autographer is a camera with sensors that look out for changes in temperature, color, direction, acceleration, and subject motion, triggering the shutter automatically up to 2,000 times a day.

### Brain-Sensing Headband

[go.nmc.org/mus](http://go.nmc.org/mus)

A new brain-sensing headband called Muse displays a user's brain activity directly on their smartphone or tablet. The ultimate goal for development is that users will be able to control televisions and other electronic devices merely by thinking about them.

### Cellphone-Charging Shirt

[go.nmc.org/zscll](http://go.nmc.org/zscll)

Researchers at the University of South Carolina converted the fibers of a t-shirt into activated carbon, turning it into a wearable hybrid super-capacitor that

can charge portable electronic devices. The inventors claim that the process they used on the t-shirt is less expensive, and greener, in comparison to conventional methods of creating electric storage devices.

### Keyglove

[go.nmc.org/fylwm](http://go.nmc.org/fylwm)

Keyglove is a wireless open-source input glove that can be used to control devices, enter data, play games, and manipulate 3D objects among other tech-based activities. Equipped with 37 contact sensors and smart controller software, the Keyglove can facilitate single-handed tasks, a feature that is ideal for handicapped or disabled users.

### Robotic Suit

[go.nmc.org/lift](http://go.nmc.org/lift)

A new robotic suit created by Koba Lab from Tokyo University of Science provides support to the wearer's back, shoulders, and elbows, enabling them to carry more weight and perform more difficult physical tasks.

### Wearable Solar Charger

[go.nmc.org/ren](http://go.nmc.org/ren)

Alta Device's solar charging mat can be attached to a backpack to continuously generate renewable electricity, which is then used to recharge a lithium battery connected with it. Once charged, the battery can be used to power a range of portable electronic devices such as a laptop, tablet, or smartphone.

### Wearable Tech at Georgia Tech

[go.nmc.org/gatech](http://go.nmc.org/gatech)

Professor Thad Starner at Georgia Tech University founded the Contextual Computing Group to develop applications and interfaces that can be worn. Projects include a mobile sign language translator, a wearable pendant that recognizes and translates one's hand gestures into actions, and an application designed to make a tablet pressure-sensitive so it monitors tremor in patients with Parkinson's disease.

## For Further Reading

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

### 10 Wearable Health Tech Devices To Watch

[go.nmc.org/hea](http://go.nmc.org/hea)

(Michelle McNickle, *Information Week*, 31 October 2012.)

The health sector is an area in which wearable devices are especially prevalent. Wearable medical technology for personal health monitoring includes smart shirts — equipped with small adhesive sensors that can monitor vital signs and can also alert a patient, doctors, or caretaker when necessary.

### Here's Proof That Wearable Tech Is The Next Big Thing

[go.nmc.org/nex](http://go.nmc.org/nex)

(Megan Rose Dickey, *Business Insider*, 5 Jan 2013.) In the consumer market, wearable technology has taken off in the form of electronic drum machine t-shirts, waterproof bikinis that absorb sunlight to charge electronics, and boots that use the heat a wearer creates from walking to charge a smartphone.

### One on One: Steve Mann, Wearable Computing Pioneer

[go.nmc.org/pione](http://go.nmc.org/pione)

(Nick Bilton, *The New York Times*, 7 August 2012.) Steve Mann, a wearable technology expert, has been using wearable computers that assist his vision since the 1970's. In this interview, he discusses the future of glass products that can be worn over the eyes to augment what we see with pertinent information. He also discusses brain-computer interfaces and the difference in mediated reality and augmented reality.

### Study: Wearable Computing Will be a \$1.5B Business by 2014

[go.nmc.org/weacom](http://go.nmc.org/weacom)

(Janko Roettgers, *Gigaom*, 31 October 12.) A 2012 Juniper study examines the evolving smart wearable device space, including products already on the market such as Fitbit, as well as prototypes not yet available, such as Google Glass. The report shows that wearable

devices are gaining traction and will grow to a \$1.5 billion business by 2014.

### Wearable Tech Pioneers Aim to Track and Augment our Lives

[go.nmc.org/wea](http://go.nmc.org/wea)

(Jane Wakefield, *BBC News*, 17 October 2012.) This article highlights the potential of wearable technology, including cameras that automatically snap photos, watches that sync with email accounts to display emails and reminders, and more.

### Wearable Technology: A Vision of the Future?

[go.nmc.org/sxgxs](http://go.nmc.org/sxgxs)

(Charles Arthur, *The Guardian*, 18 July 2012.) Bluetooth and wireless technology has paved the way for wearable computing, and a number of projects, including the Nike+ SportsWatch and Recon Instruments snowboarding goggles, are proving there is a market, especially for athletes.



## The NMC Horizon Project

**T**his report is part of a longitudinal research study of emerging technologies that began in March 2002. Since that time, under the banner of the Horizon Project, the NMC and its research partners have held an ongoing series of conversations and dialogs with its advisory boards — a group that now numbers nearly 750 technology professionals, campus technologists, faculty leaders from colleges and universities, museum professionals, teachers and other school professionals, and representatives of leading

**Under the banner of the Horizon Project, the NMC and its research partners have held an ongoing series of conversations and dialogs with its advisory boards.**

corporations from around 40 countries. For more than a decade, these conversations have been mined to provide the insights on emerging technology that are published annually in the *NMC Horizon Report* series.

The NMC Horizon Project is currently in its eleventh year, dedicated to charting the landscape of emerging technologies for teaching, learning, and creative inquiry in education globally. Each year, three full format reports are produced, focusing on higher education, K-12, and museums, respectively. In 2011, the NMC added to the three main *NMC Horizon Reports* a new series of regional and sector-based studies, called the *NMC Technology Outlooks*, with the dual goals of understanding how technology is being absorbed using a smaller lens, and also noting the contrasts between technology use in

one area compared to another. To date, the NMC has conducted studies of technology uptake in Australia, New Zealand, the UK, Brazil, Spain and Latin America, and Singapore, and has plans in place to expand that research to Europe, India, and Africa. This report, the *NMC Horizon Report: 2013 Higher Education Edition*, is the tenth in the series focusing on global higher education, and will be translated into multiple languages. Across all editions, the readership of the reports is estimated at over 1.5 million worldwide, with readers in over 150 countries.

The 51 members of this year's advisory board were purposely chosen to represent a broad spectrum of higher education; key writers, thinkers, technologists, and futurists from education, business, and industry rounded out the group. They engaged in a comprehensive review and analysis of research, articles, papers, blogs, and interviews; discussed existing applications, and brainstormed new ones; and ultimately ranked the items on the list of candidate technologies for their potential relevance to teaching, learning, or creative inquiry. This work took place entirely online and may be reviewed on the project wiki at [horizon.wiki.nmc.org](http://horizon.wiki.nmc.org).

The effort to produce the *NMC Horizon Report: 2013 Higher Education Edition* began in November 2012, and concluded when the report was released in February 2013, a period of just under three months. The six technologies and applications that emerged at the top of the final rankings — two per adoption horizon — are detailed in the preceding chapters.

Each of those chapters includes detailed descriptions, links to active demonstration projects, and a wide array of additional resources related to the six profiled technologies. Those profiles are the heart of the *NMC*



*Horizon Report: 2013 Higher Education Edition*, and will fuel the work of the NMC Horizon Project throughout 2013. To share your educational technology projects with the NMC to potentially be featured in a future *NMC Horizon Report*, the NMC Horizon Project Navigator database, or the NMC Horizon EdTech Weekly App, visit [go.nmc.org/projects](http://go.nmc.org/projects). For those wanting to know more about the processes used to generate the *NMC Horizon Report* series, many of which are ongoing and extend the work in the reports, we refer you to the report's final section on the research methodology.

**The 51 members of this year's advisory board were purposely chosen to represent a broad spectrum of higher education; key writers, thinkers, technologists, and futurists from education, business, and industry rounded out the group.**



## Methodology

The process used to research and create the *NMC Horizon Report: 2013 Higher Education Edition* is very much rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are produced using a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition. Every report draws on the

**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.**

considerable expertise of an internationally renowned advisory board that first considers a broad set of important emerging technologies, challenges, and trends, and then examines each of them in progressively more detail, reducing the set until the final listing of technologies, trends, and challenges is selected.

This process takes place online, where it is captured and placed in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions.

The section of the wiki used for the *NMC Horizon Report: 2013 Higher Education Edition* can be found at [horizon.wiki.nmc.org](http://horizon.wiki.nmc.org).

The procedure for selecting the topics in the report included a modified Delphi process now refined over years of producing the *NMC Horizon Report* series, and began with the assembly of the advisory board. The advisory board represents a wide range of backgrounds, nationalities, and interests, yet each member brings a particularly relevant expertise. Over the decade of the NMC Horizon Project research, nearly 750 internationally recognized practitioners and experts have participated on project advisory boards; in any given year, a third of advisory board members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the advisory board are encouraged — see [go.nmc.org/horizon-nominate](http://go.nmc.org/horizon-nominate).

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

Following the review of the literature, the advisory board engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions were designed to elicit

a comprehensive listing of interesting technologies, challenges, and trends from the advisory board:

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

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

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

**3 What trends do you expect to have a significant impact on the ways in which learning-focused institutions approach our core missions of teaching, research, and service?**

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

One of the advisory board's most important tasks is to answer these questions as systematically and broadly as possible, so as to ensure that the range of relevant topics is considered. Once this work is done, a process that moves quickly over just a few days, the advisory board moves to a unique consensus-building process based on an iterative Delphi-based methodology.

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each advisory board member using a multi-vote system that allows members to weight their selections. Each member is asked to also identify the timeframe during which they feel the technology would enter mainstream use — defined for the purpose of the project as about 20% of institutions adopting it within the period discussed. (This figure is based on the research of Geoffrey A. Moore and refers to the critical mass of adoptions needed for a technology to have a chance of entering broad use.) These rankings are compiled into a collective set of responses, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of technologies originally considered for any report, the twelve that emerge at the top of the initial ranking process — four per adoption horizon — are further researched and expanded. Once this “Short List” is identified, the group, working with both NMC staff and practitioners in the field, begins to explore the ways in which these twelve important technologies might be used for teaching, learning, and creative inquiry in higher education. A significant amount of time is spent researching real and potential applications for each of the areas that would be of interest to practitioners.

For every edition, when that work is done, each of these twelve “Short List” items is written up in the format of the *NMC Horizon Report*. With the benefit of the full picture of how the topic will look in the report, the “short list” is then ranked yet again, this time in reverse. The six technologies and applications that emerge are those detailed in the *NMC Horizon Report*.

For additional detail on the project methodology or to review the actual instrumentation, the ranking, and the interim products behind the report, please visit [horizon.wiki.nmc.org](http://horizon.wiki.nmc.org).



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