NMC **Horizon Report** > 2012 Higher Education Edition
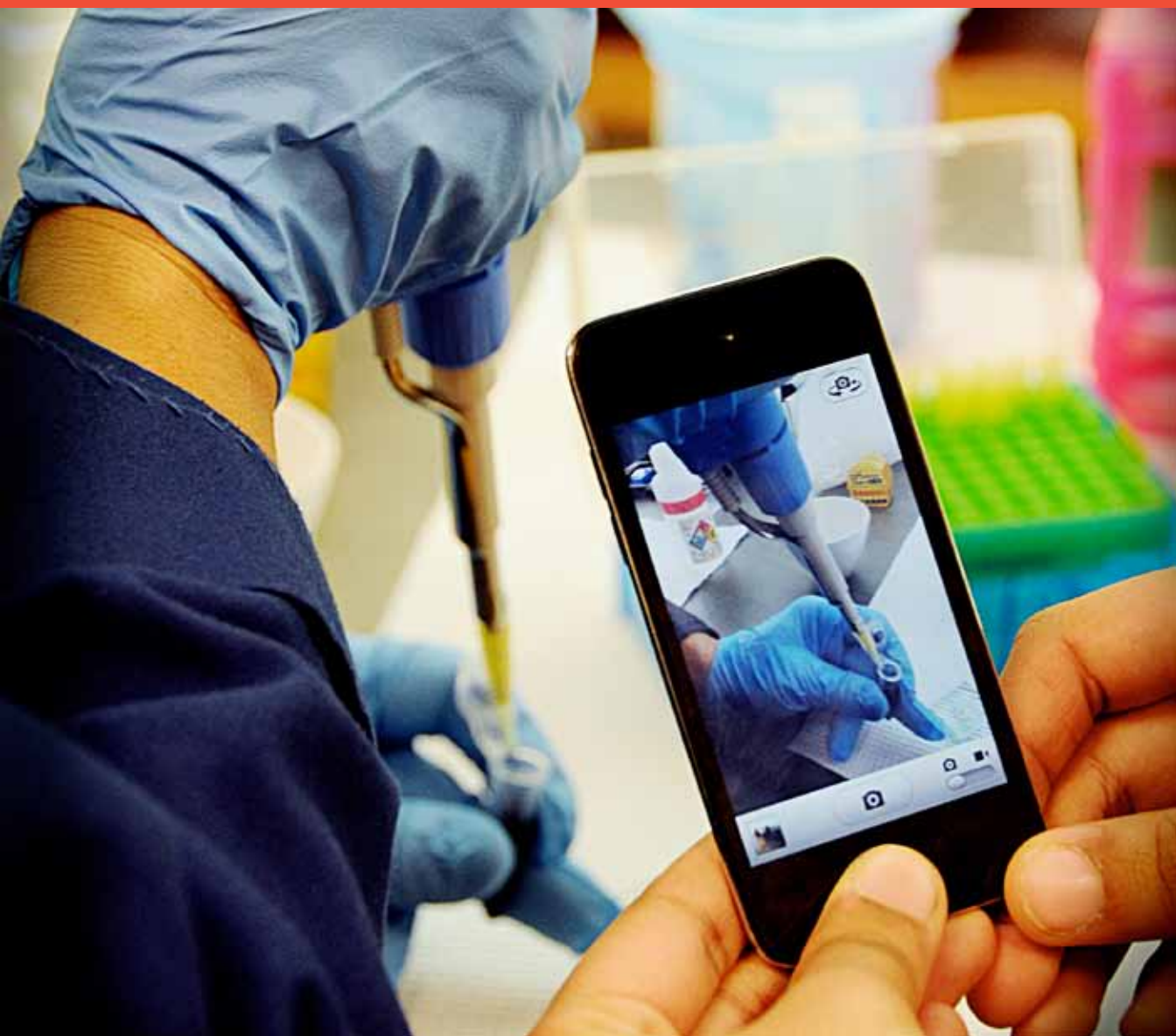
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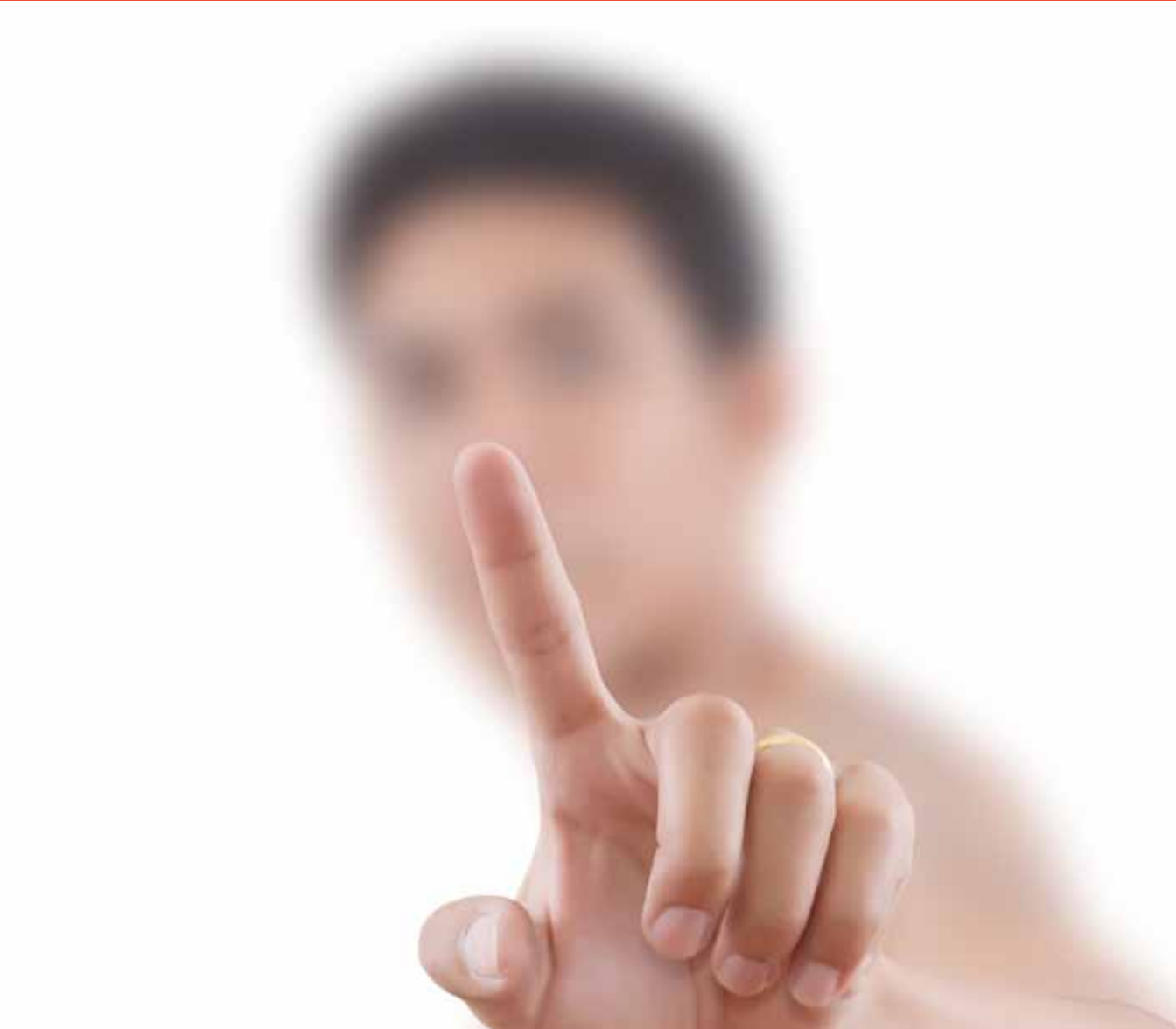Join the community.
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NMC

The NMC (New Media Consortium) is an international community of experts in educational technology — from the practitioners who work with new technologies on campuses everyday; to the visionaries who are shaping the future of learning at think tanks, labs, and research centers; to its staff and board of directors; to the advisory boards and others helping the NMC conduct cutting edge research.

> **The NMC helps its members stay at the leading edge of emerging technology.**
> **The key interest of the NMC community is in technologies and applications that make learning more relevant and more engaging.**
> **As a community, we engage in research that catalyzes discussion, we convene people around new ideas, and we build communities and networks that encourage exploration and experimentation.**

We help our hundreds of member universities, colleges, museums, and organizations drive innovation across their campuses.

> **Find out more about how you can join the NMC at go.nmc.org/join**
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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.

Contents

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The *NMC Horizon Report: 2012 Higher Education Edition* is a collaboration between the New Media Consortium and the EDUCAUSE Learning Initiative, an EDUCAUSE Program.

Citation

Cover photograph

By Kate Morgan, Director of University Relations at Penn State Lehigh Valley. As part of the University's Mobile Media pilot, two honors biology students at Penn State Lehigh Valley document, edit, and upload lab procedures for Bio 110 students to reference, using only iPod Touch 4Gs. http://mediacommons.psu.edu/mobilemedia.

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Executive Summary

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. This volume, the *NMC Horizon Report: 2012 Higher Education Edition*, was again produced in a collaborative effort with the EDUCAUSE Learning Initiative, an EDUCAUSE Program, 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 a wide 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.

Each of the three global editions of the *NMC Horizon Report* — higher education, primary and secondary education, and museum education — highlights six emerging technologies or practices that are likely to enter mainstream use with their focus sectors within three adoption horizons over the next five years. Key trends and challenges that will affect current practice over the same period frame these discussions. Over the course of just a few weeks in the late fall of 2011, the advisory board came to a consensus about the six topics that appear here in the *NMC Horizon Report: 2012 Higher Education Edition*. The examples and readings under each topic area 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.

The report's format is consistent from year to year and edition to edition, and opens with a discussion of the trends and challenges identified by the advisory board

The technologies featured in each edition of the *NMC Horizon Report* are embedded within a contemporary context that reflects the realities of the time, both in the sphere of higher education and in the world at large.

as most important for the next five years. The format of the main section of this edition closely reflects the focus of the NMC Horizon Project itself, centering on the applications of emerging technologies — in this case for higher education settings. Each section is introduced with an overview that describes what the topic is, followed by a discussion of the particular relevance of the topic to teaching, learning, and creative inquiry in higher education. Several concrete examples of how the technology is being used are given. Finally, each section closes with an annotated list of suggested readings and additional examples 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) All the ephemera of the *NMC Horizon Report: 2012 Higher Education Edition*, including the research data, the interim results, the topic preview, and this publication, can be downloaded for free on iTunes U (go.nmc.org/itunes-u).

Key Trends

The technologies featured in each edition of the *NMC Horizon Report* are embedded within a contemporary context that reflects the realities of the 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 list 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 2012 through 2017. They are listed here in the order in which the advisory board ranked them.

1 People expect to be able to work, learn, and study whenever and wherever they want to. Life in an increasingly busy world where learners must balance demands from home, work, school, and family poses a host of logistical challenges with which today's ever more mobile students must cope. Work and learning are often two sides of the same coin, and people want easy and timely access not only to the information on the network, but also to tools, resources, and up-to-the-moment analysis and commentary. These needs, as well as the increasingly essential access to social media and networks, have risen to the level of expectations. The opportunities for informal learning in the modern world are abundant and diverse, and greatly expand on earlier notions like "just-in-time" or "found" learning.

2 The technologies we use are increasingly cloud-based, and our notions of IT support are decentralized. The continuing acceptance and adoption of cloud-based applications and services is changing not only the ways we configure and use software and file storage, but also how we conceptualize those functions. It does not matter where our work is stored; what matters is that our information is accessible no matter where we are or what device we choose to use. Globally, in huge numbers, we are growing accustomed to a model of browser-based software that is device independent. While some challenges still remain, specifically with notions of privacy and sovereignty, the promise of significant cost savings is an important driver in the search for solutions.

3 The world of work is increasingly collaborative, driving changes in the way student projects are structured. Because employers value collaboration as a critical skill, silos both in the workplace and at school are being abandoned in favor of collective intelligence. To facilitate more teamwork and group communication, projects rely on tools such as wikis, Google Docs, Skype, and easily shared file-storage sites including Dropbox. Students are increasingly evaluated not just on the overall outcome, but also on the success of the group dynamic. In many cases, the way an online collaboration tool is used is an equally important outcome. Like the wiki used to create this report, such sites preserve the process and the multiple perspectives that lead to the end results.

4 The abundance of resources and relationships made easily accessible via the Internet is increasingly challenging us to revisit our roles as educators. Institutions must consider the unique value that each adds to a world in which information is everywhere. In such a world, sense-making and the ability to assess the credibility of information are paramount. Mentoring and preparing students for the world in which they will live and work is again at the forefront. Universities have always been seen as the gold standard for educational credentialing, but emerging certification programs from other sources are eroding the value of that mission daily.

5 Education paradigms are shifting to include online learning, hybrid learning and collaborative models. Budget cuts have forced institutions to re-

evaluate their education strategies and find alternatives to the exclusive face-to-face learning 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. We are beginning to see developments in online learning that offer different affordances than physical campuses, including 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.

6 **There is a new emphasis in the classroom on more challenge-based and active learning.** Challenge-based learning and similar methods foster more active learning experiences, both inside and outside the classroom. As technologies such as tablets and smartphones now have proven applications in higher education institutions, educators are leveraging these tools, which students already use, to connect the curriculum with real life issues. The active learning approaches are decidedly more student-centered, allowing them to take control of how they engage with a subject and to brainstorm and implement solutions to pressing local and global problems. The hope is that if learners can connect the course material with their own lives, their surrounding communities, and the world as a whole, then they will become more excited to learn and immerse themselves in the subject matter.

Significant Challenges

Any discussion of technology adoption must also consider important constraints and challenges, and 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 detailed 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 **Economic pressures and new models of education are bringing unprecedented competition to the traditional models of higher education.** Across the board, institutions are looking for ways to control costs while still providing a high quality of service. Institutions are challenged by the need to support a steady — or growing — number of students with fewer resources and staff than before. As a result, creative institutions are developing new models to serve students, such as streaming introductory courses over the network. As these pressures continue, other models may emerge that diverge from traditional ones. Simply capitalizing on new technology, however, is not enough; the new models must use these tools and services to engage students on a deeper level.

2 **Appropriate metrics of evaluation lag the emergence of new scholarly forms of authoring, publishing, and researching.** Traditional approaches to scholarly evaluation, such as citation-based metrics, 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 **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 most university 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 an expected norm for academic professionals, nor as a key part of degree programs.

4 **Institutional barriers present formidable challenges to moving forward in a constructive way with emerging technologies.** 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 with or adoptions of clearly innovative applications of technologies is often seen as outside the role of researcher or scientist.

5 **New modes of scholarship are presenting significant challenges for libraries and university collections, how scholarship is documented, and the business models to support these activities.** While the university library has traditionally housed collections of scholarly resources, social networks and new publishing paradigms, such as open content, are challenging the library's role as curator. Students and educators are increasingly able to access important, historic research in web browsers on devices of their choosing. As such, libraries are under tremendous pressure to evolve new ways of supporting and curating scholarship.

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 summarized below and detailed in the main body of the report.

Technologies to Watch

The six technologies featured in the *NMC Horizon Report: 2012 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 twelve 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 — are mobile apps and tablets. These two topics have become pervasive in everyday life, at least in the developed world, and students at universities and colleges have ever-increasing expectations of being able to learn on these devices whenever and wherever they may be. This year tablets have been separated from mobiles as a distinct category, preserving mobiles as a descriptor used for typical hand-held devices designed to make calls.

> **Mobile apps** are the fastest growing dimension of the mobile space in higher education right now, with impacts on virtually every aspect of informal life, and increasingly, every discipline in the university. Always-connected Internet devices using 3G

and similar cellular networks, imbedded sensors, cameras, and GPS have proved to be a feature set with hundreds of thousands of applications. Apps that take advantage of recent developments in these tools, along with advances in electronic publishing and the convergence of search technology and location awareness, made this category of software enormously interesting in a higher education context. Higher education institutions are now designing apps tailored to educational and research needs across the curriculum.

> **Tablet computing** presents new opportunities to enhance learning experiences in ways simply not possible with other devices. High-resolution screens allow users of tablets, such as the iPad, to easily share content with each other and pore over images and videos on the screen. As people tend to use tablets to supplement and not replace smartphones, they are viewed as less disruptive tools (no phone ringing and no incoming text messages), which makes them ideal tools for learning opportunities. Because tablets are able to tap into all the advantages that mobile apps bring to smaller devices, but in a larger format, higher education institutions are seeing them not just as an affordable solution for one-to-one learning, but also as a feature-rich tool for field and lab work, often times replacing far more expensive and cumbersome devices and equipment.

Mid-term Horizon
The second adoption horizon, two to three years out, is where we will begin to see widespread adoptions of two technologies that are experiencing growing interest within higher education: game-based learning and learning analytics. Educational gaming brings an increasingly credible promise to make learning experiences more engaging for students, while at the same time improving important skills, such as collaboration, creativity, and critical thinking. Over the past year, learning analytics has garnered a lot of attention. The ability to synthesize data in real-time is exciting because it changes the structure of the learning dynamic — educators can use the data to make adjustments to their teaching style that better caters to student needs.

> **Game-based learning** has grown in recent years as research continues to demonstrate its effectiveness for learning. Games for education span the range from single-player or small-group card and board games all the way to massively multiplayer online games and alternate reality games. Those at the

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first end of the spectrum are easy to integrate into the curriculum, and have long been an option in many higher education institutions; but the greatest potential of games for learning lies in their ability to foster collaboration and engage students deeply in the process of learning. Once educational gaming providers can match the volume and quality of their consumer-driven counterparts, games will garner more attention.

> **Learning analytics** loosely joins a variety of data-gathering tools and analytic techniques to study student engagement, performance, and progress in practice, with the goal of using what is learned to revise curricula, teaching, and assessment in real time. Building on the kinds of information generated by Google Analytics and other similar tools, learning analytics aims to mobilize the power of data-mining tools in the service of learning, and embrace the complexity, diversity, and abundance of information that dynamic learning environments can generate.

Far-term Horizon
On the far-term horizon, set at four to five years away from widespread adoption, are gesture-based computing and the Internet of Things. Gesture-based technology

has enabled students to learn by doing. Interfaces that react to touch, movement, voice, and facial expression allow more freedom in how we interact with our devices. The Internet of Things, a notion first outlined by Vint Cerf as one of the many reasons to move to IPv6 to expand the address space of the Internet, is converging with smart objects, and fueling considerable innovation in how these devices communicate with each other and with us. Smart objects are already well established in

Interfaces that react to touch, movement, voice, and facial expression allow more freedom in how we interact with our devices.

the commercial sector and range along a continuum from RFID sensors to near field communication (NFC). These technology topics do not yet have an abundance of well-documented project examples in higher education, but the high level of interest found in both areas indicates that they are worth following closely.

> **Gesture-based computing** moves the control of computers from a mouse and keyboard to the motions of the body, facial expressions, and voice recognition via new input devices. It makes interactions with computational devices far more intuitive and embodied. From the touchscreens on smartphones to the gesture and voice interpretation of the latest gaming systems (Xbox Kinect and Nintendo Wii) and virtual assistants, gesture-based computing enables users to learn by doing and facilitates the convergence of a user's thoughts with their movements. Large multi-touch displays support collaborative work, allowing multiple users to interact with content simultaneously.

> **The Internet of Things** is the latest turn in the evolution of smart objects — a category of small devices or methods that enable an object to be assigned a unique identifier; contain small bits of information, such as the object's age, shelf life, and

environmental data such as temperature or humidity (and much more) attached to it; and then communicate the status of that information on demand, whether optically or via electromagnetic frequencies. With the advent of the new internet Protocol, version six, those objects can now have an IP address, enabling their information store to be accessed in the same way a webcam might be, allowing real-time access to that information from anywhere. At the same time, new wireless communication strategies, such as near field communication, are making it easier for smart objects to connect to networks. The implications are not yet clear, but it is evident that hundreds of billions of devices — from delicate lab equipment to refrigerators to next-generation home security systems — will soon be designed to take advantage of such connections.

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 may also be found. Given the practical focus of the report, a listing of examples of the technology in use, especially in higher education, is a key component of each of the six main topics. Our research indicates that all six of these technologies, taken together, will have a significant impact on learning-focused organizations within the next five years.

The NMC Horizon Project

This 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 — now more than 450 technology professionals, campus technologists, faculty leaders from colleges and universities, museum professionals, teachers and other school professionals, and representatives of leading corporations from more than thirty 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.

This report, the *NMC Horizon Report: 2012 Higher Education Edition*, kicks off the tenth year of the

series, which is dedicated to charting the landscape of emerging technologies for teaching, learning, and creative inquiry in higher education globally. In 2008, 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, and Iberoamerica, and has plans in place to expand that research to Central Europe, India, Singapore, and Africa. This report, the flagship publication of the NMC Horizon Project, is translated into multiple languages every year. Over all editions, the readership of the reports is estimated at more than one million worldwide, with readers in some 100 countries.

The 47 members of this year's advisory board were purposely chosen to represent a broad spectrum of the higher education sector; 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.

The effort to produce the *NMC Horizon Report: 2012 Higher Education Edition* began in November 2011, and concluded when the report was released in February 2012, a period of just over three months. The six technologies and applications that emerged at the top of the final rankings — two per adoption horizon — are detailed in the chapters that follow.

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: 2012 Higher Education Edition,* and will

fuel the work of the NMC Horizon Project throughout 2012. 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.

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Mobile Apps

Time-to-Adoption Horizon: One Year or Less

There is a revolution that is taking place in software development that parallels the changes in recent years in the music, publishing, and retail industries. Mass market is giving way to niche market, and with it, the era of highly priced large suites of integrated software is giving way to a new view of what software should be. Smartphones including the iPhone and Android have redefined what we mean by mobile computing, and in the past three to four years, the small, often simple, low cost software extensions to these devices — apps — have become a hotbed of development. New tools are free or sell for as little as 99 cents, and anyone can be a developer. A popular app can see millions of downloads in a short time, and that potential market has spawned a flood of creativity that is instantly apparent in the extensive collections available in the app stores — themselves a new way of delivering software that reduces distribution and marketing costs significantly. Apple's app store opened in July 2008; Google's followed in October of that year. Since then, simple but useful apps have found their way into almost every form of human endeavor.

Overview

With the advent of mobile apps, the way we think about software itself is changing, and whole industries are adjusting to a new world in which sophisticated but simple tools routinely sell for 99 cents. In contrast with the model for desktop applications that stack feature upon feature in a one-size-fits-all approach, mobile apps are small, simple, and elegant. They generally do one thing, or a small list of tightly related things, extraordinarily well. They cost so little, trial versions are unnecessary, and it is simple to outfit a tablet or mobile phone with exactly the feature set you want for far less than you would pay for typical desktop software. Both Apple and Google have developed extensive

collections of apps, and adding to your set is as simple as it is inexpensive.

The app software model is clearly working: ABI research shows that over 18 billion apps had been downloaded in the Apple marketplace by October 2011, and over ten billion in the Android marketplace by December the same year. Those numbers just scratch the surface of the anticipated growth of mobile apps. A recent study by Distimo predicted that 44 billions apps will have been downloaded by 2016 — or, around seven apps per person across the entire population of the earth.

The assortment of available apps is wide-ranging, from those that extend the camera or sensors on the device ("Siesmometer", "Hipstamatic," and "360"); to new forms of newspapers and magazines ("McSweeny's"); to games that make use of gestures in clever ways ("Angry Birds"); to new forms of mapping tools ("StarWalk"); to apps that make restaurant recommendations based on the user's location ("Urbanspoon"). What makes apps as a category interesting are two key factors: the first is that there are so many to choose from — one can find an app to support almost any interest or endeavor, and the possibilities expand every day. The second is that they are inexpensive — rare is an app on someone's mobile that costs more than $1.99. Taken together, the result is that it is both easy and economical to completely customize a device to suit one's own interests.

The best apps are tightly integrated with the capabilities of the device itself, using location data, motion detection, gestures, access to social networks, and web search, to seamlessly create a full-featured experience. As just one example, users are now able to not only read an article foregrounded because of its relation to the user's location, but also to share it with their social networks, make comments, swipe over an image to see

more, and store specific content to read at a later date — all within a typical newspaper app.

In the last year, new additions to mobile operating systems have made it easier for newspapers, periodicals, and other subscription-based publications to migrate to mobile devices. Print and online publications, such as *Time, Wired,* or *Mashable*, provide users with new material on a regular basis, sometimes sending the user alerts when there is a new edition, breaking news, or a story that is relevant to the user's interests. Mobile apps designed for tablets have given many traditional print-based publications a new life, and new tools, such as iBook Author, are making it very easy for anyone to create and publish media-rich interactive pieces. The newest version of iBook is optimized for viewing interactive textbooks, and it seems that the e-readers for the Kindle and Android platforms are heading the same direction.

The mobile app marketplace reflects an expanding world of resources that fits into the palm of a hand. While the adoption of apps has been especially apparent in the consumer sector, there has also been a great interest in apps that illustrate scientific and related concepts via tools that also have practical application. Apps that support learning are commonplace. Fun, easy-to-use tools can be found for budding chefs, astronomers, physicists, artists, musicians, book lovers, and writers — and all of them are designed to go with you anywhere and to be available with a tap on a screen. The higher education sector is beginning to capitalize on this by integrating mobile apps into the curriculum and designing their own to encompass course materials and campus maps.

Relevance for Teaching, Learning, or Creative Inquiry

Mobile apps embody the convergence of several technologies that lend themselves to educational use, including annotation tools, applications for creation and composition, and social networking tools. GPS and compasses allow sophisticated location and positioning, accelerometers and motion sensors enable the apps to be designed and used in completely new ways, digital capture and editing bring rich tools for

video, audio, and imaging. Mobile apps encompass it all, and innovation in mobile device development continues at an unprecedented pace.

The potential of mobile computing is already being demonstrated in hundreds of projects at higher education institutions. Since 2009, Abilene Christian University has provided each student with an iPhone or iPod Touch, in addition to offering professors

The mobile app marketplace reflects an expanding world of resources that fits into the palm of a hand.

mobile training and support. The institution has been developing apps to extend learning outside of the classroom and documenting the results along the way in an annual mobile learning study. At the most basic level, many universities and colleges have developed map and directory apps for current students to navigate campuses and for prospective students to take virtual tours or to enhance physical tours.

As institutions begin to understand the potential of apps, they have built in features for students to check their grades, or to update them with sports scores or breaking campus news. Ohio State University's mobile app includes a campus directory, plus library resources and personal information that is tied to each student's ID. Higher education institutions have also been designing apps that enhance the classroom learning experience. The University of Warwick in the UK created an app that quizzes medical students on the human anatomy and various laboratory scenarios using video and audio clips.

While institutions are rapidly developing their own apps, they are also making use of external ones. Popular apps include those that help students and educators stay organized and exchange their findings and ideas with peers. Many apps, when coupled with digital textbooks, ease the transition for students who are accustomed to print books. For example, "Good Reader" is an app

that enables users to highlight, annotate, sketch, and add footnotes to e-books — just as they would in the print version. "JotNot Pro" is another app that allows professors to digitally distribute course documents and students to instantly scan printed documents and store them on their device.

As mobile apps become an important fixture in the business world, many universities and colleges have deployed special courses and programs to teach student entrepreneurs how to design, develop, and market them. Vanderbilt University founded the Vanderbilt Mobile Application Team in 2009 to prepare their students for high technology jobs. Since the group was founded, participating students have developed three award-winning apps. All of their work is open source, and can be used as a learning model at other institutions. At the University of Wisconsin-Madison, a faculty associate in the School of Journalism and Mass Communication has incorporated app development into her magazine publishing class, recognizing that mobile devices are taking on a prominent role in the magazine industry.

The increasing availability of network access means that the growing capabilities of mobiles are available to more students in more locations each year. Educational institutions around the world are investing in the infrastructure that supports mobile access, sponsoring programs that provide devices to students who do not already have them, and commissioning custom mobile applications to serve their communities.

A sampling of applications of mobile apps across disciplines includes the following:

> **Multimedia Production.** Students in the Instructional Systems program at Penn State University are developing a mobile video app for video ethnographers to record and annotate video in the field. The app allows users to add, edit, and delete text annotations displayed alongside the video footage. go.nmc.org/waxvi

> **Project Management.** Using the mobile app "MindJet," students can create mind maps and

organized outlines in addition to attaching notes to specific topics or automatically arranging them based on common themes. The app has built in social features that allow students to share their project plans with each other. go.nmc.org/qnquw

> **University Services.** Professor Catheryn Cheal at Oakland University, Michigan sends her students to five specific campus locations with the "SCVNGR" app on their smartphones. They answer questions about visual rhetorical space into their phone at each site. Once back in the classroom, they have the background to write their essays in a learning management system. go.nmc.org/hochw

Mobile Apps in Practice
The following links provide examples of mobile apps in use in higher education settings:

Berkeley Mobile International Collaborative
go.nmc.org/pramk
In the Berkeley Mobile International Collaborative, student-created mobile apps will be judged based on business model and utility, with ten finalist university teams competing in Barcelona.

The Cleveland Historical App
go.nmc.org/aeeue
"Cleveland Historical" is an interactive and GPS-enabled app, providing historical information on specific sites within the city in the form of images, audio, and video clips. "Cleveland Historical" is curated by the Center for Public History and Digital Humanities with stories contributed from community members, teachers, professors, and students.

iPrinceton
go.nmc.org/oadcp
Princeton University's free "iPrinceton" app enables users to catch up on athletic and academic news, browse a full library catalog, and connect to the university's social media pages. The app also connects with Blackboard for direct course support at any point.

Stanford University's iPhone and iPad Apps Course
go.nmc.org/tvlvs
Lectures and slides from Stanford's iPhone and iPad application development course can now be freely accessed online through iTunes U. The appearance of the course material made iTunes history with one million downloads by the seventh week.

The University of Michigan's Mobile Apps Center
go.nmc.org/nfhcp
University of Michigan's Mobile Apps Center brings together instruction and app building resources to allow students and faculty to create and distribute useful apps to the U-M community.

University of Virginia iPhone and Android Apps
go.nmc.org/xaess
The University of Virginia has developed its campus app through WillowTree apps. Augmented reality features allow users to personalize their maps. The app has many components useful for alumni too, allowing them to follow sporting events live and easily connect with UVA clubs and contacts.

For Further Reading

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

7 Things You Should Know about Mobile App Development
go.nmc.org/velrd
(EDUCAUSE, 19 April 2011.) This guide provides higher education institutions with helpful information to take into consideration when building an app, including accessibility standards and enterprise system integration opportunities.

Can the iPhone Save Higher Education?
go.nmc.org/abuoc
(John Cox, *NetworkWorld*, 23 March 2010.) Exploring the effect of digital devices for teaching and learning, Abilene Christian University has focused on mobile phones and how they are changing the classroom. The lecturer to student model is becoming a more collaborative and interactive model, now that instructors and students have ubiquitous and equal access to information.

How to Build a University Mobile Application: Best Practice and Insight
go.nmc.org/qnbcv
(Karen Eustice, *The Guardian*, 8 December 2011.) This article compares the different avenues universities are taking in creating and updating their mobile apps, showing the efficiency and reasoning behind each option from the developer's perspective.

Smartphones on Campus: the Search for 'Killer' Apps
go.nmc.org/wskke
(Jeffrey R. Young, *The Chronicle of Higher Education*, 8 May 2011.) There is no one size fits all app because diversity in professors and courses leads to mobile apps being used in varying degrees and manners. This article explores different examples of apps benefiting professors and students, and how they are providing links from the classroom to the community.

Taking Mobile Applications Into the Cloud
go.nmc.org/zzrut
(Mary Grush, *Campus Technology*, 31 August 2011.) Because mobile devices are limited in their capabilities, researchers are looking to resource-rich cloud-based services that, when integrated with mobile apps, will expand the depth of information mobile phones can access and the range of their function.

University Leverages Mobile App to Keep Students Connected
go.nmc.org/ehjiw
(Jeff Goldman, *Mobile Enterprise*, 17 October 11.) This article on Indiana State University's mobile app powered by Pryxis Mobile describes the challenges and decisions that were a part of the app building process, as well as marketing and monitoring the finished product.

Tablet Computing
Time-to-Adoption Horizon: One Year or Less

In the past year, advances in tablet computers have captured the imagination of educators around the world. Led by the incredible success of the iPad, which in the fourth quarter of 2011 was selling at the rate of more than 3 million units a month, other similar devices such as the Samsung Galaxy and Sony's Tablet S have also begun to enter this rapidly growing new market. In the process, tablets (a form that is distinct from tablet PCs) have come to be viewed as not just a new category of mobile devices, but indeed 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 is clear that they are independent and distinct from other mobile devices such as smartphones, e-readers, or tablet PCs. With significantly larger screens and richer gestured-based interfaces than their smartphone predecessors, they are ideal tools for sharing content, videos, images, and presentations because they are easy for anyone to use, visually compelling, and highly portable.

Overview

Led by the category-defining phenomenon that is the Apple iPad, tablets have earned their own listing in the *NMC Horizon Report* this year, completely distinct from mobiles. According to a recent study from comScore, the iPad now accounts for 97% of all tablet-based web traffic in the U.S. and 46.8% of all mobile web traffic. Similar statistics show tablets are increasingly the device of choice not just for web browsing, but also social networking and reading news. Competing models, including Motorola's Xoom and Samsung's Galaxy Tab have not yet enjoyed the success of the iPad, but together, these companies have solidified tablets as the new family of devices to watch.

Immensely portable, tablets are already a significant distribution element for magazines and e-books. iOS 5 even includes a newsstand that allows quick and easy access to newspapers and magazines and new subscriptions — with a mere touch. Even without extending their functionality via the full range of mobile apps, tablets serve as nicely sized video players with instant access to an enormous library of content; digital readers for books, magazines, and newspapers; real-time two-way video phones; easily sharable photo viewers and even cameras; fast, easy email and web browsers; and rich, full-featured game platforms — all in a slim, lightweight, portable package that fits in a purse or briefcase — but which significantly omits a traditional keyboard. That design choice, and the implications it brings for interacting with the device, is a key reason that tablets are not a new kind of lightweight laptop, but rather a completely new computing device.

When the iPad was introduced, it was described as a "lean back" experience as contrasted to the "lean forward" experience of typical computers. While second market and wireless keyboards are available for tablets, the real innovation in these devices is in how they are used. A swipe, a tap, or a pinch allows the user to interact with the device in completely new ways that are so intuitive and simple they require no manuals or instructions. The device itself encourages exploration of its capabilities, something easily demonstrated by simply placing the device in the hands of a small child. For times when a keyboard is needed, a custom-configured software keyboard appears, but the best-designed apps make little or no use of it.

Screen technology has advanced to the point that tablets are exceptionally effective at displaying visual content, such as photographs, books, and video; similar advances in gesture-based computing have moved

tablets far beyond the point and click capabilities of touchscreens, and tablets are engaging and intuitive devices to use. These combinations of features are especially enticing to educational institutions at all levels, and many K-12 institutions are considering tablets as a cost-effective alternative to the netbook when planning a one-to-one deployment. In these and other group settings, their large screens — and the ease with which the image automatically adjusts its orientation to the viewer — make it easy to share content.

Perhaps the most interesting aspect of tablets is that they owe their heritage not to the desktop, but to the mobile phone. Both iOS and Android-based tablets are designed with the app model firmly in mind, and hundreds of thousands of specialized apps are available to extend the functionality of tablets. Apps for tablets have many features in common with mobile apps, such as seamless use of location awareness, network connections, and other built-in sensors, but the larger screen real estate allows for more detailed interfaces or viewing area. Also similar to smartphone apps, apps for tablets are inexpensive and very easy to add to the device, using the same tools and online stores.

Relevance for Teaching, Learning, or Creative Inquiry

Because of their portability, large display, and touchscreen, tablets are ideal devices for one-to-one learning, as well as fieldwork. Many institutions are beginning to rely on them in place of cumbersome laboratory equipment, video equipment, and various other expensive tools that are not nearly as portable or as inexpensive to replace.

For example, the iPad has become an integral instrument in the cadaver laboratories at the University of California, Irvine. Images of body structures and radiographic films can be easily explored and manipulated on-screen, and apps such as "Epocrates Essentials" provide a mobile drug and disease reference at students' fingertips (go. nmc.org/epeif). Similarly, Duke University has been exploring the use of the iPad as an efficient way to collect global health research (go.nmc.org/fqxpm).

More and more institutions are providing their students with iPad devices that come pre-loaded with course materials, digital textbooks, and other helpful resources. Under the Griffin Technology Advantage at Seton Hill University, for example, all full-time students receive an iPad 2. Similarly, the University of Southern Mississippi is piloting up to 1,000 Galaxy Tab 10.1 devices that will be issued to students, loaded with Blackboard Mobile™ Learn. Students and professors, sharing the same hardware and software, will experience and share audio, video, and other learning materials.

Because these types of tablet programs are relatively new, many universities and colleges are conducting in depth studies to measure their outcomes. Studies including those at Abilene Christian University, Oberlin College, the Missouri University of Science and Technology, and many others have generally found

Because of their portability, large display, and touchscreen, tablets are ideal devices for one-to-one learning, as well as fieldwork.

that integrating tablets into the curriculum has led to increased student engagement and has enhanced learning experiences. However, higher education institutions are just beginning to delve into more research surrounding some of the many potential uses of tablets, including the replacement of print textbooks with e-books, the wide use of specialized apps, the expanded use of the devices' built-in sensors, GPS, gesture interface, cameras, video and audio tools, and more.

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. What makes tablets so powerful is that students already use these or very similar devices outside the classroom to download apps, connect

to their social networks, and immerse themselves in informal learning experiences. As such, students are already quite comfortable using them in both academic and social settings.

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

> **Chemistry.** In organic chemistry laboratories at the University of Illinois at Urbana-Champaign, wall-mounted iPads are equipped with a kiosk app to deliver video reviews of the lab techniques most needed by the students. Students also use the iPads throughout the chemistry courses to clarify experiment set-up and answer other procedural questions. go.nmc.org/hjjvi

> **Lecture Capture.** Tablet apps, such as McGraw Hill's "Tegrity," are used by the University of Colorado, Georgia Tech University, Fordham Law School, and many others as a campus-wide solution for recording and deploying class lectures. go.nmc.org/zmgnp

> **Mathematics.** As a collaborative project between the math support centers at three universities — Swinburne in Australia, Limerick in Ireland, and Loughborough in the UK — "MathsCasts" are videos of mathematical explanations recorded by writing on a tablet. They cover topics with which undergraduate students typically struggle. All "MathsCasts" carry a Creative Commons license and are available for free on the Swinburne website and on iTunes U. go.nmc.org/igmlf

> **Writing.** Designed and developed by the University of Queensland, UQMarkup is an iPad app developed to facilitate the integration of contextualized audio and written feedback in student writing assessments. The feedback from the app is personalized, and the responses are provided in a short, fixed, and easily understood format. go.nmc.org/hwzcu

Tablet Computing in Practice

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

iPad Makes Wall Street Debut
go.nmc.org/swnbt
During Drew University's Wall Street Semester program, students will be equipped with an iPad and apps that access and interpret financial information. Conveniently, students can read course materials on their iPads instead of carrying books, and digitally compose documents, spreadsheets, and presentations.

The iPad Replaces University Textbooks
go.nmc.org/vblpb
The University of Adelaide will replace textbooks with Apple iPads for first year students in its Science program. The University sees this as a way to allow the evolution of student learning environments to augment individual student growth.

Solar-Powered iPad Devices
go.nmc.org/ctjzq
In partnership with Apple, the Zimbabwe government is bringing solar-powered iPad devices to rural institutions across Africa that have not had consistent — or any — computer access in the past due to lack of electricity.

University of Dayton Undergraduate Viewbook
go.nmc.org/wdcwm
The free University of Dayton Viewbook app gives potential undergraduate students a virtual orientation to the school using video content, slideshows, and interactive feeds to explore academic facilities, programs, opportunities, and student life.

Valparaiso College of Engineering Releases iPad App
go.nmc.org/yqqhw
Recent Valparaiso University graduates have developed a new interactive digital magazine for the iPad that incorporates videos and photo galleries into stories so that students, faculty, alumni, and anyone interested can connect to news and happenings within the College of Engineering.

For Further Reading

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

6 Reasons Tablets are Ready for the Classroom
go.nmc.org/lcrin
(Vineet Madan, *Mashable*, 16 May 2011.) This article explores the applications of tablet computers in higher education, based on reports from classrooms that have participated in pilot studies, citing that iPads fit with students' current lifestyles.

The B-School Case Study Gets a Digital Makeover
go.nmc.org/delwj
(Erin Zlomek, *Bloomberg Business Week*, 25 July 2011.) This article demonstrates how tablets allow students a convenient way to access and interact with the many business case studies that are a core part of business school curriculum.

Campus Tour Now Comes with an iPad
go.nmc.org/hszrt
(Jody S. Cohen, *Chicago Tribune,* 9 October 2011.) Bradley University is now distributing iPads during campus tours so that when prospective students are shown areas of the campus, they can also watch videos of events that have taken place there throughout the year. Seeing laboratories and lecture halls in use gives students an understanding of what busy campus life will be like, even when touring during holidays or summer months.

Educators Evaluate Learning Benefits of iPad
go.nmc.org/whlnr
(Ian Quillen, *Education Week*, 15 June 2011.) This article discusses the use of iPad devices as learning tools, and delves into the ongoing discourse about whether they are more viable for one-to-one solutions or as part of a group of shared devices.

An iPad University: Giving It the Old College Try
go.nmc.org/zxqiy
(Lena Groeger, *Wired*, 22 July 2011.) The University of Southern California has teamed up with TouchAppMedia and 2tor, Inc. to create an online distance learning experience fully accessible with an iPad or mobile device, featuring social integrations like video chat with classmates and sharing notes and ideas on course walls and forums.

Kindle Fire: Changing the Game in Higher Education?
go.nmc.org/hdoru
(Vineet Madan, *Geek Wire*, 15 November 2011.) This article measures the new Kindle Fire to its competitor, the iPad, citing that the smaller screen of the Kindle Fire is the main shortcoming of the device for educational purposes, since students are looking to use the device to read and access multimedia, such as images and videos.

Tablets have come to be viewed as not just a new category of mobile devices, but indeed 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.

Game-Based Learning
Time-to-Adoption Horizon: Two to Three Years

ame-based learning has gained considerable traction since 2003, when James Gee began to describe the impact of game play on cognitive development. Since then, research, and interest in, the potential of gaming on learning has exploded, as has the diversity of games themselves, with the emergence of serious games as a genre, the proliferation of gaming platforms, and the evolution of games on mobile devices. Developers and researchers are working in every area of game-based learning, including games that are goal-oriented; social game environments; non-digital games that are easy to construct and play; games developed expressly for education; and commercial games that lend themselves to refining team and group skills. Role-playing, collaborative problem solving, and other forms of simulated experiences are recognized for having broad applicability across a wide range of disciplines.

Overview

According to *Trip Wire Magazine*, 61.9 million people participated in online social games in 2011, up nearly 9 million people from 2010. Forty percent of these gamers are between the ages of 20 and 34. The average age of the American gamer is now 35-years-old, which correlates with the early 1980s timeline in which the first digital games appeared with the first home computers. Ten years later, the web was born, and games began to be delivered over the Internet. The three most recent cohorts of children — those born in the early 1980s, the early 1990s, and the early 2000s — have grown up in a world where digital games have always been an important part of their lives, and entered or graduated from higher education institutions with hundreds of hours of gaming experience.

Early studies of consumer games helped to identify the aspects of games that make them especially engaging and appealing to players of various ages and of both genders: the feeling of working toward a goal; the possibility of attaining spectacular successes; the ability to problem solve, collaborate with others, and socialize; an interesting story line; and other characteristics. These qualities are replicable for educational content, though they can be difficult to design well. This challenge is one reason why game-based learning continues to be placed on the mid-term horizon.

In the most recent National Education Technology Plan, gaming was named as an ideal method of assessing student knowledge comprehension, citing the ability of games to provide immediate performance feedback to the players. Students are engaged because they are motivated to do better, get to the next level, and succeed. Proponents also underscore the productive role of play, which allows for experimentation, the exploration of identities, and even failure.

In recent years, the Serious Games movement has focused on uniting significant educational content with play. The games within this genre layer social issues or problems with game play, helping players gain a new perspective through active engagement. Research shows that players readily connect with learning material when doing so will help them achieve personally meaningful goals. Purdue University's Serious Games Center is just one of the many programs dedicated to conducting research and finding new means of collaboration with Serious Games in virtual environments.

Another area of gaming that is increasingly interesting for higher education institutions is simulation-based games. Militaries worldwide have adopted games and simulations across the entire range of skills training they provide, and the game-design insights from that

tremendous body of work are beginning to inform simulations designed for graduate students studying and training in specific subjects including medicine. "Emergency Room: Code Red" is one such popular game.

The 2011 edition of this report viewed massively multiplayer online (MMO) games as still a few years further out for learning, but increasingly interesting. This year, there has been more traction surrounding this genre of gaming. Online games including "Minecraft" and "World of Warcraft" have been integrated into course curriculum, with educators and educational technology writers frequently documenting their stories and outcomes. This type of game brings many players together to work on activities that require collaborative problem solving. They are complex, and include solo and group content, as well as goals that tie to a storyline or theme. Their link to education exists in the highest levels of interaction in which game-play requires teamwork, leadership, and discovery.

Relevance for Teaching, Learning, or Creative Inquiry

Game-based learning reflects a number of important skills higher education institutions strive for their students to acquire: collaboration, problem solving, communication, critical thinking, and digital literacy. What makes educational gaming appealing today is the plethora of genres and applications associated with it. From role-playing games to online social games to entire courses created around teaching better game design, aspects of game mechanics are well integrated in higher education curriculum.

Games related specifically to course content help students gain a fresh perspective on material and can potentially engage them in that content in more complex and nuanced ways. Alternate reality games (ARGs), in which players find clues and solve puzzles in experiences that blur the boundary between the game and real life, offer a clear example in which course content and game play can overlap. Recent examples of large-scale ARGs include Jane McGonigal's "EVOKE," a social networking game that simulates real global issues to empower people to find new and innovative

solutions. The ideas players have proposed have earned them opportunities to put their proposals into practice through internships with social innovators and business leaders around the world, and scholarships or funding for their own ventures. Stanford University created "Septris," an HTML5 mobile simulation game that teaches practicing physicians and nurses about Sepsis (blood poisoning) identification, triage, and management. Learners play the part of a physician

Proponents underscore the productive role of play, which allows for experimentation, the exploration of identities, and even failure.

managing patients as their health deteriorates. Learners read history, order labs, and assign treatments to multiple patients at a time.

The browser-based game "Ikariam" simulates life in ancient civilizations, and players learn about economics and civic responsibility by building up the economy and caring for the residents on virtual islands. Some higher education institutions are taking the incorporation of socially aware games a step further and designing entire courses around them. St. Edward's University recently launched a pilot section of a required Cultural Foundations course with an emphasis on the use of social media and experiential learning approaches. Their "Global Social Problems" course was designed using "heroic gaming" strategies. All course activities were rooted in a common set of heroic values and were represented as "character traits" on each student's profile.

Open-ended, challenge-based, truly collaborative games are an emerging category of games that seems especially appropriate for higher education. Games like these, which occur in both online and non-digital forms, can draw on skills for research, writing, collaboration, problem solving, public speaking, leadership, digital literacy, and media-making. When embedded in the curriculum, they offer a path into the material that allows

the student to learn how to learn along with mastering the subject matter. These games lend themselves to curricular content, requiring students to discover and construct knowledge in order to solve problems. They are challenging to design well, but the results can be transformative.

The challenge that persists with educational games — a good indicator of why they still reside on the mid-term horizon — is embedding traditional educational

Open-ended, challenge-based, truly collaborative games are an emerging category of games that seems especially appropriate for higher education.

content so that it looks and feels like a natural part of playing the game. Faculty members may find it difficult to make pronounced connections between specific course content and the gaming objectives. What is known, however, is that these games spark interest in students to expand their learning outside of the game. Constance Steinkuehler, for example, founding fellow of the Games+Learning+Society Initiative, found that the average MMO gamer spends 10-15 hours per week conducting online research related to the game. Digital and communication literacy goes hand in hand with game play, which is why it continues to be of great interest to educators.

A sampling of applications of game-based learning across disciplines includes the following:

> **Music.** In McGill University's "Open Orchestra" simulation game, a workstation uses high definition panoramic video and surround sound to provide musicians with the experience of playing in an orchestra or singing in an opera. A touchscreen in the music stand displays an electronic version of the score and the system controls, as well as a visualization that

compares the student's performance to that of a professional musician. go.nmc.org/udrgw

> **Online Learning.** Students in an Adult Education undergraduate online course at the University of British Columbia are participating in a role-playing game, in which they are reporters who are writing articles for an imaginary journal called *Adult Educator Weekly*. They also post comments as "readers" and vote for the best article. The results showed that the students posted more in the journal than they used to in LMS discussion forums. go.nmc.org/yvrzz

> **Science.** "MicroExplorer3D," developed by North Carolina State University, provides an avenue for students who do not have access to a microscopy lab to learn the parts of a compound microscope. Students interact with the 3D model of a compound microscope by clicking (web) or touching (mobile), zoom into detailed views of the parts, and open menu items and descriptions with photograph and video examples. go.nmc.org/kwgmb

Game-Based Learning in Practice
The following links provide examples of game-based learning in use in higher education settings:

3D GameLab
go.nmc.org/vedmb
Developed by Boise State University, 3D GameLab is a unique quest-based learning platform that can turn any classroom into a living game. 3D GameLab helps teachers tie innovative learning activities to standards, providing learners choice while they game their way through a competency-based curriculum.

Cycles of Your Cognitive Learning, Expectations, and Schema
go.nmc.org/gcogy
A University at Albany research team is developing a video game that will show people negative aspects of their own decision-making processes, specifically when they are confronted with incomplete information and operating under time pressure.

GAMeS Lab at Radford University
go.nmc.org/qlohz
The purpose of the Games, Animation, Modeling, and Simulation (GAMeS) Lab at Radford University is to design interactive mobile games and study their impact on student engagement and learning. The GAMeS Lab has designed iPod Touch and iPad games for schools in rural, southwestern Virginia, and is collaborating with the participating educators to determine how best to integrate these games within the existing curricula.

Meet the Earthwork Builders
go.nmc.org/cyaow
Funded by the National Endowment for the Humanities, a team of content specialists and game developers is making a video game prototype about the Newark Earthworks, an ancient lunar observatory in Newark, Ohio. Through the game, players will learn about the lunar observatory and gain a more global understanding of different cultures.

SciEthics Interactive
go.nmc.org/khreb
This project, funded by HP and the National Science Foundation, is designed to create virtual simulations with a science and ethics focus. Upper level undergraduate and graduate students can experience real world situations in the safety of a virtual environment.

simSchool
go.nmc.org/dkbbl
A flight simulator for teachers, simSchool provides challenging teaching scenarios that develop the knowledge and skills needed for classroom success. Research has indicated that training time on the simulator makes a significant difference in a teacher's self-efficacy and sense of the focus of control.

For Further Reading

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

5 Teaching Tips for Professors — From Video Games
go.nmc.org/lssnv
(Jeffrey R. Young, *The Chronicle of Higher Education*, 24 January 2010.) This article shares best practices on how to successfully incorporate gaming into university and college curriculum, underscoring that game-based learning is not a solution for all subjects and that games are no quick fix, but take research and classroom testing by the educator to ascertain their success.

Games and Learning: Teaching as Designing
go.nmc.org/cooat
(James Gee, *The Huffington Post*, 21 April 2011.) James Gee builds a case for games as catalysts for more interaction, creativity, and critical thinking in learning. He likens gamers to designers as they must understand the "rule system" to be successful.

Games in the Library
go.nmc.org/fmtam
(Anastasia Salter, *The Chronicle of Higher Education*, 13 December 2011.) This article takes a logistical perspective to game-based learning, focusing on the difficulty of disseminating a gaming experience to a large classroom of varying students, and proposing that a game library is a good option to provide access and information as well as to track inventory.

A Neurologist Makes the Case for the Video Game Model as a Learning Tool
go.nmc.org/rqvxp
(Judy Willis, *Edutopia,* 14 April 2011.) The neurologist behind this article equates the success of game-based learning with the release of dopamine, a physiological response to a prosperous choice or action, and outlines the phases of this natural learning process.

What Does Game-Based Learning Offer Higher Education?
go.nmc.org/qcuno
(Justin Marquis, OnlineUniversities.com, 14 October 2011.) This article explores the benefits of gaming at the university level by breaking down a hypothesis by game designer, Jane McGonigal, which recognizes specific positive attributes of gamers that can translate to productivity in the classroom and beyond.

Learning Analytics
Time-to-Adoption Horizon: Two to Three Years

*L**earning analytics refers to the interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues. Data are collected from explicit student actions, such as completing assignments and taking exams, and from tacit actions, including online social interactions, extracurricular activities, posts on discussion forums, and other activities that are not directly assessed as part of the student's educational progress. The goal of learning analytics is to enable teachers and schools to tailor educational opportunities to each student's level of need and ability in close-to-real time. Learning analytics promises to harness the power of advances in data mining, interpretation, and modeling to improve understandings of teaching and learning, and to tailor education to individual students more effectively. Still in its early stages, learning analytics responds to calls for accountability on campuses and aims to leverage the vast amount of data produced by students in academic activities.*

Overview

At its heart, learning analytics is about analyzing the wealth of information about students in a way that would allow schools to make informed adjustments to a student's learning experience, drawing on new ways of observing patterns in complex data. This sort of intervention is not new — school counselors and student services professionals have long used information such as student attendance records, grades, teacher observations, test scores, and the like to identify at-risk students. Learning analytics builds on this heritage, but aims to go much further than these tried and true strategies, merging information from disparate sources to create a far more robust and nuanced picture of learning as it happens that can be used to improve both teaching and learning environments.

Learning analytics was featured in the *NMC Horizon Report: 2011 Higher Education Edition* on the far-term horizon. This year, largely because of a major initiative focused on its refinement, the topic has been moved to the mid-term horizon, and is poised to make the transition from concept to practice. In 2010, EDUCAUSE announced a major program in partnership with the Gates Foundation under the Next Generation Learning Initiative that identified learning analytics as one of five key areas for development. That same year, the HP Catalyst Initiative established the Measuring Learning Consortium, led by Carnegie Mellon University, in which several large-scale international learning analytics projects are working towards common solutions. These projects, and others located at a number of higher education institutions, are driving not only the science behind learning analytics, but also interest. As the science and technical aspects of learning analytics are solved, one can expect to see significant development activity as campuses begin to implement learning analytics strategies.

This interest has not escaped large publishers, such as McGraw Hill ("Connect") and Pearson ("MyLabs"), who have begun to establish their own learning analytics solutions and have hired dedicated employees whose job is to provide learning analytics expertise as the emerging technology evolves. The initial focus of these efforts is on integration with existing learning management systems (LMS). Several researchers feel that this is a necessary part of a comprehensive solution, but is insufficient. To move learning analytics forward, many would argue that analytics must include more than LMS data. Other factors, such as the impact of the learning environment (especially online, but also physical environments), knowledge gained via informal learning, and metrics on skills including creativity, leadership, and innovation are seen as

equally important indicators of the overall quality of student performance.

Relevance for Teaching, Learning, or Creative Inquiry

Until recently, research on learning in higher education has centered primarily on identifying students who might be at risk of failure in a course or program, and designing interventions to address short-term issues that may be preventing them from succeeding in their coursework. The Signals project at Purdue University is an exemplary instance of this use. Initiated in 2007, Signals gathers information from SIS, course management systems, and course grade books to generate a risk level for students, and those designated as at-risk are targeted for outreach. Similarly, the University of Maryland, Baltimore County supplements their Blackboard course management system with a self-service feedback tool for students and educators called "Check My Activity."

The larger promise of learning analytics, however, is that when correctly applied and interpreted, it will enable faculty to more precisely understand students' learning needs and to tailor instruction appropriately far more accurately and far sooner than is possible today. This has implications not simply for individual student performance, but in how educators perceive the processes of teaching, learning, and assessment. By offering information in real time, learning analytics can support immediate adjustments, suggesting a model of curriculum that is more fluid and open to change.

Prospects for learning analytics tools include commercial applications designed for other purposes that might be adapted to support a learning analytics use case, and those developed specifically to accomplish learning analytics tasks. It is still a bit early in the life cycle of this technology for specialized tools, but applications such as Mixpanel analytics, which offers real-time data visualization documenting how users are engaging with material on a website, have obvious potential in hybrid and online courses. Similarly, Userfly, designed for usability testing, allows the behavior of visitors on a website to be recorded, after which it can be replayed and analyzed.

Broader sorts of analytics tools have a wider applicability for learning analytics, and Gephi is a good example. This free, open source interactive visualization and exploration platform allows not only easy visual exploration of complex data, but also provides tools like social network analysis, link relationships in scale-free networks, and much more.

Among the tools developed specifically for learning analytics is Socrato, an online learning analytics service that designs custom diagnostic and performance reports for tutoring or training centers and schools. SNAPP (Social Networks Adapting Pedagogical Practice), developed by the University of Wollongong in

The goal of learning analytics is to enable teachers and schools to tailor educational opportunities to each student's level of need and ability in close-to-real time.

Australia, is designed to expand on the basic information gathered within learning management systems; this information set typically centers on how often and for how long students interact with posted material. SNAPP uses visual analysis to show how students interact with discussion forum posts. Teachscape's Classroom Walkthrough program allows teachers to collect data and analysis on student knowledge comprehension using their mobile devices. Across the board, however, it is clear that a full-featured set of learning analytics tools is still some time way.

As higher education institutions continue to refine the theory and practice of learning analytics — especially as they begin to design their own platforms — they will need to preemptively tackle the issue of data privacy and determine what extent of information to share with students and other institutions.

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

> **Business and Communications.** Students at the University of British Columbia are examining web and social analytics to decipher meaningful trends about human behavior. go.nmc.org/ugtei

> **Medicine.** Learning analytics was used at the Graduate School of Medicine at the University of Wollongong to help design a new curriculum with a strong clinical focus. The approach provided evidence of appropriate curriculum coverage, student engagement, and equity while students were on clinical placement. go.nmc.org/zgxnk

> **Science, Technology, Mathematics, and Engineering (STEM)**. The University of Michigan uses a system called ECoach in large introductory STEM courses. ECoach uses information about student background, motivations, and recent performance to provide feedback, encouragement, and advice that are tailored to each student. go.nmc.org/vvoqp

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

Collaborative Assessment Platform for Practical Skills (video)
go.nmc.org/rhymf
Amrita University is reaching more students in rural India via a multilingual collaborative platform that can be used remotely to teach language, promote adaptive learning, and run virtual experiments. The platform will include a framework for the assessment of reporting and procedural skills, so that students can better concentrate their efforts on the subject areas they need to master.

CoreDogs
go.nmc.org/bypup
CoreDogs is a platform for creating digital textbooks for blended learning courses. While completing the exercises in the books, students receive formative feedback and assessments on their knowledge

comprehension. The platform also provides educators with data on student behavior.

Grade Discrepancy Project
go.nmc.org/lfbnu
The University of Minnesota is using data from their course management systems to determine whether the use of an online grade book can serve as a mitigating factor for helping lower achieving students estimate their final grades more accurately. The goal is to provide students with better information to guide their preparation for end-of-term exams, papers, and projects.

Learning Catalytics
go.nmc.org/mymtv
Developed by the Mazur Group at Harvard University, Learning Catalytics supports peer-to-peer instruction, and provides real-time feedback during class. Faculty can engage students with questions about course material with numerical, algebraic, textual, or graphical responses, and the platform helps group students for follow-up discussions.

SoLAR's Open Online Learning Analytics Course
go.nmc.org/pntpb
Hosted by Athabasca University for the Society for Learning Analytics Research (SoLAR), this free online course is an introduction to learning analytics and the role the approach plays in knowledge development. Also included is an overview of learning analytics platforms and the optimal organization of information flow.

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

Data Mining and Online Learning
go.nmc.org/nyhsn
(Jim Shimabukuro, *Educational Technology & Change Journal*, 7 August 2011.) In order to benefit from learning analytics, educators must incorporate it into their daily workflow, which can be time consuming. The author explains his method of timely analysis and response.

How Data and Analytics Can Improve Education
go.nmc.org/btans
(Audrey Watters, *O'Reilly Radar*, 25 July 2011.) Analytics and data captured by digital platforms and programs can be helpful for the learner to access as well as educators. This interview with education theorist George Siemens addresses the importance and consequences of privacy issues within learning analytics.

Learning Analytics: The Coming Third Wave
go.nmc.org/mknvy
(Malcolm Brown, EDUCAUSE Learning Initiative, April 2011.) This article discusses the current position of learning analytics in education, and how third party applications are beginning to make the tools more cost-effective. It also addresses the ethics involved in deploying learning analytics platforms.

Monitoring the PACE of Student Learning: Analytics at Rio Salado College
go.nmc.org/apwgj
(Mary Grush, *Campus Technology*, 14 December 2011.) Rio Salado's PACE (Progress and Course Engagement) automated tracking system generates reports so that instructors can easily see who is at risk in a given course, on the eighth day of the course, when there is still plenty of time to address the situation.

Social Learning Analytics: Technical Report
go.nmc.org/nvbjg
(Simon Buckingham Shum and Rebecca Ferguson, Knowledge Media Institute, the Open University, UK, June 2011.) This paper studies the technological needs of implementing accurate learning analytics in an online academic setting. Unprecedented amounts of digital data are now available from online social platforms, but the goal is to narrow analytics to only pedagogically relevant information.

What are Learning Analytics?
go.nmc.org/nqxvg
(George Siemens, *eLearnspace*, 25 August 2010.) This article presents an overview of learning analytics and discusses how it might be applied in learning institutions. A chart is included to depict the process of learning analytics.

By offering information in real time, learning analytics can support immediate adjustments, suggesting a model of curriculum that is more fluid and open to change.

Gesture-Based Computing
Time-to-Adoption Horizon: Four to Five Years

It is already common to interact with a new class of devices entirely by using natural movements and gestures. The Microsoft Surface, Apple's iOS devices (iPad, iPhone and iPod Touch), and other gesture-based systems accept input in the form of taps, swipes, and other ways of touching. The Nintendo Wii and Microsoft's Kinect system extend that to hand and arm motions, or body movement. These are the first in a growing array of alternative input devices that allow computers to recognize and interpret natural physical gestures as a means of control. Gesture-based computing allows users to engage in virtual activities with motions and movements similar to what they would use in the real world, manipulating content intuitively. The idea that simple gestures and natural, comfortable motions can be used to control computers is opening the way to a host of input devices that look and feel very different from the keyboard and mouse — and that are increasingly enabling our devices to infer meaning from the movements and gestures we make.

Overview

Gesture-based devices are already commonplace. Tapping or swiping a finger across a screen is the way millions of people interact with their mobile devices every day. The screens for the iPhone and iPad, and Android-based tablets and smartphones, for example, all react to pressure, motion, and even the number and direction of fingers touching the devices. Some devices react to shaking, rotating, tilting, or moving the device in space.

Over the past few years, gaming systems have increasingly incorporated new gesture-based technology. Xbox Kinect and Nintendo Wii, for example, continue to explore the potential of human movement in gaming. The Wii functions by combining a handheld, accelerometer-based controller with a stationary infrared sensor to determine position, acceleration, and direction. The Kinect system eliminates the hand-held controller and discerns commands and input by analyzing the visual field. Development in this area centers on creating a minimal interface, and in producing an experience of direct interaction such that, cognitively, the hand and body become input devices themselves. These systems recognize and interpret patterns in gross motor movements, including body movements and facial expressions. Players can jump, dance, point, and more and their actions catalyze the actions that take place on the screen.

In previous years, the *NMC Horizon Report* has documented two major development paths for gesture-based computing: marker-based and markerless. While both pathways continue to see development, what makes gesture-based computing especially interesting this year is two-fold. First is the increasingly high fidelity of systems that understand gestures and their nuances. This is allowing much more subtle hand and arm gestures — and even facial gestures — to be used to control devices.

The second interesting development is the convergence of gesture-sensing technology with voice recognition, allowing, just as it does in human conversation, for both gesture and voice to communicate the user's intentions to devices. Siri, the virtual assistant included in the iPhone 4s, is a particularly successful example of this convergence, seamlessly juxtaposing the voice interface alongside the now routine taps and swipes. Another indication of this convergence is that both LG and Samsung recently announced "smart" televisions equipped with both gesture and voice control.

Gesture-based computing is changing the ways that we interact with computers, both physically and

mechanically. As such, it is at once transformative and disruptive. Researchers and developers are gaining a sense of the cognitive and cultural dimensions of gesture-based communicating, and the full realization of the potential of gesture-based computing within higher education will require intensive interdisciplinary collaborations and innovative thinking about the very nature of teaching, learning, and communicating.

Relevance for Teaching, Learning, or Creative Inquiry

It is clear that gesture-based computing has found a natural home in gaming and in mobile devices, but its potential uses are broader. Software that relies not on specific languages, but on natural human movements common to all cultures has a compelling utility in countries such as India, which has 30 native languages with more than a million speakers. A natural interface opens up a key barrier between the user and his or her machine, and indeed all that is required to see this is to put a gesture-enabled device in the hands of a two-year-old.

Devices that encourage users to touch them, move, or otherwise use play as a means to explore are particularly intriguing to schools. Such devices, which currently are primarily illustrated by Android and Apple smartphones and tablets, the Microsoft Surface and Promethean's ActivPanel, and the Nintendo Wii and Microsoft Kinect systems, open up a wide range of uses for learners. Gesture-enabled devices aid collaboration, sharing, and group interactions.

Nonetheless, while gesture-based computing is garnering a lot of excitement in the consumer space, an extensive review was unable to uncover many current examples in higher education of gesture-based software or devices being applied to specific learning examples. As an enabling or assistive technology, however, gesture-sensing techniques are already having profound implications for special needs and disabled individuals. For example, devices with gesture control are already helping blind, dyslexic, or otherwise disabled students, reducing their dependence on keyboards. Researchers at McGill University are developing a system that allows those with visual impairments to get more feedback with fine degrees of touch. Gesture-based computing algorithms are also being used to interpret body language and even sign language.

As an experimental media, however, it is easy to find examples of projects that are pushing the edges of gesture-recognition, especially as it converges with

Gesture-based computing allows users to engage in virtual activities with motions and movements similar to what they would use in the real world, manipulating content intuitively.

voice recognition in natural user interface applications. The idea of being able to have a completely natural interaction with your device is not new, but neither has its full potential been realized. Recent advances across the board in the underlying technologies, along with strong interest in the consumer electronics segment, bode well for this category of technologies to continue to see new and compelling developments.

A sampling of applications for gesture-based computing across disciplines includes the following:

> **Art and Fashion Design.** Created by students at Ball State University, "Morp Holuminescence" uses body gestures to adjust the light in a room for optimal viewing results. Designed for use in the fashion industry, the system offers an integrated lighting and sensor system, much of it built using the open-source Arduino prototyping platform. go.nmc.org/bnikw

> **Music**. The EyeMusic project at the University of Oregon uses eye-tracking sensors to compose multimedia productions based on the movements

of the user's eye movement. The performer looks at a physical location to visually process it or to create a sound, and EyeMusic reconciles those two motivations to achieve perceptual-motor harmony.
go.nmc.org/hmhxq

> **Science and Medicine.** Researchers at Norrkoping Visualization Centre and the Center for Medical Image Science and Visualization in Sweden have created a

Gesture-based computing is changing the ways that we interact with computers, both physically and mechanically. As such, it is at once transformative and disruptive.

virtual autopsy using a multi-touch table. Detailed CT scans are created from a living or dead person and transferred to the table where they are manipulated with gestures, allowing forensic scientists to examine a body, make virtual cross-sections, and view layers including skin, muscle, blood vessels, and bone.
go.nmc.org/edaic

Gesture-Based Computing in Practice
The following links provide examples of gesture-based computing in use in higher education settings:

3Gear Systems
go.nmc.org/tahtr
A pair of MIT graduate students created a marker-based gesture interaction system that would cost about one US dollar to produce, using off the shelf computer cameras and a pair of Lycra gloves. This economical advancement in user interfaces will make human interaction with computers and digital devices more natural.

LZI Technology
go.nmc.org/ophom
European-based company Extreme Reality is creating software that will allow users to control computer programs, games, and mobile devices with their hand gestures and movements. The technology will work with mechanisms already built into computers and mobile devices so no extra hardware will be required.

Mogees: Gesture-Based Recognition with Contact-Microphone
go.nmc.org/kepyk
Using a contact microphone, two researchers connected to a system that processes sound in real-time and turns any surface into its own touchscreen. This system is transforming the vibrations transmitted from touch into waveforms that a computer will recognize.

MudPad
go.nmc.org/xjtek
Researchers in the Media Computing Group at RWTH Aachen University are developing a localized active haptic feedback interface, called MudPad, for fluid touch interfaces in order to offer more nuanced ways to interact with screens through touch.

Zero Touch
go.nmc.org/xpsge
Researchers at Texas A&M University have developed a multi-touch system from infrared sensors that allows precision free-air interaction. Users reach into a frame lined with sensors, and can use their hands, elbows, arms, head, or any object, such as a pen, to create compositions on their computer screens.

For Further Reading
The following articles and resources are recommended for those who wish to learn more about gesture-based computing:

7 Areas Beyond Gaming where Kinect Could Play a Role
go.nmc.org/yskco
(Alex Howard, O'Reilly Radar, 3 December 2010.) This article looks at how the gesture-based Kinect System from Microsoft can have broad use beyond its intended

use as a gaming platform. Uses include applications in art, health, and education.

Gesture Recognition Moves Beyond Gaming
go.nmc.org/auimq
(Steve Sechrist, Software Quality Connection, 23 May 2011.) In the context of the major developments in gesture recognition, the author discusses the potential for Kinect-style natural user interfaces.

LG adds Google TVs, Smart TVs get Voice and Gesture Control
go.nmc.org/eilfc
(James K. Willcox, *Consumer Reports*, 9 January 2011.) LG Electronics is releasing televisions that double as computer monitors so users can download apps from the Android Market to surf the web on their televisions. The SmartTV platform will also have voice and gesture control, and built-in Wi-Fi to beam content like music, photos, and videos from a notebook to the television set.

SoftKinetic Previews Next-Gen Gesture Interfaces
(Video)
go.nmc.org/qhjle
(SoftKinetic, youtube.com, 29 March 2011.) In this video prepared by SoftKinetic for the 2011 Consumer Electronics Show, the next generation of gesture interfaces is illustrated. SoftKinetic is developing 3D gesture control middleware for a wide range of devices and platforms.

To Win Over Users, Gadgets Have to Be Touchable
go.nmc.org/lagrp
(Claire Cain Miller, *New York Times*, 1 September 2010.) This article discusses how gesture-based computing has become a prevalent way that we interact with our computers, especially mobile devices such as smartphones and tablets.

The idea of being able to have a completely natural interaction with your device is not new, but neither has its full potential been realized.

Internet of Things

Time-to-Adoption Horizon: Four to Five Years

he Internet of Things has become a sort of shorthand for network-aware smart objects that connect the physical world with the world of information. A smart object has four key attributes: it is small, and thus easy to attach to almost anything; it has a unique identifier; it has a small store of data or information; and it has a way to communicate that information to an external device on demand. The Internet of Things extends that concept by using TCP/IP as the means to convey the information, thus making objects addressable (and findable) on the Internet. Objects that carry information with them have long been used for the monitoring of sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, identification, and similar applications. Smart objects are the next generation of those technologies — they "know" about a certain kind of information, such as cost, age, temperature, color, pressure, or humidity — and can pass that information along easily and instantly. They can be used to digitally manage physical objects, monitor their status, track them throughout their lifespan, alert someone when they are in danger of being damaged or spoiled — or even to annotate them with descriptions, instructions, warranties, tutorials, photographs, connections to other objects, and any other kind of contextual information imaginable. The Internet of Things would allow easy access to these data.

Overview

The Internet of Things, a concept advanced by IP co-creator Vint Cerf, is the next step in the evolution of smart objects — interconnected items in which the line between the physical object and digital information about it is blurred. The advent of IPv6 has extended the Internet address space significantly, thus providing an avenue for any object, like is done with today's web cams or shared printers, to use the Internet to transmit and receive data and information from an object or piece of equipment. Vint Cerf noted that already we have Internet-enabled phones, appliances, picture frames, and office equipment. It is not a large step to envision Internet-enabled electric meters that use the Smart Grid to let your house know to raise the ambient temperature a degree to help offset a peak load. Indeed, Cerf sees the Smart Grid as an accelerator for the Internet of things.

While there are examples, such as the Smart Grid, of what the Internet of Things might look like as it unfolds, it is still today more concept than reality. At the same time, the underlying technologies that will make it possible — smart sensors that can easily be attached to everyday objects to monitor their environment or status; new forms of low-energy radio transmission that can enable the sensor to send its information wirelessly or via electric lines to a network hub; and an expanded address space for the Internet — are all well understood, easily mass-produced, and inexpensive.

Smart objects have appeared in several previous editions of the *NMC Horizon Report*, and are described in the opening paragraph as having the attributes of being easy to attach, often much like a sticker; uniquely identifiable; a small data store; and a way to read and write to that store of data. Several radio-based technologies are being explored as the first point of transmission, from the simple and ubiquitous RFID approach broadly used for inventory control to the proximity-based secure data exchange made possible via Nokia's near field communication (NFC) technology. NFC was designed to allow users to make secure payments to kiosks, gas pumps, or dispensing machines via smartphones, but it will also allow smart objects to communicate securely over small distances.

Today, NFC is optimized for payment data, and thus works over distances of just a few inches, but when that is extended to a few feet, as RFID is today, secure wireless communications between objects in a room and a wireless hub will be possible.

Relevance for Teaching, Learning, or Creative Inquiry

The advantages of Smart Grid technologies in efficiently managing energy resources are an obvious benefit to any organization, and similar remote monitoring and control via the Internet is already finding its way into laboratories where such sharing of expensive resources has long been a part of how institutions collaborate. Smart objects will allow a similar approach to be applied to all sorts of materials and delicate artifacts. The devices required to do so are small, do not require batteries or external power, can communicate wirelessly, and are inexpensive. They can be attached to any object very discretely, and then used to track, monitor, maintain, and keep records about the object.

Anthropology and history departments will have an instant window into the condition of the objects, with the Internet being the mechanism for real-time monitoring of current location, environment, and movement of an object in their care or collections. Once such information is accessible, it is easy to imagine it being attached to other sorts of information in ways that will blur the line between the object itself and content related to it. For example, every bone in an Allosaurus skeleton has a story — when it was discovered, its position in the body, the temperature at which it is being stored, its provenance info, and more. An Internet of Things would make it simple to attach all that information directly to the bones themselves via an IP-enabled smart object that adds a constant stream of monitoring information about the physical object.

In the classroom, IP-addressable projectors can already stream the slides or videos professors are sharing so that students who could not physically attend class can view the presentations and lecture materials from wherever they are. Similarly, small smart sensors placed in study rooms around campus buildings could provide real-time updates on the occupancy of the rooms via the network. When placed inside loaner equipment, these sensors would allow campus managers to know if a sensitive camera or piece of equipment had been dropped or otherwise put at risk while on loan. In fieldwork, when attached to scientific samples, IP-enabled sensors could use the Internet to alert scientists and researchers to conditions that might impair the quality or utility of the samples.

> ## The advent of IPv6 has extended the Internet address space significantly, thus providing an avenue for any object to use the Internet to transmit and receive data and information from an object or piece of equipment.

A sampling of applications of the Internet of Things across disciplines includes the following:

> **Attendance.** Northern Arizona University is using student cards that are embedded with RFID tags to track their class attendance. This is helping professors who teach large classes by automating a once manual process. go.nmc.org/jvhzg

> **Marine Biology.** Researchers are using an RFID system to track marine animals' behavior, even in saltwater, with a network of antennas set up in a given area that read data from the tiny transponders attached to the organisms as they pass by. go.nmc.org/cikkq

> **Resource Management.** The El Paso Health Sciences Center at Texas Tech University adopted a campus-wide RFID system to track the location of science lab equipment and resources. A built in reporting suite updates users on check-in and check-out information, and the system also enables users to make online resource transfers. The Center has reported that the

time it takes to account for inventories has drastically decreased. go.nmc.org/qulqx

Internet of Things in Practice

The following links provide examples of the Internet of Things in use in higher education settings:

Amarino
go.nmc.org/uyllx
Amarino, developed by MIT, is a toolkit that allows users to control the lights in a room, and detect exposure levels to radiation or other potentially harmful environmental factors through their smartphones.

NYU's Sensitive Buildings Class
go.nmc.org/nhqfj
New York University's ITP program offers a course where students create smart habitats for city dwellers. Students learned how sensor management systems work and created their own prototypes with Digi products.

Otago Museum Radio Tracking System
go.nmc.org/pjouu
In an effort to increase security, Otago Museum launched a project that entails the installation of a radio tracking system to monitor all of its objects. Each artifact will be tagged, and RFID readers will track the items as they move around the museum space.

Penn State Behrend's RFID Center of Excellence
go.nmc.org/kxwlh
Penn State Behrend's RFID Center conducts research and outreach on RFID technology to better integrate it into the business school curriculum, assist IT providers to attain RFID expertise, and provide prototype testing services for customized applications.

Smart Grid Developments in 2011 (pdf)
go.nmc.org/zlszm
This annual report by energy management firm, KEMA, tracks the progress of smart grid development around the globe. They consider three critical factors when evaluating the progress of Smart Grid deployments: technology advancement, deployment track record, and policy and regulatory drivers.

UVM Environmental Building Goes Green
go.nmc.org/leeue
Students and faculty in the Rubenstein School of Environment and Natural Resources have "rehabbed" the Aiken building which now has temperature sensors that advise when to open or shut the windows, and carbon dioxide sensors that trigger more fresh air into a classroom when the CO_2 level gets too high.

For Further Reading

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

How the "Internet of Things" Is Turning Cities Into Living Organisms
go.nmc.org/cxmqs
(Christopher Mims, *Scientific American*, 6 December 2011.) If city systems are able to react to information stored in the cloud, a city could be "a virtual nervous system" that immediately responds to environmental conditions like rainstorms.

The Internet Gets Physical
go.nmc.org/yirhc
(Steve Lohr, *The New York Times*, 17 December 2011.) Smart devices are already a major link in human interaction, but they are further linking humans to their environment in ways that will benefit energy conservation, transportation, health care, food distribution, and more.

Internetting Every Thing, Everywhere, All the Time
go.nmc.org/tgyqn
(Cherise Fong, *CNN*, 2 November 2008.) Any object can do the same things as a web page and smart objects are becoming more prevalent. This article outlines some current examples of how smart technology is actualizing "The Internet of Things," where objects, beings, and data seamlessly interact.

Launching Google Wallet on Sprint
go.nmc.org/hurhd
(Google Mobile Blog, 19 September 2011.) This announcement from Google explores Google Wallet — a new method of ecommerce that allows people

to make purchases from their phones with near field communication as the secure mechanism for storing and transmitting user payment information.

NFC Technology: 6 Ways it Could Change Our Daily Lives
go.nmc.org/lumcp
(Sarah Kessler, *Mashable*, 6 May 2010). Contactless payment and infotags containing schedules and announcements are both cited in this article as two of the most potentially transformative features of near field communication.

Anthropology and history departments will have an instant window into the condition of the objects, with the Internet being the mechanism for real-time monitoring of current location, environment, and movement of an object in their care or collections.

Methodology

The process used to research and create the *NMC Horizon Report: 2012 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 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: 2012 Higher Education Edition* can be found at 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 board represents a wide range of backgrounds, nationalities, and interests, yet each member brings a particularly relevant expertise. Over the decade of the NMC's Horizon Project research, more than 450 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.

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 dozens 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 four to 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 challenge(s) 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

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.

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.

The NMC Horizon Project:
2012 Higher Education Advisory Board

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