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- William Gibson

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Each of the three global editions of the *NMC Horizon Report* — higher education, primary and secondary education (K-12), 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.



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Interested in these emerging technology topics? Learn more about them and other edtech insights by “liking” us on Facebook at facebook.com/newmediaconsortium and following us on Twitter at twitter.com/nmcorg.



The NMC Horizon Report: 2012 K-12 Edition is a collaboration between the New Media Consortium, the Consortium for School Networking, and the International Society for Technology in Education.

The research behind the *NMC Horizon Report: 2012 K-12 Edition* is a collaboration between the New Media Consortium (NMC), the Consortium for School Networking (CoSN), and the International Society for Technology in Education (ISTE). Their critical participation in the production of this report and their strong support for the NMC Horizon Project is gratefully acknowledged. To learn more about the NMC, visit www.nmc.org; to learn more about CoSN visit www.cosn.org; to learn more about ISTE, visit www.iste.org.

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ISBN 978-0-9846601-4-8

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Citation

Johnson, L., Adams, S., and Cummins, M. (2012).

NMC Horizon Report: 2012 K-12 Edition. Austin, Texas: The New Media Consortium.

The NMC Horizon Report: 2012 K-12 Edition is made possible via a grant from HP.



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Photo by North-West University. Students on the Vaal Triangle campus in Vanderbijlpark, South Africa, where mobile learning approaches are being researched. Photo submitted for the HP Catalyst Project Showcase: go.nmc.org/hpcatalyst-north-west-u

Inside Front and Back Cover Photograph

Photo by Julie Bohnenkamp. Kindergarten 1:1 iPad Classroom at Center Grove Elementary in Greenwood, Indiana participating in part of an Indiana Department of Education Innovation grant. www.centergrove.k12.in.us/impossibilities

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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 K-12 Edition*, examines emerging technologies for their potential impact on and use in teaching, learning, and creative inquiry within the environment of pre-college education. While there are many local factors affecting the practice of education, there are also issues that transcend regional boundaries and questions we all face in K-12 education; it was with these questions in mind that this report was created. The *NMC Horizon Report: 2012 K-12 Edition* is the fourth in the K-12 series of reports and is produced by the NMC in collaboration with the Consortium for School Networking (CoSN), and the International Society for Technology in Education (ISTE), with the generous support of HP's Sustainability & Social Innovation team.

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

Each of the three global editions of the *NMC Horizon Report* — higher education, primary and secondary

education (K-12), 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

The *NMC Horizon Report: 2012 K-12 Edition*, examines emerging technologies for their potential impact on and use in teaching, learning, and creative inquiry within the environment of pre-college education.

course of just a few weeks in the early Spring of 2012, the advisory board came to a consensus about the six topics that appear here in the *NMC Horizon Report: 2012 K-12 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 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 K-12 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 K-12 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 a wide collection of other helpful projects and readings, can all be found in the project's open content database — the NMC Horizon Project Navigator (navigator.nmc.org) — and in the NMC Horizon EdTech Weekly App for the iPhone and iPad (go.nmc.org/app). All the background materials for the *NMC Horizon Report: 2012 K-12 Edition*, including the research data, the preliminary selections, the topic preview, and this publication, can be downloaded for free on iTunes U (go.nmc.org/itunes-u).

Technologies to Watch

The six technologies featured in the *NMC Horizon Report: 2012 K-12 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 schools within the next 12 months; the mid-term horizon, within two to three years; and the far-term, within four to five years. It should be noted at the outset that the *NMC Horizon Report* is not a predictive tool. It is meant, rather, to highlight emerging technologies with considerable potential for our focus areas of education and interpretation. Each of the six is already the target of work at a number of innovative organizations around the world, and the projects we showcase here reveal the promise of a wider impact.

Near-term Horizon

On the near-term horizon — that is, within the next 12 months — are two related but distinct categories: *mobile devices & apps* and *tablet computing*. These two sets of technologies have become a pervasive part of everyday life in much of the world, and are growing everywhere. Students have ever-increasing expectations of being

able to work, play, and learn on these devices whenever they want and wherever they may be.

> **Mobile devices & apps** are increasingly valued as important learning tools in K-12. Once banned from the classroom, mobile devices & apps have become such compelling tools that schools are beginning to rethink standing policies, and some are even beginning to implement “bring your own device” (BYOD) programs. The potential applications of mobiles are vast, and range from graphing complex mathematical equations to storing and sharing notes and e-book annotations. Apps in particular are the fastest growing dimension of the mobile space in the K-12 sector right now, with impacts on virtually every aspect of informal life, and increasingly, potential in almost every academic discipline. Always-connected Internet devices using 3G, 4G, and similar cellular networks, imbedded sensors, cameras, and GPS have inspired hundreds of thousands of applications. With a steady flow of new apps that take advantage of the continual stream of enhancements to these tools, as well as key advances in electronic publishing, and the convergence of search technology and location awareness, mobile devices & apps grow more and more interesting with each passing month.

> **Tablet computing** presents new opportunities to enhance learning experiences in ways simply not possible with mobile phones, laptops, or desktop computers, and is especially suited for one-to-one learning in the K-12 environment. High-resolution screens allow users of tablets, such as the iPad and Galaxy, to easily share content, images, and video. They are engaging and viewed as less disruptive than other hand-held devices (no phone ringing and no incoming text messages). Because tablets are able to tap into all the advantages that mobile apps bring to smaller devices but in a larger format, schools are seeing them not just as affordable solutions for one-to-one learning, but also as feature-rich tools for all sorts of assignments as well, often 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 K-12 education: *game-based learning* and *personal learning environments*. 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, the definition of personal learning environments has transcended its original ties and dependence on learning management systems. Personal learning environments (PLEs) have come to refer to any collection of resources and content that students have chosen to use in directing their own learning, at their own pace.

- > **Game-based learning** has gained more traction 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 single-player or small-group end of the spectrum are easy to integrate into the curriculum, and have long been an option in many schools; but the greatest potential of games for learning lies in their ability to foster collaboration and engage students deeply in the process of learning. Currently, the integration of games into K-12 is largely driven by individual educators who are motivated to experiment with gaming at school. There is a small but growing set of organizations that partner with schools to help them design or implement games, but until a way is found to marshal resources more effectively in support of game-based learning, it will remain on the mid-term horizon.
- > **Personal learning environments (PLEs)**, as outlined in this year's report, refer to the personal collections of tools and resources a person assembles to support their own learning — both formal and informal. The conceptual basis for PLEs has shifted significantly in the last year, as smartphones, tablets, and apps have begun to emerge as a compelling alternative to browser-based PLEs and e-portfolios. There has been a corresponding move away from centralized,

server-based solutions to distributed and portable ones. Despite the use of the word 'environment' in the name, the notion of a physical or virtual space is somewhat irrelevant to a PLE. The goal is for students to have more control over how they learn in school, just as they do at home, and for teachers to set expectations that their students will be actively engaged in designing and supporting their own learning strategies. Personal learning environments rely on enabling technologies, especially cloud computing and mobile devices, that make the learning environment portable, networked, and personally relevant.

Far-term Horizon

On the far-term horizon, set at four to five years away from widespread adoption, are *augmented reality* and *natural user interfaces*. Augmented reality is an intuitive doorway through which data can be easily attached to real world objects, settings, and processes in a way that facilitates a deeper understanding of what is being seen. Natural user interfaces make the technology we use far simpler and easier to use than ever before. Interfaces that react to touch, movement, voice, and even facial expressions are fundamentally changing how we interact with our devices — and our expectations for them. These technologies are several years away from mainstream use, but already it is clear that their impact will be significant, despite the lack of well-documented K-12 project examples. The high level of interest and investment in both areas are clear indicators that they are worth following closely.

- > **Augmented reality (AR)** refers to the layering of information over a view or representation of the normal world, offering users the ability to access place-based information in ways that are compellingly intuitive. Augmented reality brings significant potential to supplement information delivered via computers, mobile devices, video, and even the printed book. Adding to the experience, most of the current tools do this in ways that the user can control and manipulate in real-time. While augmented reality is much simpler to create and use now than ever before, it is still several years away from widespread adoption in schools, although

for informal education, it is already commonplace. History and science museums use augmented reality in creative ways to show visitors the science behind a phenomena as it happens, or what a building looked like centuries ago as they view it through the camera on their smartphones or tablets. Although AR

of progress has been made by exploring applications in these areas.

Natural user interfaces have proven especially beneficial for autistic, blind, deaf, and other special needs students; a great deal of progress has been made by exploring applications in these areas.

is a well-understood technology, and the enabling technologies are readily available, the lack of school-based examples justifies its placement on the far-term horizon.

- > **Natural user interfaces** allow computers to respond to gestures, motions of the body, facial expressions, voice, sound, and other environmental cues, and are replacing the keyboard and mouse as the standard for computer/human interaction. The various technologies that enable natural user interfaces are making interactions with computational devices far more intuitive, and often so simple that no instructions are even needed to use them. The device teaches you as you interact with it. From the touchscreens on smartphones and tablets, to the gesture and voice interactions built into the latest gaming systems (Xbox Kinect and Nintendo Wii, for example), to capable virtual assistants like Siri on the iPhone 4S, natural user interfaces enable users to learn by doing and seamlessly convert thought to action. Large multi-touch displays support collaborative work, allowing multiple users to interact with content simultaneously. Natural user interfaces have proven especially beneficial for autistic, blind, deaf, and other special needs students; a great deal

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

The advisory board of 46 technology experts spanned 22 countries this year, and their names are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled topics will have a significant impact on the practice of primary and secondary education around the globe over the next five years. The key trends driving interest in their adoption, and the challenges schools and school systems will need to address if they are to reach their potential, also represent their perspective, and are the focus of the next sections of the *NMC Horizon Report: 2012 K-12 Edition*, where each is detailed in the context of schools, teaching, and learning.



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 K-12 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 K-12 education. Once detailed, the list of trends was then ranked according to how significant each was likely to be for K-12 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 of 2012 through 2017. They are listed here in the order in which the advisory board ranked them.

1 Education paradigms are shifting to include online learning, hybrid learning and collaborative models. Budget cuts have forced schools to re-evaluate their education platforms and find alternatives to the exclusive face-to-face learning models. As such, what once was seen as a challenge has now become an increasingly interesting trend. Students already spend much of their free time on the Internet, learning and exchanging new information through various resources, including 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 similar — if not better — environments than classrooms, including opportunities for increased collaboration while equipping students with stronger digital skills. Hybrid models, when designed and implemented successfully, enable students to learn at

their own pace and style, whenever they want from wherever they are.

2 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 is again at the forefront. K-12 institutions have always been seen as critical paths to educational credentialing, but challenges from competing sources are redefining what these paths can look like.

3 As the cost of technology drops and school districts revise and open up their access policies, it is becoming increasingly common for students to bring their own mobile devices. A growing number of schools are launching “Bring Your Own Device” (BYOD) programs so that students can use the devices they already own in class as well as in the informal and out-of-school environments they are ubiquitous in now. This is happening partly because of how BYOD impacts budgets; schools can spend less money on technology overall if students use their own, while funneling the funds they do spend to help students who cannot afford their own devices. The interest in BYOD programs can also be attributed to an attitude shift as schools are beginning to better understand the capabilities of smartphones and other devices that still remain banned on most campuses.

4 People expect to be able to work, learn, and study whenever and wherever they want. This trend is certainly true for most adults, and many well-

paying jobs literally can be done from anywhere that has a mobile Internet connection. It is also true for many of today's school-age children, who live their lives in a state of constant connection to their peers, social groups, and family. While some decry the constant flow of information as a distraction or worse (with some justification), others see the opportunity to "flip" expectations about what is homework and what is schoolwork by taking advantage of those connections

If learners can connect the course material with their own lives and their surrounding communities, then they will become more excited to learn and immerse themselves in the subject matter.

as learning opportunities. The implications for formal learning are profound, as flipping uses the resources on the Internet to free up valuable teacher classroom time, and fundamentally changes the teacher-student relationship. When students know how to use their network connections for more than texting, learning becomes much more serendipitous, opening the door to "just-in-time" learning, and "discovered" learning.

5 Technology continues to profoundly affect the way we work, collaborate, communicate, and succeed. Increasingly, technology skills are critical to success in almost every arena, and those who are more facile with technology will advance while those without access or skills will not. The digital divide, once seen as a factor of wealth, is now seen as a factor of education: those who have the opportunity to learn technology skills are in a better position to obtain and make use of technology than those who do not. Evolving occupations, multiple careers, and an increasingly mobile workforce contribute to this trend.

6 There is a new emphasis in the classroom on more challenge-based, 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 schools, 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 and their surrounding communities, then they will become more excited to learn and immerse themselves in the subject matter. Studies of challenge-based learning in practice, including two authored by the NMC, depict an increase in the uptake of 21st Century Skills among learners, including leadership and creativity.



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 personal experience, in detailing a long list of challenges schools face in adopting any new technology. The most important of these are detailed below, but it was clear from the discussions with the experts that behind the challenges listed here is also a pervasive sense that local and organizational constraints are likely the most important factors in any decision to adopt — or not to adopt — a given technology.

Even K-12 institutions that are eager to adopt new technologies may be constrained by school policies, 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 K-12 community as a whole. The highest ranked challenges they identified are listed here, in the order in which the advisory board ranked them.

1 Digital media literacy continues its rise in importance as a key skill in every discipline and profession, especially teaching. This challenge appears at the top of the list because despite the widespread agreement on the importance of digital media literacy, training in the supporting skills and techniques is still very rare in teacher education. As classroom professionals begin to realize that they are limiting their students by not helping them to develop

and use digital media literacy skills across the curriculum, the lack of formal training is being offset through professional development or informal learning, but we are far from seeing digital media literacy as a norm. This challenge is exacerbated by the fact that digital literacy

Technology can and should support individual choices about access to materials and expertise, amount and type of educational content, and methods of teaching.

is less about tools and more about thinking, and thus skills and standards based on tools and platforms have proven to be somewhat ephemeral.

2 K-12 must address the increased blending of formal and informal learning. Traditional lectures and subsequent testing are still dominant learning vehicles in schools. In order for students to get a well-rounded education with real world experience, they must also engage in more informal in-class activities as well as learning to learn outside the classroom. Most schools are not encouraging students to do any of this, nor to experiment and take risks with their learning — but a new model, called the “flipped classroom,” is opening the door to new approaches. The flipped classroom uses the abundance of videos on the Internet to allow students to learn new concepts and material outside of school, thus preserving class time for discussions, collaborations with classmates, problem solving, and experimentation. The approach is not a panacea, and designing an effective blended learning

model is key, but the growing success of the many non-traditional alternatives to schools that are using more informal approaches indicates that this trend is here to stay for some time.

3 The demand for personalized learning is not adequately supported by current technology or practices.

The increasing demand for education that is customized to each student's unique needs is driving the development of new technologies that provide more learner choice and control and allow for differentiated instruction, but there remains a gap between the vision and the tools needed to achieve it. It has become clear that one-size-fits-all teaching methods are neither effective nor acceptable for today's diverse students.

Technology can and should support individual choices about access to materials and expertise, amount and type of educational content, and methods of teaching.

4 Institutional barriers present formidable challenges to moving forward in a constructive way with emerging technologies.

A key challenge is the fundamental structure of the K-12 education establishment — aka “the system.” As long as maintaining the basic elements of the existing system remains the focus of efforts to support education, there will be resistance to any profound change in practice. Learners have increasing opportunities to take their education into their own hands, and options like informal education, online education, and home-based learning are attracting students away from traditional educational settings. If the system is to remain relevant it must adapt, but major change comes hard in education. Too often it is education's own processes and practices that limit broader uptake of new technologies.

5 Learning that incorporates real life experiences is not occurring enough and is undervalued when it does take place.

This challenge is an important one in K-12 schools, because it can greatly impact the engagement of students who are seeking some connection between the world as they know it exists outside of school, and their experiences in school that are meant to prepare them for that world. Use of project-based learning practices that incorporate real-life experiences, technology and tools that are already

familiar to students, and mentoring from community members are examples of practices that can bring the real world into the classroom. Practices like these may help retain students in school and prepare them for further education, careers, and citizenship in a way that traditional practices are failing to do.

6 Many activities related to learning and education take place outside the walls of the classroom and thus are not part of traditional learning metrics.

Students can take advantage of learning material online, through games and programs they may have on systems at home, and through their extensive — and constantly available — social networks. The experiences that happen in and around these venues are difficult to tie back to the classroom, as they tend to happen serendipitously and in response to an immediate need for knowledge, rather than being related to topics currently being studied in school.

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 and have been identified as “Technologies to Watch.” They each have been placed on one of three possible adoption horizon that span the coming five years, and are detailed in the main body of the report, which follows.



Mobile Devices & Apps

Time-to-Adoption Horizon: One Year or Less

Mobile phones — distinct from new sorts of larger format mobile devices such as tablets — have as a category proven more interesting and more capable with each passing year. 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. 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. Apple's app store recently passed 25 billion downloads — with 10 billion in just the last eight months — and simple but useful apps have found their way into almost every form of human endeavor. The power of apps, coupled with the portability of mobile devices, is causing many schools to take another look at their policies regarding mobile devices. Many see mobiles as a key aspect of Bring Your Own Device (BYOD) environments.

Overview

Mobile devices have become one of the primary ways that youth interact with and learn from each other. Edison Research reports that in the U.S. alone, 61% of Americans age 12 and up own a mobile device, and 44% specifically own a smartphone. In affluent areas, those percentages are even higher; it is extremely common now for children, at younger and younger ages, to own and comfortably use smartphones. Common Sense Media reports that 52% of children even under eight-years-old have access to mobile media, and of this group, 11% spend an average of 43 minutes per day specifically with a mobile phone.

At the same time that phones have become more capable, and more pervasive among school-age

children, mobile apps have redefined the way we think about software itself. Sophisticated but simple tools routinely sell for as little as 99 cents, or are even free. It is easy and cheap to outfit a smartphone with exactly the feature set you want, and many people are

In the U.S. alone, 61% of Americans age 12 and up own a mobile device, and 44% specifically own a smartphone.

even beginning to see the mobile platform as the most compelling home for one's personal learning collection of tools and resources. Both Apple and Google have developed extensive collections of apps, and adding new tools and resources is as simple as it is inexpensive.

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 and iTunes U, 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 e-readers for the Kindle and Android platforms are heading the same direction.

As the potential of mobile computing is being demonstrated across an ever-growing list of K-12 education institutions, a successful shift from a traditional to a mobile environment still requires planning and research.

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 K-12 education sector is beginning to capitalize on this by integrating mobile apps into the curriculum and revising their school policies to allow the use of mobile devices and by extension, mobile apps.

Relevance for Teaching, Learning, or Creative Inquiry

Mobile devices & 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, and digital capture and editing bring rich tools for video, audio, and imaging. Mobile devices & apps encompass all this, and innovation in the mobile space continues at an unprecedented pace.

At the same time, schools are relaxing their mobile policies and opening up new and creative opportunities for students to use their smartphones and accompanying apps as learning tools. Forsyth County Schools in Georgia is one particularly good example of how schools can successfully open the door to students using their own devices, and they offer a collection of informative resources (go.nmc.org/forsyth). They have provided their teachers with professional development so they are able to use the devices themselves. Third grade students have made videos from their mobiles and much of the student bodies have become experts in digital media creation — a 21st Century Skill of growing importance. Students are engaged and feel empowered as creators of substance. At New Milford High School in New Jersey, students use their smartphones to access Poll Everywhere (go.nmc.org/poll) and answer questions from the teacher, who is then able to see everyone's responses in real-time to gauge the class' overall understanding of the material.

As the potential of mobile computing is being demonstrated across an ever-growing list of K-12 education institutions, a successful shift from a traditional to a mobile environment still requires planning and research. **Osseo Area Schools in Minnesota deployed an organic strategy, where they first allowed student-owned devices in a few classrooms and monitored the impact before transitioning to a school-wide, and eventually a district-wide implementation.**

One of the main attractions for incorporating mobiles so prominently in the classroom is that apps used in tandem with class curriculum can help students better understand complex material. The new Khan Academy app puts supplemental instructional videos, ranging from art history to linear equations, in the hands of students, while the interactive "Aero!" app makes physics easier to

grasp by focusing on the flight dynamics of an albatross. Apps with interactive components enable students to learn by doing, not just by listening to teacher lectures. The “Elements” app has been the best example of this, and a catalyst for the launch of similar apps. Students are able to explore elements from the periodic table by using the touchscreen to rotate 3D images — an experience that mimics the act of physically holding the elements. Similarly, the “Frog Dissection” app leads students through a virtual exploration of the frog anatomy — an alternative for schools without access to science laboratory equipment, as well as for squeamish students.

Apps such as “Evernote” allow students to add video, photos, and more to their notes and readily share them with their peers. Students can store individual notebooks in the app, organized by subject, and easily perform a search to find a specific term in their notes while they are studying at home. One freshman English teacher from the Lodi Unified School District in California is using “Edmodo” to post alerts to her students about assignments and keep track of homework submissions. Students use it to turn in their assignments, share notes, and check their grades.

The increasing availability of network access means that the growing capabilities of mobiles are available to more students in more locations each year. Schools 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 designing class curriculum to incorporate interaction with smartphones and apps.

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

> **Language Arts.** Hazeldale Elementary School in Oregon uses the app “Toontastic” to learn pronunciation, grammar, and vocabulary. Through this app, students create their own animated stories and watch replays of the scenes they have created, which helps them understand and correct any mistakes. go.nmc.org/orego

> **Mathematics.** Third graders at Gobles Elementary

School in Michigan are using smartphones to draw diagrams to help understand multiplication. The early results are promising, showing that students are more engaged in the material, and teachers have noticed an improvement in student performance and attitude. go.nmc.org/goble

> **Research and Analysis.** Richard S Fowler School in St. Albert, Alberta is using mobile devices to empower students to do research and data analysis for solving complex problems, publish with multimedia, communicate with peers and experts, and work collaboratively. go.nmc.org/rsfgs

Mobile Devices & Apps in Practice

The following links provide examples of mobile devices & apps in use in K-12 education settings:

Idaho Digital Learning Mobile Initiative

go.nmc.org/idaho

Last spring, Idaho Digital Learning launched an initiative that allows specific content within existing classes to be accessible through a mobile app and is creating additional mobile accessible learning activities.

The “Magic of Learning” via Smartphone

go.nmc.org/magic

The Girls’ Schools Association, representing most of the UK’s independent girls’ schools, is encouraging the use of smartphones in the classroom, particularly as a means of replacing traditional textbooks. They also believe it is important for students to be able to learn responsible use of the technology and improve their research skills.

Metcalf Laboratory School: Apps in the Classroom

go.nmc.org/metca

The teachers at Metcalf Laboratory School in Illinois are exploring the use of apps as classroom learning tools. They built a website to share their reviews of specific apps and how they have integrated them into components of their curriculum. Their findings cover a wide range of disciplines, from algebra to etymology.

Smartphones at Swiss Primary School

go.nmc.org/swiss

At a Swiss primary school, 5th grade students are

equipped with smartphones and allowed to use the Internet services at no charge. As a result, students have become more engaged in the content and their digital literacy has increased.

For Further Reading

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

7 Myths About BYOD Debunked

go.nmc.org/7myth

(Lisa Neilsen, *The Journal*, 9 November 2011.) BYOD has become a controversial subject. Some arguments against it are that BYOD deepens the digital divide or that it will cause students to be distracted. This article confronts the current concerns and explains why they are invalid.

10 Schools Encouraging Smartphones in the Classroom

go.nmc.org/10sch

(Jeff Dunn, *Edudemic*, 12 December 2011.) This article explores 10 schools that are creatively using smartphones in their classrooms. Uses range from interacting with educational apps and programs to submitting homework, to graphing and tracking science experiments to performing “web quests.”

How Mobile Apps Are Changing Classrooms and Education

go.nmc.org/howmo

(Piyush Mangukiya, *Huffington Post*, 3 February 2012.) This article describes how mobile apps are adding to the in-classroom experience as well as extending the classroom outside of the building. In the classroom, engagement is increased. Full course curriculums can be published to platforms like iTunes U so that content is available outside the classroom.

In Some Cash-Strapped Schools, Kids Bring Their Own Tech Devices

go.nmc.org/insom

(Tina Barseghian, *MindShift*, 3 February 2012.) Mankato Public School System in Minnesota encourages students to bring any tech devices they own to school, which

they connect to the school’s wireless network to use in class. The school has also purchased a limited number of devices to be available for students who do not have their own. This article addresses the pros and cons of this strategy.

More American Students Use Personal Tech Devices in the Classroom

go.nmc.org/morea

(Charles Atkeison, *CNN*, 11 August 2011.) Students using their own mobiles and devices in the classroom have seen grade increases on assignments, as they are now able to better understand learning material. The author cites specific examples of schools that are allowing students to bring their own devices and includes differing reactions from parents.

My Teacher Is an App

go.nmc.org/mytea

(Stephanie Banchemo and Stephanie Simon, *Wall Street Journal*, 12 November 2011.) This article explores how more than ever, students are learning outside the classroom via mobile apps. The technology supports and encourages informal learning, which, in turn, helps students perform better in the classroom.

Time to Repeal the Cellphone Ban, Students Say

go.nmc.org/timet

(Schoolbook, *The New York Times*, 2 November 2011.) This article examines mobiles in schools from the student perspective, citing that bans on cell phones demonstrate an underestimation of students’ responsibility. Students are already using mobiles anyway, and incorporating them thoughtfully into school will only increase the responsible and creative uses.



Tablet Computing

Time-to-Adoption Horizon: One Year or Less

In the past two years, advances in tablets have captured the imagination of educators around the world. Led by the incredible success of the iPad, which in 2011-12 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 market. In the process, the tablet (a form that is distinct from tablet PCs) has 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 gesture-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* series this year, completely distinct from mobiles. According to a recent study from Chitika, the iPad now accounts for more than 95% of all tablet-based web traffic in the U.S., and 88% of global tablet web traffic. Similar statistics show tablets are increasingly the device of choice for social networking and reading news. The newest iPad, with its revamped retina display and advanced HD camera, has added even more capability to the platform. Competing models, including Kindle Fire, Sony's S, Motorola's Xoom and Samsung's Galaxy Tab have not yet enjoyed the

success of the iPad (though 10% of South Koreans now own the Galaxy Tab, according to Android Beats), 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 easy access to newspapers, magazines, and managing subscriptions — with a mere touch. Even without extending their

The device itself encourages exploration of its capabilities, something easily demonstrated by simply placing the device in the hands of a small child.

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

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.

Recent research indicates that tablets, because they are designed to easily share their screens, foster key 21st Century Skills in students, including creativity, innovation, communication, and collaboration.

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 natural user interfaces have moved tablets far beyond the point and click capabilities of touchscreens, and tablets are engaging and intuitive devices to use. This combination of features is especially enticing to educational institutions at all levels, and a growing number of K-12 institutions are considering tablets as a cost-effective alternative 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

Relevance for Teaching, Learning, or Creative Inquiry

Because of their portability, large display, and touchscreen, tablets are ideal devices for one-to-one deployments. A number of schools are using the devices to support and enhance inquiry-based learning, challenge-based learning, and other forms of active learning, and recent research indicates that tablets, because they are designed to easily share their screens, foster key 21st Century Skills in students, including creativity, innovation, communication, and collaboration. As a result, more and more schools are choosing tablets as one-to-one devices.

Calgary Science School, for example, has been a one-to-one school for the past five years. Last year, they introduced the iPad into their environment and have found already that the device has enabled students to become producers and creators, rather than passive consumers, of content. The school is documenting its iPad journey with the hopes that their findings will be beneficial to other educators embarking on similar explorations (go.nmc.org/calga). Pleasant City Elementary School in Florida is using the iPad as a vehicle to increase student performance by using iBooks and iBooks Author for content-driven, interactive lessons. Their goal is to create a library of e-books that gives educators current and meaningful content that engages students in the subject matter (go.nmc.org/pleas).

Tablets also have proven benefits for students with special needs. At Belle View Elementary School in Virginia, the iPad has enabled autistic students to better communicate with their teachers what they are thinking and needing. At Auburn School in Maryland, students with social and communication disabilities are

sitting together, poring over content displayed on the iPad, making eye contact with one another. Students can choose from a wide spectrum of apps and e-books, such as EngLit and the enhanced e-book for T.S. Elliot's "The Wasteland," (go.nmc.org/tselli) that provide easy-to-comprehend notes on the text, video interviews with authors and scholars, and other reading aids.

While tablet programs are still very new, a number of major studies are underway or recently completed that look to measure their outcomes, and many are moving quickly to share results — this bodes well for continued further adoptions. One such group is iPads for Education, based in Australia (go.nmc.org/ipads). They are compiling resources, first-hand accounts from educators, app reviews, case studies, and more that document the results of using the iPad for a wide variety of applications. Overall, the outcomes are very positive, including increased student engagement and sense of leadership, and better teamwork and communication. Still to be adequately documented in K-12 are other 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.

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

- > **Literature.** One elementary school teacher is using the iPad to update traditional student literature circles and make them more effective. Using a variety of features and apps, including "Edmodo" and "GoodReader," he has access to group member contributions, and with iBooks, students are able to share notes, annotate, and bookmark multiple passages to refer to later. go.nmc.org/litcir
- > **Mathematics.** A third grade teacher at Millstone Elementary School in New Jersey is using the "Math Bingo" app to help students master math concepts through gaming. Students receive immediate feedback when they make an incorrect answer and are rewarded when they pass through various levels. go.nmc.org/mills

- > **Physics.** High school classes are using the iPad app "Clinometer" to measure slope, object surfaces, precise angles of incline and decline, and more. The app uses the motion sensor of the iPad, which enables students to guide the device to an equilibrium and work on their balance skills. go.nmc.org/clino

Tablet Computing in Practice

The following links provide examples of tablet computing in use in K-12 education settings:

Archbishop Mitty High School's iPad Program

go.nmc.org/mitty

Named an Apple Distinguished School, Archbishop Mitty High School in California launched an iPad program in which students are graphing quadratic equations and parabolic functions in their mathematics classes, exploring interactive maps in their social studies classes, creating presentations, and performing a wide variety of other tasks across multiple disciplines.

iPad for Autistic Kids

go.nmc.org/ipada

In South Africa, the Key School for Specialised Education is using the iPad to help autistic students with their communication skills. The iPad is easier to use than traditional computers because it can be manipulated via touch to give the students immediate feedback. Nonverbal students have been more interactive, communicating through pictures or repeating words pronounced by the iPad.

Ringwood North Primary's CBL Project

go.nmc.org/ringw

As part of Apple's global "Challenge Based Learning" program, 5th and 6th grade students at Ringwood North Primary School in Melbourne, Australia used one-to-one iPad devices to research areas hit by natural disasters and the issues those communities faced. From there, they planned out and implemented solutions to help the communities recover.

SVSD iPad Pilot

go.nmc.org/svsd

Snoqualmie Valley School District in Washington embarked on an iPad pilot program to identify teacher

and student training needs, understand how the iPad can enhance student learning and achievement, and provide avenues for teachers to network and share best practices on integrating the device into the curriculum.

Youth LINKS

go.nmc.org/youth

Global Nomad Group's exchange program Youth LINKS is using tablets to reach a wider audience in Kabul, Afghanistan and across the United States. Youth LINKS is a year-long program connecting six schools in the US with six schools in Afghanistan via videoconferencing and online platforms. The program can be extended to any place that has a wireless signal.

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 education, based on reports from classrooms that have participated in pilot studies, citing that iPads fit with students' current lifestyles.

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.

Intel Releases Rugged Education Tablet for the Developing World

go.nmc.org/intel

(Josh Smith, *GottaBe Mobile*, 10 April 2012.) Intel has created a tablet called Intel Studybook that is made to be resistant to water and dust, as well as being more durable when dropped. This looks like a great option for mobile labs in which students take tablets out with them for field research.

iPads: What are We Learning? (PDF)

go.nmc.org/albert

(Government of Alberta, 3 October 2011.) Alberta Education hosted an event for school authorities that are exploring the use of iPads in schools, which resulted in a report that covers subjects including student engagement and enhanced student assessment.

Math That Moves: Schools Embrace the iPad

go.nmc.org/matht

(Winnie Hu, *The New York Times*, 4 January 2011.) Roslyn High School on Long Island handed out 47 iPads to students and teachers in two humanities classes for a pilot program in which iPads replace textbooks, allow students to correspond with teachers, turn in papers and homework assignments, and preserve a record of student work in digital portfolios. The school sees the investment as one that will pay for itself by cutting future costs in printing and textbook costs.

Six Examples of iPad Integration in the 1:1 Classroom

go.nmc.org/sixexa

(Andrew Marcinek, *Edutopia*, 24 April 2012.) In this article, an instructional technologist at Burlington High School in Massachusetts explains why iPads have become invaluable. He describes how six different teachers at his high school are using the devices to engage students across a variety of disciplines.



Game-Based Learning

Time-to-Adoption Horizon: Two to Three Years

Game-based learning refers to the integration of games or gaming mechanics into educational experiences. This topic has gained considerable traction over the past decade as games have proven to be effective learning tools, and beneficial in cognitive development and the fostering of soft skills among students, such as collaboration, communication, problem-solving, and critical thinking. The forms of games grow increasingly diverse and some of the most commonly used for educational purposes include alternate reality games (ARG), massively multiplayer online games (MMO), and global social awareness games. Most games that are currently used for learning across a wide range of disciplines share similar qualities: they are goal-oriented; have strong social components; and simulate some sort of real world experience that students find relevant to their lives. As game-based learning garners more attention in academia, developers are responding with games expressly designed to support immersive, experiential learning.

Overview

Despite steady interest from educators, game-based learning has been tantalizingly just out of reach for the K-12 mainstream, and again appears on the mid-term horizon, still two to three years away. This may be because a compelling supporting technology or concrete set of tools has not emerged that schools can broadly use to bring game-based learning to life, although tablets may open that door more broadly. For much of the last decade, the integration of game-based learning into K-12 classes has usually been the work of one or a small group of motivated educators who incorporate elements of gaming into lesson plans.

Nonetheless, the rationale for using games for learning continues to resonate with many educators. With now

more than a decade of solid exploration completed, it is clear that when applied properly, games can yield powerful outcomes — a concept now recognized at the highest levels of education policy. In the most recent National Education Technology Plan, gaming was named

Despite steady interest from educators, game-based learning has been tantalizingly just out of reach for the K-12 mainstream.

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, to get to the next level, and ultimately, to 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.

Perhaps the most popular games at the K-12 level come in app form. This is especially true as an increasing number of schools invest in one or more key enabling technologies — mobiles or tablets, for example, where games are the most downloaded genre of apps, followed

closely by news, maps, and social networking. For April 2012, four of the top five most downloaded apps in the iTunes store were games. Educational games like “Dabble,” the fast-thinking word game, and “Move the Turtle,” a game for young and aspiring programmers, are used both inside and outside of the classroom.

Over the past couple years, there has also been more traction surrounding massively multiplayer online (MMO) games. Online games including “Minecraft”

soft skills schools strive for 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 that enable students to experience the world from someone else’s eyes, to online social games that present real world problems and raise global awareness, to the incorporation of game design in computer science classes, game mechanics can be integrated on many different levels in K-12 curriculum.

From role-playing games that enable students to experience the world from someone else’s eyes, to online social games that present real world problems and raise global awareness, to the incorporation of game design in computer science classes, game mechanics can be integrated on many different levels in K-12 curriculum.

(go.nmc.org/massi) and “World of Warcraft” have been integrated into course curriculum, with educators and educational technology writers frequently documenting their stories and outcomes. MMOs bring 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

While most games contain a clear reward system for players (moving up a level, receiving badges or points, etc.), what may be most appealing to educators is that games provide students a safe place to learn from failure. In games, exploration is inherent and there are generally no high-stakes consequences. Children are able to experiment and take risks to find solutions without the feeling that they are doing something wrong. Games encourage students to make and learn from mistakes, which is a particularly important concept in the K-12 setting.

For schools that are daunted by the notion of starting from scratch to incorporate game-based learning, there are a growing number of organizations that are helping with this process. Creative Academies, for example, works with schools to focus content and curriculum around game development. They work with students to develop simulations and animations for the grade levels below them (go.nmc.org/creati). EdGE is another such organization, devoted to research and game design at the K-12 level (go.nmc.org/edge). Game design in itself is recognized as a successful way of engaging students with specific content by allowing them to creatively design their own games or activities to reach a specific learning outcome.

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, are one way that course content and game

play can overlap. “Statecraft X” is one such example, addressing the principles of governance in a high school social studies curriculum. Students learn political and leadership skills as they are assigned the role of governors in a medieval kingdom, where they have to overcome many challenges in order to develop and sustain a viable and thriving kingdom. In the process, they also learn the relationship between citizenship and governance (go.nmc.org/states).

Open-ended, challenge-based, truly collaborative games are an emerging category of games that prepare K-12 students for their continued education and the workforce. Games like these, which occur both online and in 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 students to learn how to learn along with mastering the subject matter. Such games require 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 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. 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:

- > **Chemistry.** Developed by the Learning Sciences Lab at the National Institute of Education in Singapore, the “Legends of Alkhimia” video game supports the chemistry curriculum for middle school and high school students. Students learn the subject by performing chemistry experiments, while positioned

in the role of apprentice chemists. The curriculum in the game adheres to the performance–play–dialog model of design for game-based learning. Students learn through inquiry. go.nmc.org/legen

- > **Humanities.** “Minecraft” is used in the humanities program at Yokohama International School in Japan, primarily as an engaging way for sixth and seventh grade students to collaborate on models of buildings and explore simulated natural and man-made environments. The game is incorporated into the units Early Humans, Earth and Man, Early Civilizations, and the Renaissance — all of which emphasize

Perhaps the most popular games at the K-12 level come in app form.

fundamental architectural and civic structures and the interaction between humans and the natural environment. go.nmc.org/minec

- > **Social Studies.** Third graders at HTS Independent School in Ontario, Canada, are using the SimCity iPad game to learn about the similarities and differences between rural and urban communities. They are building their own cities from the ground up and figuring out how to keep residents satisfied in the process, facing issues such as natural disasters, transportation, and residential taxes. go.nmc.org/htsin

Game-Based Learning in Practice

The following links provide examples of game-based learning in use in K-12 education settings:

Catalysts for Change

go.nmc.org/catal

The Institute for the Future and the Rockefeller Foundation teamed up to create “Catalysts for Change,” a game where players must plan and implement ways to alleviate world poverty. The game invites players to share their own ideas or to build upon more than 600 ideas that have been brainstormed by non-profit groups from all over the globe. Renowned game master Jane McGonigal helped design the game platform.

Design Corps

go.nmc.org/design

The Learning Games Network, in partnership with the State of Kentucky Department of Education, launched Design Corps as a project-based alternative to motivate and inspire learning and deeper understanding of subjects and topics across the curriculum. They have created a game design tool kit that reinforces important elements of research, documentation, communication, and collaboration with teachers as students develop games.

Game Designs Online

go.nmc.org/gamed

Big World Learning created an online course that brings together educational experts, gaming professionals and young learners over 10 weeks to learn to design and produce computer games. A weekly videoconference provides instruction for students alongside an asynchronous web space to set tasks, store learning resources and promote student discussion. Each week covers a separate element of game design, and a different industry expert joins each session.

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.

National STEM Video Game Challenge

go.nmc.org/stemc

As a component of President Obama's initiative to promote a renewed focus on Science, Technology, Engineering, and Math (STEM) education, the National STEM Video Game Challenge is a multi-year competition whose goal is to motivate interest in STEM learning among America's youth by tapping into students' natural passion for playing and making video games.

For Further Reading

The following articles and resources are recommended

for those who wish to learn more about game-based learning:

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.

Kids and Video Games: Why Children Should Play More

go.nmc.org/kidsan

(Scott Steinberg, *Venture Beat*, 13 March 2012.) This article highlights aspects of gaming, such as interactivity and creativity. Many gaming scenarios require strategic thinking, interpretative analysis, plan formulation, and the ability to respond to change.

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 author of 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.

New Learners of the 21st Century: Dr. James Gee

(Video)

go.nmc.org/newle

(PBS, 13 February 2011.) In this interview with educational gaming expert James Gee, he discusses how gaming environments stimulate advanced problem solving and innovation. He breaks down the structure of games, asserting that all good games are just sets of problems that must be solved by learning something new or applying what one has just learned.

The Only Game in Town

go.nmc.org/theon

(Alex Ross, *The Varsity*, 18 March 2012.) This article discusses the potential of augmented reality games that allow the player to interact within a narrative. David Fono, lead designer for the upcoming Toronto-based

augmented reality game, ZED.TO, is focusing on the storytelling possibilities.

Student-Created Video Games Enter Science Class

go.nmc.org/stude

(Jennifer Roland, *MindShift*, 2 April 2012.) Many schools are participating in Globaloria, a U.S. program that enables K-12 students to design educational games with global and social relevance. This article cites several success stories and discusses how the gaming activities have improved soft skills in students, including collaboration and self-directed learning.

What may be most appealing to educators is that games provide students a safe place to learn from failure. In games, exploration is inherent and there are generally no high-stakes consequences.



Personal Learning Environments

Time-to-Adoption Horizon: Two to Three Years

Personal learning environments (PLEs) support self-directed and group-based learning, designed around each user's goals, with great capacity for flexibility and customization. The term has been evolving for some time, but has crystallized around the personal collections of tools and resources a person assembles to support their own learning — both formal and informal. The conceptual basis for PLEs has shifted significantly in the last year, as smartphones, tablets, and apps have begun to emerge as a compelling alternative to browser-based PLEs and e-portfolios. Along with that, there has been a corresponding move away from centralized, server-based solutions to distributed and portable ones. Using a growing set of free and simple tools and applications, such as a collection of apps on a tablet, it is already quite easy to support one's ongoing social, professional, learning and other activities with a handy collection of resources and tools that are always with you. While the concept of PLEs is still fairly fluid, it is clear that a PLE is not simply a technology but an approach or process that is individualized by design, and thus different from person to person.

Overview

PLEs serve a dual purpose: They enable students to determine the style and pace at which they learn while exposing them to technologies that they may not otherwise encounter in traditional classroom settings that will help prepare them for university and the workforce. Though PLEs often emerge in the same conversations as learning management systems, there is a distinct and sometimes overlooked difference between the two. Learning management systems by nature are more about the ephemera of learning than the actual learning itself; it is the gathering of course calendars, assignments, and all other relevant content in a single place where both students and teachers

can access everything. On the other hand, PLEs are described as more about personalizing the environment and experiences at an individual level.

The underlying technologies needed to construct a personal learning environment are relatively straightforward and readily available now. For example, a person's smartphone or tablet and the growing collection of apps they have chosen to download directly represents their assortment of interests. With hundreds of thousands of apps available in multiple marketplaces, it is easy to see how no two people share the exact same set of apps. Everyone has distinctive preferences and approaches learning and exploration differently. This is the basic premise of personal learning environments. Many educators now believe that the ways we learn informally can, and even should, inform the experiences we create at school.

Though effective personal learning environments center around the learner and not the technology, personal learning environments draw significantly on enabling technologies and tools. Cloud computing, for example, allows users to easily store the content they want, and cloud-based productivity tools such as Google Apps and WikiSpaces enable them to share their content with others, gather new and relevant items, write personal commentary, complete assignments, and more. YouTube, iTunes U, Facebook, and other social media and open content platforms provide users with an outlet to discover new content and disseminate their own. Using a mobile device or tablet as the home for a PLE is a natural and intuitive approach that makes it both easy to access and portable.

The essential idea behind personal learning environments is that students are put in charge of the learning process, with a focus on how they can support

their own needs and preferences. The goal is to give the student permission to make their learning as effective and efficient as possible.

Relevance for Teaching, Learning, or Creative Inquiry

In concept, personal learning environments would encourage students to approach learning in ways best suited to their individual needs. Visual learners, for example, might be able to obtain material from a different source than auditory learners. Students using PLEs may further benefit from the practice of keeping track of, and curating, their own resource collections. Personal learning environments are seen as a way to shift the control over learning — particularly its pace, style, and direction — to the learner. When building their own environments and collections of resources, students are learning new research and content aggregation tactics, perhaps without even knowing it.

Many software and service providers are looking to become the next generation portals for personal learning. Schools experimenting with PLEs have turned to Symboloo (go.nmc.org/symba), Netvibes (go.nmc.org/netvi), Diigo (go.nmc.org/diigo), and Cengage (go.nmc.org/cenga) for simple dashboard solutions, or places to tag, store, and share content. Teachers can post predetermined lessons with educational components chosen by the student, and reflective of their interests. Providers such as the newly launched Junyo (go.nmc.org/junyo) integrate analytics to measure student learning across many different platforms and learning environments.

It remains unclear if these sorts of centralized tools will remain part of the evolution of personal learning environments. Some see PLEs merging with digital portfolios to provide a record of their learning that students can carry with them as they move through the various stages of their educational pursuits. This notion places the focus of PLEs on carving out a long-term identity for each student that may ultimately help them get into colleges and universities and provide prospective employers with extensive personal insight, a change that many feel is a move away from the basic tenets of the approach.

Despite the fact that there is a range of easy-to-use tools that could be used to construct personal learning environments, the emerging focus on helping students assess and select tools is still somewhat nascent. In the 2011 edition of this report, PLEs were placed on the far-term horizon because they were still in the conceptual development phase. In the past year, however, with the growing interest in smartphones and tablets, PLEs have gotten a conceptual “reboot” that now sees a

While the concept of PLEs is still fairly fluid, it is clear that a PLE is not simply a technology but an approach or process that is individualized by design, and thus different from person to person.

distributed model as both practical and promising — and as such, the topic moved to the mid-term horizon as it becomes more clear how schools might approach implementation.

A sampling of applications of personal learning environments across disciplines includes the following:

- > **Literature.** In a fifth grade class at Springside Chestnut Hill Academy in Pennsylvania, students are responsible for creating their own Wiki pages. They add content developed in Google Docs to videos, podcasts, web links, photos, and other materials gathered from the web. go.nmc.org/spring
- > **Professional Development.** The University of Florida College of Education offers a free, open course for any educators that want to explore how personal learning environments impact inquiry in K-12 education. It offers a repository of resources and an area where teachers chronicle their classroom experiences in implementing PLEs. go.nmc.org/yzjtf

- > **Science.** Scitable is a free science library and personal learning tool that allows students to explore subjects including genetics, science communication, and career planning. Students can ask experts questions, join discussions, and get help with concepts they do not understand. Teachers have access to a network of resources to build their own online science classroom for their students. go.nmc.org/scita

Personal Learning Environments in Practice

The following links provide examples of personal learning environments in use in K-12 education settings:

Gooru

go.nmc.org/gooru

Gooru is a STEM education research, search, and curation portal that relies on crowd sourcing and collective intelligence. A team of educators is tagging curated teaching resources at the conceptual level. They identify factually correct, image rich web content that can aid students and teachers when they are learning about a specific subject, such as velocity.

The Learning Hub

go.nmc.org/yokoh

At Yokohama International School in Japan, each student has their own blog that develops into their electronic portfolio and personal learning environment. Students use a wide variety of web-based tools to connect, collaborate, create, and share with both local and global audiences.

LTISD Learning Portal

go.nmc.org/ltisd

In Texas, Lake Travis Independent School District students have 24/7 access to a web-based learning environment from school, home, and their mobile devices. Online textbooks, digital supplemental resources, subscription research services, and teacher notes, presentations, and simulation tools are organized in the portal. The system was built so that thousands of students can access content on demand, at their own pace.

The PLAYground

go.nmc.org/thepl

The PLAYground is an online platform for the curation, creation and circulation of user-generated learning activities that encourages children and adults to learn and teach each other. It is designed to cultivate and promote learning activities centered on the idea of a challenge. Each challenge synthesizes a hands-on learning activity and encourages participants to collaborate, remix, and disseminate information.

Shared Learning Collaborative

go.nmc.org/shared

This project is developing a common data layer and encouraging independent software vendors to build personalized learning applications for five pilot states. In the process, the project is establishing common ways to exchange education data among systems and feed information to students, teachers, administrators and education scientists.

Trail Shuttle

go.nmc.org/trail

Developed in Singapore, Trail Shuttle is a self-directed learning platform that uses technology to enable students to build their own learning programs. A web-based tool kit helps students create their programs, a mobile app lets them explore and experience those programs from wherever they are, and a monitoring app allows teachers to track student progress.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about personal learning environments.

5 Video Case Studies of E-portfolio Implementation + an Implementation Toolkit

go.nmc.org/5video

(Tony Bates, *Online Learning and Distance Education Resources*, 3 April 2012.) JISC has created an e-portfolio implementation toolkit based on 12 UK, four Australian, and three New Zealand institutions that documented their experiences of using e-portfolios in various courses. There are also videos of five UK universities to serve as examples.

Happy For iPad Helps Curious Kids Discover The Web...Safelygo.nmc.org/happl

(Sarah Perez, *Tech Crunch*, 17 April 2012.) This article explores the new iPad app “Happy,” a collection of original and curated content for kids, including online videos, games, and stories. The app focuses on subjects that children deem fun (dinosaurs, outer space, etc.) and integrates educational features and information.

Preparing Students to Learn Without Usgo.nmc.org/prepa

(Will Richardson, *ASCD Educational Leadership*, February 2012.) This article emphasizes how teaching can be geared toward the specific interests of each individual student, making topics more relevant and interesting. As our culture moves toward customization of gadgets, playlists, and search results that reflect each individual's taste, many education models are becoming more individually focused.

Students Want Personalized Learning, Mobile Technologygo.nmc.org/stuwan

(Laura Devaney, *eSchool News*, 26 April 2012.) A recent study facilitated by Project Tomorrow shows students' and parents' approval of in-class mobile devices to support more personalized learning experiences. This article provides specific examples of how students are using technology to learn new concepts, including via social media platforms.

TED's New Site Turns Any YouTube Video Into a Lessongo.nmc.org/tednew

(Sarah Kessler, *Mashable*, 25 April 2012.) TED's new online “flip it” tool allows users to take any YouTube video, add supplemental content and resources, and track participation and responses to create a complete lesson, which has direct implications for personalized learning. This article includes images depicting an example of a finished video lesson.

This Time It's Personalgo.nmc.org/thistime

(Jennifer Demski, *The Journal*, 4 January 2012.) This article emphasizes the crucial role of changing the current classroom infrastructure to make it more student-centered in order to incorporate technology in a transformative way. The author states that incorporating new technological tools into outdated teacher-centered structures will not be effective.

Many educators now believe that the ways we learn informally can, and even should, inform the experiences we create at school.



Augmented Reality

Time-to-Adoption Horizon: Four to Five Years

Augmented reality (AR), a capability that has been around for some time, is shifting from what once required rooms of equipment to a set of simple-to-use tools with tremendous potential. The layering of information over 3D space produces a new experience of the world, sometimes referred to as “blended reality,” bringing with it new expectations regarding access to information and new opportunities for learning. While the most prevalent uses of augmented reality so far have been in the consumer sector (for marketing, social engagement, amusement, or location-based information), new uses seem to emerge almost daily, as tools for creating new applications become even easier to use. A key characteristic of augmented reality is its ability to respond to user input. This interactivity confers significant potential for learning and assessment; with it, students can construct new understanding based on interactions with virtual objects that bring underlying data to life.

Overview

The concept of blending — or augmenting — what we see in the real world with related information, data, media, and even live action is a powerful one. Augmented reality aims to do just that as a means to enhance the information we can perceive with our senses. The first modern application of augmented reality was when a cinematographer developed a simulator in the early 1960s that incorporated visuals, smells, and vibrations. By the 1990s, augmented reality was being put to use by a number of major companies for visualization, training, and other purposes. Now, the technologies that make AR possible are powerful and compact enough to deliver augmented reality experiences to personal computers — and even mobile devices. Early mobile applications began to appear

in 2008, and now many AR applications and tools for mobiles are on the market.

Augmented reality applications can either be marker-based, which means that the camera must perceive a specific visual cue in order for the software to call up the correct information, or markerless. Markerless applications use positional data, such as a mobile's GPS and compass, or image recognition, where input to the camera is compared against a library of images to find a match. Markerless applications have wider applicability since they function anywhere without the need for special labeling or supplemental reference points. Layar (go.nmc.org/rfomi) has been a leader in this space with augmented reality applications for the Android and iPhone platforms. Layar Vision is a markerless application of AR that makes it easy to develop apps that can recognize real world objects and overlay information on top of them.

In the commercial and entertainment sectors, augmented reality has been used so effectively, it is often not even noticed by the casual observer. For example, the floating yellow line that appears in telecasts of American football games is an AR application that represents where a team must drive to reach a “first down.” Games were quick to integrate the technology, and early examples such as *Halo* and *Rainbow Six* made the presentation of “heads up” data commonplace. In both of these examples, most observers see the added information as simply part of the experience.

Today, advancements both in AR technology and mobile capabilities are increasingly driving this technology into the handheld space. The cameras and screens in smartphones, tablets and other mobile devices now serve as uniquely convenient tools to combine real world data with virtual data. Sensor-based AR uses GPS

capability, image recognition, and the devices' built-in compasses to pinpoint where a mobile device is on the planet and where its camera is pointing, and then use that information to overlay relevant facts, data, or visuals at appropriate points on the screen.

While augmented reality has appeared in several previous editions of the *NMC Horizon Report*, always on the mid- or far-term horizon, what makes it fresh this year is the announcement of Google's Project Glass (go.nmc.org/proje). Up until this point, many augmented reality products and services relied on webcams and smartphone cameras to layer information over images. In the case of Project Glass, users actually wear the device; information, entertainment, and a variety of content are layered directly into their line of vision. Since Google's announcement, a growing list of companies is stepping up to compete with similar products of their own. The popular sportswear line Oakley, for example, is already planning the release of its own heads-up display technology, designed especially to aid athletes.

The most common uses of augmented reality currently are in entertainment and marketing, but schools are likely to follow as the technology matures and becomes even more simplified. Museum and cultural organizations are the first of the learning sectors to frequently and effectively use augmented reality, and the lessons learned there are easily applicable to schools. For example, a groundbreaking project by the City of Philadelphia Department of Public Records has used sensor-based augmented reality as a way to showcase some 93,000 historic photographs from the city's archives. Working with geographic services company, Azavea, they mapped the entire *PhillyHistory* collection.

Relevance for Teaching, Learning, or Creative Inquiry

One of the most promising aspects of augmented reality is that it can be used for visual and highly interactive forms of learning, allowing the overlay of data onto the real world. Augmented reality is an active, not a passive technology; students can use it to construct new understanding based on interactions with virtual objects that bring underlying data to life as it responds

to user input. Dynamic processes, extensive datasets, and objects too large or too small to be manipulated can be brought into a student's personal space at a scale and in a form easy to understand and work with. Students find connections between their lives and their education through the addition of a contextual layer.

The layering of information over 3D space produces a new experience of the world, sometimes referred to as “blended reality,” bringing with it new expectations regarding access to information and new opportunities for learning.

The ability to transfer learning from one context to another is a significant skill, one that AR can facilitate in its overt use of context and layering.

AR that relies on mobile devices leverages an increasingly ubiquitous tool that is blurring the boundaries between formal and informal learning. Indeed, the potential for just-in-time learning and exploration is a deeply compelling aspect of this technology.

Augmented reality has strong potential to provide powerful, contextual, *in situ* learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world. One of the easiest ways to visualize that potential is the ease with which it can make invisible things visible, such as the X-ray pictures or the preparatory drawings of a centuries-old painting, or to restore things to a previous state, such as illustrating the way the Berlin Wall appeared before it was torn down. Most of the activity happening in this area is taking place in universities and at museums, but the work going on there can easily be transferred to K-12 settings. Museums commonly use simple AR tools to provide straightforward, yet

engaging visuals and facts that are “layered” over objects or physical settings when viewed through phones or tablets. Providing students layered information about a historical object is a simple approach to giving students a deeper learning experience.

Augmented reality first appeared in the 2010 edition of this report, also on the far-term horizon, which signifies

One of the most promising aspects of augmented reality is that it can be used for visual and highly interactive forms of learning, allowing the overlay of data onto the real world.

the technology’s lack of movement in the K-12 sector. It still remains a consumer-driven technology with limited research and use case examples specifically occurring in schools.

A sampling of applications of augmented reality across disciplines includes the following:

- > **Art History.** San Diego’s School in the Park developed an augmented reality experience for its students built around a Chinese folktale. The activity required students to work through academic problems associated with the materials found in the San Diego Museum of Art’s Asian Art Exhibit. At each step, the students interact with the items through a handheld computer that triggers a geographic location using Layar technology. go.nmc.org/sandi
- > **Reading.** “Letters Alive” is a supplemental reading program utilizing augmented reality to teach children ages 4-8 how to read. Animal and vocabulary cards are placed under a 3Cam document camera to build sentences and display 3D like animations. This technology is leveraged to teach early literacy skills using research based best practices. go.nmc.org/letter

- > **STEM.** At Super School University, an afterschool program, teachers and students from 34 countries are working as backpack journalists and scientists, using the uninhabited island of Santa Luzia, Cape Verde for a virtual collaborative STEM project. Custom software has been created for the project websites, computers, and mobile devices. go.nmc.org/stem

Augmented Reality in Practice

The following links provide examples of augmented reality in use that have direct implications for K-12 settings.

Augmented Reality for Special Education

go.nmc.org/augme

This wiki was launched to explore the applications of augmented reality for special education, specifically for deaf and blind students. Augmented reality glasses, for instance, have potential to serve as speech recognition aids to display text as others are talking, allowing freedom for a deaf individual to attend speaking engagements without a sign language interpreter.

BuildAR

go.nmc.org/build

BuildAR is a Layar-based augmented reality platform that allows people — even without development experience — to create and host mobile augmented reality content online. Student-created content can be enhanced with augmented reality in creative ways.

The Earthquake AR Project

go.nmc.org/earthq

The Earthquake AR project was started in response to the 2011 earthquake in Christchurch, New Zealand. The project is exploring how mobile augmented reality can reveal data sets that would be helpful in the reconstruction of a demolished building.

Getting Learning out of the Classroom with Augmented Reality

go.nmc.org/getti

One educator is exploring ways students can learn and interpret their surroundings using two free GPS-enabled apps that allow users to attach audio recordings and

other information to a particular place in order to augment reality.

LearnAR

go.nmc.org/learn

LearnAR is an augmented reality resource that makes use of a digital, video, or web camera to display virtual content layered over real world content. For example, to learn how the body works, major organs of the body are displayed on screen when the user points his webcam toward another person's chest. Students from subscribing schools can print out AR markers that then can display intricate 3D models for further examination.

Who Do You Think You Really Are?

go.nmc.org/uqthc

The London Natural History Museum developed an interactive dinosaur film optimized for tablets that incorporates gesture-based manipulation and augmented reality, where extinct creatures appear to roam the Attenborough Studio space.

For Further Reading

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

21st Century Lessons with Mobile Augmented Reality (Video)

go.nmc.org/lesso

(*K12 Mobile Learning*, 26 May 2011.) Mobile AR tools are a convenient way to augment classroom resources in a way that allows students to use their devices for discovering new or hidden content. This video displays how simple it can be to attach videos to handwritten text, creating a lively experience with paper, a pen, and a mobile device.

Augmented Reality: Coming Soon to a School Near You?

go.nmc.org/arcomi

(Sarah Jackson, *MindShift*, 20 April 2012.) Because the number of people who own a mobile device has drastically increased in the past five years, AR programs are more readily available. This article explores ARIS, an open source mobile learning platform that facilitates

interactive storytelling through the use of augmented reality. Educators do not require any programming experience to start building their own games, specific to their curriculum.

Augmented Reality for Chemists (Video)

go.nmc.org/augm

(Art Olson, *Chemical & Engineering News*, 19 September 2011.) This video makes augmented reality easier to understand by demonstrating how it is built, using a webcam to track all the possible motions of a 3D model of a chemical.

Google's 'Project Glass' Augmented Reality Glasses Are Real And In Testing

go.nmc.org/glass

(Chris Velazco, *Tech Crunch*, 4 April 2012.) Google has revealed its augmented reality glasses model that will allow the user to do things like snap a photo on command, send a text by voicing it, and display the location of nearby friends. But the author of this article notes that it may be a while before we see these in public.

An Open Letter to Augmented Reality

go.nmc.org/openl

(Clark Dever, *Wired UK*, 13 February 2012.) This letter asserts a different perspective about the path that augmented reality has taken. The writer believes that there have not been adequate advancements in the technology given the level of buzz it has garnered. He urges augmented reality developers to leverage cloud-connect experiences and drop the notion of smartphone cameras and webcams as the sole looking glasses for augmented reality.

TEDxYouth: Marko Todorovic on AR

go.nmc.org/tedxy

(Marko Todorovic, TED, 8 December 2011.) Marko Todorovic of Live View Studio discusses and demonstrates benefits and applications of augmented reality to connect youth with educational content. Books and other objects become interactive when hidden information is displayed through a smartphone or other digital device.



Natural User Interfaces

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 iPad, iPhone and iPod Touch, Xbox Kinect, Nintendo Wii, the new class of “smart TVs” and a growing list of other devices built with natural user interfaces accept input in the form of taps, swipes, and other ways of touching; hand and arm motions; body movement; and increasingly, natural language. 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. Natural user interfaces allow users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively. 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. What makes natural user interfaces especially interesting this year is the burgeoning high fidelity of systems that understand gestures, facial expressions, and their nuances, as well as the convergence of gesture-sensing technology with voice recognition, which allows users to interact in an almost natural fashion, with gesture, expression, and voice communicating their intentions to devices.

Overview

Natural user interfaces 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 handheld 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.

The convergence of gesture-sensing technology with voice recognition allows for both gesture and voice to communicate the user's intentions to devices — just as it does in human conversation. 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.

Natural user interfaces are 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 natural user interfaces, and the full realization of the potential of natural user interfaces within K-12 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 natural user interfaces have found a home in gaming and in mobile devices, but their 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 natural user interfaces are garnering a lot of excitement in the consumer space, an extensive review was unable to uncover many current instances in K-12 of gesture-based software or devices being applied to specific learning examples. As an enabling or assistive technology, however, natural user interfaces 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. Natural user interface 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 natural user interface projects that are pushing the edges of gesture-recognition, especially

as it converges with 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

Natural user interfaces allow users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively.

electronics segment, bode well for this category of technologies to continue to see new and compelling developments.

A sampling of applications for natural user interfaces across disciplines includes the following:

- > **Language.** SchoolNet South Africa and Microsoft worked with Lakeside Park Primary in rural KwaZulu-Natal to test English language acquisition through the use of Xbox Kinect gaming technology. The evaluation study conducted in 2011 recorded an overall marked improvement in vocabulary, which in turn, impacted language comprehension and literacy skills. The study also reported that the natural user interface helped students to better unlock the curriculum. go.nmc.org/schone
- > **Mathematics.** The non-profit Mind Research Institute recently launched its "ST Math" Touch K-5 web-based software games that are enhanced by the properties of touchscreens on iPads and Android and Microsoft devices. Students experience how math works by interacting with virtual manipulatives to solve math problems. go.nmc.org/mindr
- > **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

Natural User Interfaces in Practice

The following links provide examples of natural user interfaces in use that have direct implications for K-12 settings:

Microsoft Kinect in Grade 1

go.nmc.org/microki

Alberta Education is exploring the use of Microsoft Kinect in developing young students' motor skills while encouraging active learning. In the experiment, students will use the unit to interact with baby wildcats and learn all about wildlife.

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 will turn any surface into its own touchscreen. The system transforms the vibrations transmitted from touch into waveforms that a computer can recognize.

NUI Group

go.nmc.org/nuigr

The Natural User Interface Group is a global research community that is focused on the open discovery of natural user interfaces. Most recently, they have worked with a team that has developed a gesture-enabled system called "TouchMi," which uses multiple cameras to recognize gestures in three dimensions.

Virtual Autopsy Table

go.nmc.org/norrk

With the Virtual Autopsy Table, detailed computed tomography 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.

Wearable Multi-touch Projector

go.nmc.org/weara

Microsoft Research has unveiled a prototype of a Wearable Multitouch Projector that turns any surface into a multitouch display. The projector itself can be easily mounted on one's shoulder, and uses a depth-sensing system to enable user interaction on the projected interface.

For Further Reading

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

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 for academia to promote creativity and experimentation among students and researchers.

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.

The Power of Natural User Interfaces

go.nmc.org/thepo

(Bill Gates, *The Gates Notes*, 28 October 2011.) Microsoft founder, Bill Gates, discusses how natural user interfaces give us the ability to interact with our devices the same way we interact with each other. He explains that people who lack even the most basic literacy skills can easily use Kinect and other natural user interfaces that are gesture-enabled.

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, *The New York Times*, 1 September 2010.) This article discusses the evolution of touchscreens, and how they have quickly become the prevalent manner of interacting with devices, especially smartphones and tablets.

Using Kinect to Engage Students

go.nmc.org/senai

(SENAI – Education Technologies, 27 December 2011.) This post contains a series of videos and offers an introduction to integrating Kinect into classroom activities. The “interaction” project outlined by two Brazilian professors explores the use of Xbox Kinect for simulations used in teaching and industrial solutions.

Natural user interfaces are changing the ways that we interact with computers, both physically and mechanically. As such, it is at once transformative and disruptive.



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 — a group that now numbers more than 500 technology professionals, campus technologists, faculty leaders from colleges and universities, museum professionals, teachers and other school professionals, and representatives of leading

The 46 members of this year's advisory board were purposely chosen to represent a broad spectrum of the K-12 sector; key writers, thinkers, technologists, and futurists from education, business, and industry rounded out the group.

corporations from more than 30 countries. For more than a decade, these conversations have been mined to provide the insights on emerging technology that are published annually in the *NMC Horizon Report* series.

The NMC Horizon Project is currently in its tenth year, dedicated to charting the landscape of emerging technologies for teaching, learning, and creative inquiry in 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 Brazil. This report, the *NMC Horizon Report: 2012 K-12 Edition*, is the fourth in the series focusing on pre-college education. The flagship *NMC Horizon Report*, focused on higher education, is translated into multiple languages every year. Over all editions, the readership of the reports is estimated at over one million worldwide, with readers in over 100 countries.

The 46 members of this year's advisory board were purposely chosen to represent a broad spectrum of the K-12 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 k12.wiki.nmc.org.

The effort to produce the *NMC Horizon Report: 2012 K-12 Edition* began in February 2012, and concluded when the report was released in June 2012, a period of four months. The six technologies and applications that emerged at the top of the final rankings — two per adoption horizon — are detailed in the preceding chapters.

Each of those chapters includes detailed descriptions, links to active demonstration projects, and a wide

array of additional resources related to the six profiled technologies. Those profiles are the heart of the *NMC Horizon Report: 2012 K-12 Edition*, and will fuel the work of the NMC Horizon Project throughout 2012. To share your educational technology projects with the NMC to potentially be featured in a future *NMC Horizon Report*, the NMC Horizon Project Navigator database, or the NMC Horizon EdTech Weekly App, visit go.nmc.org/projects. For those wanting to know more about the processes used to generate the *NMC Horizon Report* series, many of which are ongoing and extend the work in the reports, we refer you to the report's final section on the research methodology.

The NMC Horizon Project is currently in its tenth year, dedicated to charting the landscape of emerging technologies for teaching, learning, and creative inquiry in education globally.



Methodology

The process used to research and create the *NMC Horizon Report: 2012 K-12 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

Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition.

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 into 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 K-12 Edition* can be found at k12.wiki.nmc.org.

The procedure for selecting the topics in the report included a modified Delphi process now refined

over years of producing the *NMC Horizon Report* series, and began with the assembly of the advisory board. The advisory board represents a wide range of backgrounds, nationalities, and interests, yet each member brings a particularly relevant expertise. Over the decade of the NMC Horizon Project research, more than 500 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 K-12. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

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

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

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

- > **What would you list among the established technologies that some educational institutions are using today that arguably all institutions should be using broadly to support or enhance teaching, learning, or creative inquiry?**
- > **What technologies that have a solid user base in consumer, entertainment, or other industries should educational institutions be actively looking for ways to apply?**
- > **What are the key emerging technologies you see developing to the point that learning-focused institutions should begin to take notice during the next 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 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 K-12 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 [k12.wiki.nmc.org](https://wiki.nmc.org).



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The NMC and its research partners have held an ongoing series of conversations and dialogs with its advisory boards — a group that now numbers more than 500 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 30 countries.





ISBN 978-0-9846601-4-8

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