THE **HORIZON** REPORT

2010 EDITION

a collaboration between
The NEW MEDIA CONSORTIUM
and the
EDUCAUSE Learning Initiative
An EDUCAUSE Program

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EXECUTIVE SUMMARY

The annual *Horizon Report* describes the continuing work of the New Media Consortium's Horizon Project, a qualitative research project established in 2002 that identifies and describes emerging technologies likely to have a large impact on teaching, learning, or creative inquiry on college and university campuses within the next five years. The *2010 Horizon Report* is the seventh in the series and is produced as part of an ongoing collaboration between the New Media Consortium (NMC) and the EDUCAUSE Learning Initiative (ELI), an EDUCAUSE program.

In each edition of the *Horizon Report,* six emerging technologies or practices are described that are likely to enter mainstream use on campuses within three adoption horizons spread over the next one to five years. Each report also presents critical trends and challenges that will affect teaching and learning over the same time frame. In the seven years that the Horizon Project has been underway, more than 400 leaders in the fields of business, industry, technology, and education have contributed to this long-running primary research effort. They have drawn on a comprehensive body of published resources, current research and practice, their own considerable expertise, and the expertise of the NMC and ELI communities to identify technologies and practices that are beginning to appear on campuses or are likely to be adopted in the next few years. The 2010 Advisory Board, like those before it, considered a broad picture of emerging technology and its intersection with the academic world through a close examination of primary sources as well as through the lens of their own experiences and perspectives. The research methodology employed in producing the report is detailed in a special section that follows the body of the report.

The report's format is consistent from year to year, opening with a discussion of the trends and challenges identified by the Advisory Board as most critical for the next five years. The format of the main section closely reflects the focus of the Horizon Project itself, centering on the applications of emerging technologies to teaching, learning, and creative inquiry. Each topic is introduced with an overview that describes what it is, followed by a discussion of the particular relevance of the topic to education, creativity, or research. Examples of how the technology is being, or could be applied to those activities are given. Finally, each section closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report and a link to the tagged resources collected during the research process by project staff, the Advisory Board, and others in the growing Horizon Project community.

Key Trends

The technologies featured in each edition of the Horizon Report are embedded within a contemporary context that reflects the realities of the time, both in the sphere of academia and in the world at large. To assure this perspective, each Advisory Board researches, identifies, and ranks key trends that are currently affecting the practice of teaching, learning, and creative inquiry, and uses these as a lens for its later work. These trends are surfaced through an extensive review of current articles, interviews, papers, and new research. Once identified, the list of trends is ranked according to how significant an impact they are likely to have on education in the next five years. The following four trends have been identified as key drivers of technology adoptions for the period 2010 through 2015; they are listed here in the order they were ranked by the Advisory Board.

- *The abundance of resources and relationships made easily accessible via the Internet is increasingly challenging us to revisit our roles as educators in sense-making, coaching, and credentialing.* 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, the central role of the university when it

achieved its modern form in the 14th century, is again at the forefront. Universities have always been seen as the gold standard for educational credentialing, but emerging certification programs from other sources are eroding the value of that mission daily.

- *People expect to be able to work, learn, and study whenever and wherever they want to.* Life in an increasingly busy world where learners must balance demands from home, work, school, and family poses a host of logistical challenges with which today's ever more mobile students must cope. A faster approach is often perceived as a better approach, and as such people want easy and timely access not only to the information on the network, but to their social networks that can help them to interpret it and maximize its value. The implications for informal learning are profound, as are the notions of "just-in-time" learning and "found" learning, both ways of maximizing the impact of learning by ensuring it is timely and efficient.

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

- *The work of students is increasingly seen as collaborative by nature, and there is more cross-campus collaboration between departments.* While this trend is not as widespread as the others listed here, where schools have created

a climate in which students, their peers, and their teachers are all working towards the same goals, where research is something open even to first year students, the results have shown tantalizing promise. Increasingly, both students and their professors see the challenges facing the world as multidisciplinary, and the need for collaboration great. Over the past few years, the emergence of a raft of new (and often free) tools has made collaboration easier than at any other point in history.

Critical Challenges

Along with current trends, the Advisory Board notes critical challenges that face learning organizations, especially those that are likely to continue to affect education over the five-year time period covered by this report. Like the trends, these are drawn from a careful analysis of current events, papers, articles, and similar sources, as well as from the personal experience of the Advisory Board members in their roles as leaders in education and technology. Those challenges ranked as most significant in terms of their impact on teaching, learning, and creative inquiry in the coming years are listed here, in the order of importance assigned them by the Advisory Board.

- *The role of the academy — and the way we prepare students for their future lives — is changing.* In a 2007 report, the American Association of Colleges and Universities recommended strongly that emerging technologies be employed by students in order for them to gain experience in "research, experimentation, problem-based learning, and other forms of creative work," particularly in their chosen fields of study. It is incumbent upon the academy to adapt teaching and learning practices to meet the needs of today's learners; to emphasize critical inquiry and mental flexibility, and provide students with necessary tools for those tasks; to connect learners to broad social issues through civic engagement; and to encourage them to apply their learning to solve large-scale complex problems.

- *New scholarly forms of authoring, publishing, and researching continue to emerge but appropriate metrics for evaluating them increasingly and far too often lag behind.* Citation-based metrics, to pick one example, are hard to apply to research based in social media. New forms of peer review and approval, such as reader ratings, inclusion in and mention by influential blogs, tagging, incoming links, and retweeting, are arising from the natural actions of the global community of educators, with increasingly relevant and interesting results. These forms of scholarly corroboration are not yet well understood by mainstream faculty and academic decision makers, creating a gap between what is possible and what is acceptable.

- *Digital media literacy continues its rise in importance as a key skill in every discipline and profession.* The challenge is due to the fact that despite the widespread agreement on its importance, training in digital literacy skills and techniques is rare in any discipline, and especially rare in teacher education programs. As faculty and instructors 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 reality is exacerbated by the fact that as technology continues to evolve, digital literacy must necessarily be less about tools and more about ways of thinking and seeing, and of crafting narrative. That is why skills and standards based on tools and platforms have proven to be somewhat ephemeral and difficult to sustain.

- *Institutions increasingly focus more narrowly on key goals, as a result of shrinking budgets in the present economic climate.* Across the board, institutions are looking for ways to control costs while still providing a high quality of service. Schools are challenged by the need to support a steady — or growing — number of students with fewer resources and staff than before. In this atmosphere, it is critical for information and media professionals to emphasize the importance of continuing research into emerging technologies as a means to achieve key institutional goals. As one example, knowing the facts about shifting server- and network-intensive infrastructure, such as email or media streaming, off campus in the current climate might present the opportunity to generate considerable annual savings.

These trends and challenges are having a profound effect on the way we experiment with, adopt, and use emerging technologies. These aspects of the world that surround and permeate academia serve as a frame for considering the probable impacts of the emerging technologies listed in the sections that follow.

Technologies to Watch

The six technologies featured in each *Horizon Report* are placed along three adoption horizons that indicate likely time frames for their entrance into mainstream use for teaching, learning, or creative inquiry. The near-term horizon assumes the likelihood of entry into the mainstream for institutions within the next twelve months; the mid-term horizon, within two to three years; and the far-term, within four to five years. It should be noted that the *Horizon Report* is not a predictive tool. It is meant, rather, to highlight emerging technologies with considerable potential for our focus areas of teaching, learning, and creative inquiry. Each of them is already the focus of work at a number of innovative institutions around the world, and the work we showcase here reveals the promise of a wider impact.

On the near-term horizon — that is, within the next 12 months — are *mobile computing* and *open content.*

Mobile computing, by which we mean use of the network-capable devices students are already carrying, is already established on many campuses, although before we see widespread use, concerns about privacy, classroom management, and access will need to be

addressed. At the same time, the opportunity is great; virtually all higher education students carry some form of mobile device, and the cellular network that supports their connectivity continues to grow. An increasing number of faculty and instructional technology staff are experimenting with the possibilities for collaboration and communication offered by mobile computing. Devices from smart phones to netbooks are portable tools for productivity, learning, and communication, offering an increasing range of activities fully supported by applications designed especially for mobiles.

Open content, also expected to reach mainstream use in the next twelve months, is the current form of a movement that began nearly a decade ago, when schools like MIT began to make their course content freely available. Today, there is a tremendous variety of open content, and in many parts of the world, open content represents a profound shift in the way students study and learn. Far more than a collection of free online course materials, the open content movement is a response to the rising costs of education, the desire for access to learning in areas where such access is difficult, and an expression of student choice about when and how to learn.

The second adoption horizon is set two to three years out, where we will begin to see widespread adoptions of two well-established technologies that have taken off by making use of the global cellular networks — *electronic books* and *simple augmented reality.* Both of these technologies are entering the mainstream of popular culture; both are already used in practice at a surprising number of campuses; and both are expected to see much broader use across academia over the next two to three years.

Electronic books have been available in some form for nearly four decades, but the past twelve months have seen a dramatic upswing in their acceptance and use. Convenient and capable electronic reading devices combine the activities of acquiring, storing, reading, and annotating digital books, making it very easy to collect and carry hundreds of volumes in a space smaller than a single paperback book. Already in the mainstream of consumer use, electronic books are appearing on campuses with increasing frequency. Thanks to a number of pilot programs, much is already known about student preferences with regards to the various platforms available. Electronic books promise to reduce costs, save students from carrying pounds of textbooks, and contribute to the environmental efforts of paper-conscious campuses.

Simple augmented reality refers to the shift that has made augmented reality accessible to almost anyone. Augmented reality used to require specialized equipment, none of which was very portable. Today, applications for laptops and smart phones overlay digital information onto the physical world quickly and easily. While still two to three years away from widespread use on campuses, augmented reality is establishing a foothold in the consumer sector, and in a form much easier to access than originally envisioned.

On the far-term horizon, set at four to five years away for widespread adoption, but clearly already in use in some quarters, are *gesture-based computing* and *visual data analysis.* Neither of these two technologies is yet commonly found in campus settings, but the high level of interest and the tremendous amounts of research in both areas indicates that they are worth following closely.

Gesture-based computing is already strong in the consumer market and we are seeing a grow-ing number of prototypical applications for train-ing, research, and study, though this technology is still some time away from common educa-tional use. Devices that are controlled by natural movements of the finger, hand, arm, and body are becoming more common. Game companies in particular are exploring the potential offered by consoles that require no handheld control-ler, but instead recognize and interpret body motions. As we work with devices that react to

us instead of requiring us to learn to work with them, our understanding of what it means to interact with computers is beginning to change.

Visual data analysis, a way of discovering and understanding patterns in large data sets via visual interpretation, is currently used in the scientific analysis of complex processes. As the tools to interpret and display data have become more sophisticated, models can be manipulated in real time and researchers are able to navigate and explore data in ways that were not possible previously. Visual data analysis is an emerging field, a blend of statistics, data mining, and visualization, that promises to make it possible for anyone to sift through, display, and understand complex concepts and relationships.

Each of these technologies is described in detail in the body of the report. These sections open with a discussion of what the technology is and why it is relevant to teaching, learning, and creative inquiry. Examples of the technology in practice, especially in academia, are listed there to illustrate how it is being adopted at the current time. Our research indicates that all six of these technologies, taken together, will have a significant impact on learning-focused organizations within the next five years.

Regular readers of the *Horizon Report* will note that some topics have strong ties to topics that were featured in past editions. Mobile computing, in particular, is the latest aspect of a trend toward smaller, more powerful computing devices that has grown over the past three years. We have watched mobile phones become increasingly capable and flexible. As described here, the topic of mobile computing encompasses handheld devices with the ability to access the Internet, a group of devices that includes the mobile phones most people carry as well as other often specialized devices that are increasingly powerful, but still able to be held easily in one hand. The significance of mobile computing is not so much in the device used, but in the ability to easily access an expanding cellular network and fully-featured tools from the palm of your hand.

Simple augmented reality and gesture-based computing also have roots in previous editions. Augmented reality first appeared in the *2005 Horizon Report* on the far-term horizon, returning in 2006 with a focus on its applications for visualizing large data sets, a use that is now common in many research labs. Today, augmented reality has become simple and available on the computers and mobile devices we already own. Gesture-based computing is one offshoot of a group of technologies that was noted in the first *Horizon Report,* published in 2004; multimodal interfaces, as this group was called, included gestural as well as other types of input. Gesture-based computing also has ties to context-aware computing, featured in 2005 and as context-aware devices in 2006.

The Horizon Project

Since March 2002, under the banner of the Horizon Project, the New Media Consortium has held an ongoing series of conversations and dialogs with hundreds of technology professionals, campus technologists, faculty leaders from colleges and universities, and representatives of leading corporations from more than two dozen countries. In each of the past six years, these conversations have resulted in the publication each January of a report focused on emerging technologies relevant to higher education. As the report is produced, an Advisory Board engages in lively dialogs using a wide range of articles, published and unpublished research, papers, scholarly blogs, and websites. The result of these dialogs is a list of the key technologies, trends, challenges, and issues that knowledgeable people in technology industries, higher education, and learning-focused organizations are thinking about.

In 2008 and 2009, the NMC convened additional advisory boards to engage in a new series of regional and sector-based companion editions of the *Horizon Report,* 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 with another. To date, companion editions have been prepared that center on Australia and New Zealand, on the K-12 sector, and on small- to medium-sized businesses.

Each time a report is undertaken, the NMC uses qualitative research methods to identify the technologies selected for inclusion in that report, beginning with a survey of the work of other organizations and a review of the literature with an eye to spotting interesting emerging technologies. When the cycle starts, little is known, or even can be known, about the appropriateness or efficacy of many of the emerging technologies for these purposes, as the Horizon Project expressly focuses on technologies not currently in widespread use in academe. In a typical year, 75 or more of these technologies may be identified for further investigation; for the 2010 report, more than 110 were considered.

By engaging a wide community of interested parties, and diligently searching the Internet and other sources, enough information is gathered early in the process to allow the members of the Advisory Board to form an understanding of how each of the discovered technologies might be in use in settings outside of academe, to develop a sense of the potential the technology may have for higher education settings, and to envision applications of the technology for teaching, learning, and creative inquiry. The findings are discussed in a variety of settings — with faculty, industry experts, campus technologists, and of course, the Horizon Advisory Board. Of particular interest to the Advisory Board every year is finding educational applications for these technologies that may not be intuitive or obvious.

Increasingly the Horizon Project is a global effort. Each year at least a third of the members of the advisory board represent countries outside of North America. Since 2007, with the aid of the Universitat Oberta de Catalunya, the *Horizon Report* has been translated into Spanish and Catalan. In 2008, the Horizon Project expanded with the publication of its first-ever regional report, the *2008 Horizon Report: Australia-New Zealand Edition.* The *2009 Horizon Report* was also translated into Japanese, German, and Chinese, as well as Spanish and Catalan, and plans are in place to add to those translations for the current report. In 2010, in partnership with the Universitat Oberta de Catalunya, a new Spanish-language report is planned especially for Ibero-America that will look at the entire body of work from the project.

Each *Horizon Report* is produced over a period of just a few months so that the information is timely and relevant. This year, the effort to produce the report began in September 2009, and concluded when the report was released in January 2010, a period of just over four months. The six technologies and applications that emerged at the top of the final rankings — two per adoption horizon — are detailed in the chapters that follow.

Each of those chapters includes detailed descriptions, links to active demonstration projects, and a wide array of additional resources related to the six profiled technologies. Those profiles are the heart of the *2010 Horizon Report,* and will fuel the work of the Horizon Project throughout 2010-11. For those wanting to know more about the processes used to generate the *Horizon Report,* many of which are ongoing and extend the work in the report, we refer you to the report's final section on the research methodology.

MOBILE COMPUTING

Time-to-Adoption Horizon: One Year or Less

The available choices for staying connected while on the go are many — smart phones, netbooks, laptops, and a wide range of other devices access the Internet using cellular-based portable hotspots and mobile broadband cards, in addition to wi-fi that is increasingly available wherever people congregate. At the same time, the devices we carry are becoming ever more capable, and the boundaries between them more and more blurred. In the developed world, mobile computing has become an indispensable part of day-to-day life in the workforce, and a key driver is the increasing ease and speed with which it is possible to access the Internet from virtually anywhere in the world via the ever-expanding cellular network.

Overview

Mobiles as a category have proven more interesting and more capable with each passing year, and continue to be a technology with new surprises. The mobile market today has nearly 4 billion subscribers, more than two-thirds of whom live in developing countries. Well over a billion new phones are produced each year, a flow of continuous enhancement and innovation that is unprecedented in modern times. The fastest-growing sales segment belongs to smart phones — which means that a massive and increasing number of people all over the world now own and use a computer that fits in their hand and is able to connect to the network wirelessly from virtually anywhere. Thousands of applications designed to support a wide range of tasks on virtually any smart-phone operating system are readily available, with more entering the market all the time. These mobile computing tools have become accepted aids in daily life, giving us on-the-go access to tools for business, video/audio capture and basic editing, sensing and measurement, geolocation, social networking, personal productivity, references, just-in-time learning — indeed, virtually anything that can be done on a desktop.

Users increasingly expect anytime, anywhere access to data and services that not very long ago were available only while sitting in front of a computer linked to the network via a cable. In addition to the typical software for email, communication, and calendaring, new tools allow users to manage personal information (such as Evernote, Nozbe,

Wesabe, and TripIt), collaborate and easily access and share files (Dropbox and CalenGoo are two of many possible examples), or keep abreast of social networks (Limbo, Facebook, Foursquare, Whrrl), and generally make checking and updating work, school, or personal information flows something easily done on the fly.

For many people all over the world, but especially in developing countries, mobiles are increasingly the access point not only for common tools and communications, but also for information of all kinds, training materials, and more. An ever more common pattern is for people to look to mobile computing platforms as their device of choice, as they are often far cheaper than desktop or laptop computers. For this group, mobile computing devices are more affordable, more accessible, and easier to use than desktop computers, and provide more than enough functionality to serve as their primary computing device.

A middle ground for those who need a little more flexibility and power from a mobile platform includes netbooks, smartbooks, or other specialized devices. Smaller and lighter than a laptop, this category of devices can access the Internet via multiple networks. Netbooks run typical productivity and communications applications, using a standard keyboard and a compact laptop-like design. More specialized devices, like ebooks, email readers, and others are customized for a single purpose. The advantages they offer are storage and portability; the Kindle, for instance, makes it easy to carry a library

full of reading material, while the Peek email reader delivers email access on a very compact device.

Relevance for Teaching, Learning, or Creative Inquiry

The portability of mobile devices and their ability to connect to the Internet almost anywhere makes them ideal as a store of reference materials and learning experiences, as well as general-use tools for fieldwork, where they can be used to record observations via voice, text, or multimedia, and access reference sources in real time. At Ball State University, students gather meteorological data around campus, using Twitter on mobile devices to aggregate and disseminate their findings. At the University of Kansas, geology labs are being augmented by carefully designed field experiments that students can complete in blocks of three hours.

As faculty use of mobile computing has grown, studies have begun to emerge documenting the efficacy of both the tools and the techniques used to employ them. At Abilene Christian University, for example, all incoming freshmen were issued an iPhone or iPod Touch in 2009, providing a broad canvas upon which to explore the use of mobiles for instruction. One section of a chemistry course received laboratory preparation and safety lectures via podcast for mobile devices rather than in the classroom; performance scores for these students indicated that the mobile lectures were equally effective. At Franklin & Marshall College, sixteen faculty in the year-long mLearning Pilot Project are using iPod Touches to explore ways mobile computing can be used in teaching, learning, and research in disciplines like history, psychology, religious studies, world languages, government, classics, and more.

A Houston Community College pilot held in spring 2009 compared study habits of two groups of students enrolled in the same anatomy course. One group, issued mobile devices, was found to work on the course during spare moments such as while waiting for appointments. The other group, using only desktop computers, appeared to spend less time overall working with the course content online. At the Open University of Catalunya (UOC), where many students commute or attend classes around full-time work schedules, course materials are made available not only in paper format, but also in audio, video, and text formats designed for mobile access. The University of Waterloo, another campus with a large commuter population, piloted delivery of materials for online courses to the BlackBerry platform. The response was very positive, and students noted increased time spent accessing course materials as well as higher levels of collaboration with classmates.

The potential of mobile computing is being demonstrated in hundreds of projects at higher education institutions. Students in the University of Alabama's Computer-Based Honors program, for example, are developing an application for the iPhone and iPod Touch that will deliver blood-sugar check reminders to patients with type 2 diabetes and provide resources about diabetes management, as well as collect information on how patients using the tool are succeeding in keeping their blood sugar under control. These data will be used in a research project comparing the effects of standard patient-care practices with self-management practices as facilitated by the mobile application. A custom tool developed at Purdue University, Hotseat (http://purdue.edu/hotseat), allows students to use their mobile devices to contribute to discussions, ask and answer questions, and respond to teacher prompts through any of several channels, including Facebook, Twitter, the Hotseat mobile application, or a web application. Students in a history course at the University of Texas-Dallas used Twitter to discuss course topics during class; the tweets were displayed on a large screen to encourage cross-group communication.

A sampling of other applications of mobile computing across a variety of disciplines includes the following:

- **Chemistry.** At Bluegrass Community & Technical College, outdoor fieldwork has replaced many "cookbook" chemistry labs. Students use tablet

PCs to record and analyze field research, present their findings, and compare results in real time.

- **History.** The Edinburgh College of Art, the University of Edinburgh, and the EDINA Data Centre collaboratively developed a mobile app called Walking Through Time. The app overlays historical maps onto current maps of the viewer's location, showing street views and areas of interest from prior times.

- **Information Technology.** Students at the University of Michigan developed an application for Google's Android platform that measures power consumption on mobiles. The app, called PowerTutor, is designed to help software developers create more efficient applications.

- **Medicine.** Harvard Medical School has released an iPhone app about the H1N1 virus, including maps of outbreaks, a symptom checker, and tips for avoiding infection or dealing with illness. The app is the first in a planned series of mobile applications developed at HMS in collaboration with medical school scientists and doctors.

Mobile Computing in Practice

The following links provide examples of mobile computing.

Cellular Colleges: The Next Small Thing
http://www.universitybusiness.com/viewarticle.aspx?articleid=1233

(James Martin and James E. Samels, *University Business,* February 2009.) Following the lead of Japan's Fukuoka-based Cyber University, several colleges in the United States are now planning full, media-rich courses delivered via smart phone.

CMU Students, Professors Find Benefits with iPod Technology in Classroom
http://www.news.cmich.edu/2009/10/cmu-students-professors-find-b/

(*The News @ Central,* 28 October 2009.) Students in Central Michigan University's

Introduction to Teaching Course — which serves nearly 650 freshmen and transfer students — use mobile devices to access reference material, respond to professors' questions, and take polls during class.

iPhone the Body Electric
http://www.unews.utah.edu/p/?r=092409-2

At the University of Utah, researchers have developed a suite of mobile apps to allow scientists, students, doctors, and patients to study human anatomy, visualize large data sets in 3D, manipulate and analyze large numbers of high-resolution images, and evaluate medical problems.

Mobile Libraries
http://www.lib.ncsu.edu/m/about.html

The North Carolina State University library now offers a mobile application that provides a catalog search, information about computer availability in labs, and access to a reference librarian.

San Francisco Museum of Modern Art Mobile Tours
http://www.sfmoma.org/events/1556

The San Francisco Museum of Modern Art is offering two new mobile applications: Making Sense of Modern Art Mobile and the Rooftop Garden iPhone Tour. MSoMA Mobile is available on iPod Touches that may be borrowed by museum visitors and includes interviews with architects, artists, and curators; video footage; and music and poetry related to the collection. The Rooftop Garden tour is available at no cost as an application in the iTunes Store.

Smartphones Fill Med School Prescription
http://www.allbusiness.com/health-care/health-care-professionals-physicians-surgeons/13161277-1.html

At the University of Louisville School of Medicine, residents use smartphones instead of prescription pads and multiple reference books. Patients and residents alike approve of the new system.

For Further Reading

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

GSM Coverage Maps

http://www.gsmworld.com/Roaming/Gsminfo/Index.Shtml

GSM World provides detailed information about cellular network operators worldwide, as well as up-to-date coverage maps for countries around the globe. Specific details included are network, roaming, services (including broadband), and coverage information for over 860 networks in 220 countries or areas of the world.

The Mobile Campus

http://www.insidehighered.com/news/2009/09/21/iphones

(Steve Kolowich, *Inside Higher Ed,* 21 September 2009.) One year after implementing its campus-wide policy of issuing each freshman an iPhone or iPod Touch, Abilene Christian University challenged instructors to integrate mobile learning into their classes and surveyed the campus community about the results.

MOCA: Gathering Instant Student Feedback on Mobile Devices

http://www.utexas.edu/academic/diia/about/postcards

This case study from the University of Texas at Austin describes the Mobile Ongoing Course Assessment (MOCA) tool developed by the Division of Instructional Innovation and Assessment. MOCA is used to assess student learning and engage students in discussion. MOCA may be accessed from any web-capable mobile device.

Teaching with Technology Face-Off: iPhones vs. PCs

https://chronicle.com/blogPost/Teaching-With-Technology/4547

(Jeffrey R. Young, *The Chronicle of Higher Education,* 25 February 2009.) One professor found that students with access to an iPhone studied more than those who used only a PC.

Delicious: Mobile Computing

http://delicious.com/tag/hz10+mobile

Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report.* To add to this list, simply tag resources with "hz10" and "mobile" when you save them to *Delicious.*

OPEN CONTENT

Time-to-Adoption Horizon: One Year or Less

The movement toward open content reflects a growing shift in the way academics in many parts of the world are conceptualizing education to a view that is more about the process of learning than the information conveyed in their courses. Information is everywhere; the challenge is to make effective use of it. Part of the appeal of open content is that it is also a response to both the rising costs of traditionally published resources and the lack of educational resources in some regions, and a cost-effective alternative to textbooks and other materials. As customizable educational content is made increasingly available for free over the Internet, students are learning not only the material, but also skills related to finding, evaluating, interpreting, and repurposing the resources they are studying in partnership with their teachers.

Overview

A new educational perspective, focused on collective knowledge and the sharing and reuse of learning and scholarly content, has been gaining ground across the globe for nearly a decade. Open content has now come to the point that it is rapidly driving change in both the materials we use and the process of education. At its core, the notion of open content is to take advantage of the Internet as a global dissemination platform for collective knowledge and wisdom, and to design learning experiences that maximize the use of it.

Open content, as described here, has its roots in a number of seminal efforts, including the Open Content Project, MIT's Open Courseware Initiative (OCW), the Open Knowledge Foundation, and work by the William and Flora Hewlett Foundation and others. Many of these projects focused on creating collections of sharable resources and on devising licenses and metadata schemata. The groundswell of interest in open content described here is differentiated from early work by its primary focus on the use of open content and its place in the curriculum. The role of open content producers has evolved as well, away from the idea of authoritative repositories of content and towards the broader notion of content being both free and ubiquitous. Building on the trailblazing models of institutions like MIT, schools like Tufts University (and many others) now consider making their course materials available to the public a social responsibility.

An outgrowth of that perspective is the emergence of open-content textbooks that can be "remixed" — that is, customized, modified, or combined with other materials — and a number of publishers are finding ways to support authors of such materials. One such publisher, Flat World Knowledge, provides access to textbooks authored for open use, making it very easy for faculty to individually tailor a text for use in their own class. Flat World Knowledge operates as a publisher, reviewing book submissions and using a traditional editing process before release; however, electronic copies of the textbooks are free. Students only pay for print copies, and authors receive royalties for these purchases whether the book has been customized or not.

At the center of many discussions of open content are the challenges of sharing, repurposing, and reusing scholarly works; related to those discussions are concerns about intellectual property, copyright, and student-to-student collaboration, and solid work has been done by groups such as Creative Commons, the Academic Commons, Science Commons, and others to address many of the concerns commonly voiced. Many believe that reward structures that support the sharing of work in progress, ongoing research, highly collaborative projects, and a broad view of what constitutes scholarly publication are key challenges that institutions need to solve. Also to be addressed are reputation systems, peer review processes, and new models for citation of the new

forms of content that are likely outgrowths of open content initiatives.

While a number of highly structured projects exist to provide access to open content, in general, the open content community is diffuse and distributed; learning to find useful resources within a given discipline, assess the quality of content available, and repurpose them in support of a learning or research objective are in and of themselves valuable skills for any emerging scholar, and many adherents of open content list that aspect among the reasons they support the use of shareable materials.

Relevance for Teaching, Learning, or Creative Inquiry

Open content shifts the learning equation in a number of interesting ways; the most important is that its use promotes a set of skills that are critical in maintaining currency in any discipline — the ability to find, evaluate, and put new information to use. Almost as important is that the same set of materials, once placed online and made sharable via the appropriate licensing, can inform a wide variety of learning modalities, not the least of which is learning for the sheer joy of discovery.

Communities of practice and learning communities have formed around open content in a great many disciplines, and provide practitioners and independent learners alike an avenue for continuing education. OpenLearn (http://openlearn.open.ac.uk), a project of the Open University in the U.K., offers anyone the opportunity to join a study group while working through their open course content. OpenLearn practices a method known as "supported open learning," in which students work through content at their own pace with help and guidance from a tutor. Faculty communities of practice are flourishing as well; at Trinity University, for example, faculty endorsed an Open Access policy that enables them to place copies of their scholarly works in an open-access repository shared by several liberal arts colleges.

Many sources of open content can easily be found in Creative Commons (http://creativecommons.

org), Teachers Without Borders (http://www.teacherswithoutborders.org), and other online communities, while portals like Folksemantic (http://www.folksemantic.com) offer a single point of entry to many open content offerings. Learning communities associated with services like Diigo or Twine can point educators in the right direction via the social networking equivalent of "word of mouth."

A sampling of other open content projects across disciplines includes the following:

- **Art History.** Smarthistory, an open educational resource dedicated to the study of art, seeks to replace traditional art history textbooks with an interactive, well-organized website. Search by time period, style, or artist (http://smarthistory.org).

- **Graduate Studies.** The Tokyo Institute of Technology offers 35 graduate level courses, open and free of charge, in the schools of science and engineering, bioscience and biotechnology, innovation management, and others.

- **Health Sciences.** The Johns Hopkins Bloomberg School of Public Health provides open-access classes to further the goal of improving global understanding of health-related issues. Courses include the school's most popular subjects, including adolescent health, infectious disease, genetics, and aging.

- **Literature.** *Looking for Whitman* (http://looking-forwhitman.org) is an open-access, multi-institutional experiment, dedicated to the study of the life and works of Walt Whitman.

Open Content in Practice

The following links provide examples of open content.

American Literature before 1860
http://enh241.wetpaint.com

> Students in this course, held at Mesa Community College, contribute to the open course material as part of their research. MCC also features a number of lectures on YouTube (see http://www.youtube.com/user/mesacc#p/p).

Carnegie Mellon University's Open Learning Initiative
http://oli.web.cmu.edu/openlearning

The Open Learning Initiative offers instructor-led and self-paced courses; any instructor may teach with the materials, regardless of affiliation. In addition, the courses include student assessment and intelligent tutoring capability.

Connexions
http://cnx.org

Connexions offers small modules of information and encourages users to piece together these chunks to meet their individual needs.

DnaTube
http://www.dnatube.com

This site offers a YouTube-like library of science videos, including lectures, interviews, animations, and demonstrations. Search by category (mathematics, archeology, physics); topics (viruses, mitosis); or featured videos, which include the editors' choices.

eScholarship: University of California
http://escholarship.org/about_escholarship.html

eScholarship provides peer review and publishing for scholarly articles, books, and papers, using an open content model. The service also includes tools for dissemination and research.

MIT OpenCourseWare
http://ocw.mit.edu

The Massachusetts Institute of Technology publishes lectures and materials from most of its undergraduate and graduate courses online, where they are freely available for self-study.

Open.Michigan's dScribe Project
https://open.umich.edu/projects/oer.php

The University of Michigan's Open.Michigan initiative houses several open content projects. One, dScribe, is a student-centered approach to creating open content. Students work with faculty to select and vet resources, easing the staffing and cost burden of content creation while involving the students in developing materials for themselves and their peers.

OTTER
http://www.le.ac.uk/otter

The University of Leicester's OTTER project (Open, Transferable and Technology-enabled Educational Resources) pilots and evaluates systems for releasing educational content under an open license.

For Further Reading

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

Center for Social Media Publishes New Code of Best Practices in OCW
http://criticalcommons.org/blog/content/center-for-social-media-publishes-new-code-of-best-practices-in-ocw

(Critical Commons, 25 October 2009.) The advocacy group Critical Commons seeks to promote the use of media in open educational resources. Their *Code of Best Practices in Fair Use for Open-CourseWare* is a guide for content developers who want to include fair-use material in their offerings.

Countries Offer Different Takes to Open Online Learning
http://chronicle.com/article/Countries-Offer-Different/48775

(Simmi Aujla and Ben Terris, *The Chronicle of Higher Education,* 11 October 2009.) Many countries are using open educational resources to reach students who would otherwise be unable to attend university.

Creative Commons
http://www.creativecommons.org

Creative Commons has created a set of legal tools consistent with the rules of copyright that make it not only possible but easy for people to share and build upon the work of others. The organization provides free licenses that allow anyone to create, share, and use open content.

Flat World Knowledge: A Disruptive Business Model

http://industry.bnet.com/media/10003790/flat-world-knowledge-a-disruptive-business-model

(David Weir, *BNET,* 20 August 2009.) Flat World Knowledge is enjoying rapid growth, from 1,000 students in the spring of 2009 to 40,000 in the fall semester using their materials. The company's business model pays a higher royalty percentage to textbook authors and charges students a great deal less than traditional publishers.

Open Content and the Emerging Global Meta-University

http://www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume41/OpenContentandtheEmergingGloba/158053

In this article drawn from his 2005 Clair Maple Memorial Address at the Seminars on Academic Computing, MIT President Emeritus Charles Vest discusses open content and outlines the promise and opportunity that drove the creation of MIT OpenCourseWare.

***Delicious:* Open Content**

http://delicious.com/tag/hz10+opened

Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report.* To add to this list, simply tag resources with "hz10" and "opened" when you save them to *Delicious.*

ELECTRONIC BOOKS

Time-to-Adoption Horizon: Two to Three Years

As the technology underlying electronic readers has improved and as more titles have become available, electronic books are quickly reaching the point where their advantages over the printed book are compelling to almost any observer. The convenience of carrying an entire library in a purse, pocket, or book bag appeals to readers who find time for a few pages in between appointments or while commuting. Already firmly established in the public sector, electronic books are gaining a foothold on campuses as well, where they serve as a cost-effective and portable alternative to heavy textbooks and supplemental reading selections.

Overview

Electronic books have reached mainstream adoption in the consumer sector; in 2009, the Kindle was Amazon.com's best selling product, with more than 390,000 titles available. The very first electronic versions of books were those digitized by Project Gutenberg in the 1970s. Electronic books were meant to be read using a computer until the late 1990s; at that time, special devices for reading electronic books, known as e-readers or simply readers, began to appear on the market. The latest readers offer a high fidelity reading experience that offers most of the affordances of the printed book, with enhancements like wireless connectivity and ample storage that allow the typical device to hold more than 1,000 titles.

This ready availability of a selection of capable readers is one of the factors contributing to the success of electronic books. Not only are there many models available to please a variety of tastes — besides the Amazon Kindle, the Sony Reader, the new Barnes & Noble Nook, and a number of reader applications for iPhones, Android phones, and other smartphones have entered the market — but the capabilities of readers have advanced to the point where the experience truly rivals that of reading a paper book. Paper and ink color, font, type size, even the way pages are turned, are all customizable. Text is clear and crisp, with enough contrast to make it easy to read, and the devices are comfortable to hold for long periods of time.

Supported by such a wide variety of readers, electronic books have enjoyed a dramatic rise in popularity over the last year — Kindle editions, for example, now account for half of Amazon's sales of books available both in print and for the Kindle. Readers of electronic books may be reading more, as well. Kindle owners, according to Amazon, buy three times as many books as they did before they had Kindles; Sony reports that Reader owners download about eight books per month — as compared to fewer than seven books per year purchased by the average American book buyer in 2008[1].

The list of available titles, already broad and growing rapidly, is spurring that interest. Virtually all new books are available in electronic form, as well as classics, and popular books from the last 50 years. Collections of copyright-free texts, including great works of literature, are available at little or no cost. Publishers are releasing more titles in electronic formats as the popularity grows, leading to a wider selection of current books and new releases. Cost is generally a little lower than buying a paperback edition.

Wirelessly connected readers make purchasing an electronic book a simple matter, often delivering a new volume in less than a minute. Purchases can be made at any time, from virtually any location, at no additional cost, and with no subscription or access fee. The convenience of having an entire library of books, magazines, and newspapers — each remembering exactly where you left off the last time you looked at them — and all in a single, small device is one of the most compelling aspects driving electronic reader sales.

1 See *E-Book Fans Are Proving to be Enthusiastic Readers,* NYTimes.com, 20 October 2009 (http://www.nytimes.com/2009/10/21/technology/21books.html?_r=2).

Relevance for Teaching, Learning, or Creative Inquiry

While the typical electronic reader could conceivably hold the entire sum of textbooks and readings for the entirety of one's academic experience, campuses have been slower to adopt electronic books than the general public for three primary reasons, but all of them are becoming less of a constraint.

The primary obstacle was simply availability. While a great variety of consumer titles are available electronically, textbooks or academic works have been published in electronic formats far less frequently. Secondly, as the reader technology developed, the ability to easily render high quality illustrations was initially limited. The last obstacle was related to the publishing model. Where electronic versions were available, they were most commonly viewed as ancillary to the printed version, which had to be purchased before the electronic version could be accessed — and the early versions were not in formats compatible with most readers.

Over the past year or so, however, those obstacles have each started to fall away. Many academic titles are now available, and many more are in the pipeline. Amazon, for example, now lists some 30,000 academic titles; all of the major textbook publishers have electronic versions in the Amazon education catalog. Advances in electronic reader technology have brought electronic versions of academic texts to a level with printed ones. The newest readers can display graphics of all kinds and make it easy to bookmark and annotate pages and passages. Annotations can be exported, viewed online, shared, and archived. In addition, electronic readers offer keyword searching, instant dictionary lookups and, in some cases, wireless Internet access. The experience of reading and note taking is becoming as easy in electronic form as it is in paper. Major publishers have largely uncoupled print and electronic sales of academic texts as well.

An encouraging number of colleges and universities are running pilot programs with electronic books.

The Kindle DX, a larger format version of the device expressly built for academic texts, newspapers, and journals, is being piloted at Arizona State University, Ball State University, Case Western Reserve University, Pace University, Princeton, Reed College, Syracuse University, and the University of Virginia Darden School of Business. Northwest Missouri State University and Penn State have embarked on pilots using the Sony Reader. Johns Hopkins is piloting the enTourage eDGe, which combines the functions of an e-reader, a netbook, a notepad, and an audio/video recorder and player in one handheld device. Many other similar projects could be listed here, as the number of campus-based evaluation pilots is large and growing rapidly.

An obvious draw for students is the advantage of having a single handheld reading device that can easily accommodate the entirety of readings involved in one's study, as well as all the essential reference texts. In a pilot program, Seton Hall University's Teaching, Learning & Technology Center found that students appreciated the ability to store and review a semester's worth of material in electronic form.

Princeton University — which spent over $5 million on paper last year, one-fifth of which comprised printouts in student computing clusters — has launched a pilot program with the goal (among others) of determining whether students with electronic readers will print less paper. The Kindles contain course readings that would normally be put on reserve in book, PDF, or photocopy form.

A survey of current projects shows that electronic books are being explored in virtually every discipline, although full-scale movement to electronic books is still two to three years away. A sampling of projects includes the following:

- **Extracurricular Reading.** The library at Fairleigh Dickinson University offers a selection of electronic readers that students may check out, including Amazon Kindles, Sony Readers, and iPod Touches. Each reader includes a selection of reference books, popular titles, literature, and more.

- **Foreign Language.** First-year French students at the University of Texas at Austin use an online interactive textbook with a print-on-demand component, available in color or black-and-white. The online portion includes audio clips of each part of the text and video clips to explore the culture of France (http://www.laits.utexas.edu/fi).

- **Humanities.** The Humanities E-Book (HEB), offered to institutions on a subscription basis by the American Council of Learned Societies, is a digital collection of 2,200 humanities texts. Students at subscribing institutions may browse and read the collection online or order printed copies on demand.

- **Physics.** MIT, in conjunction with Ball State University, produced an electronic book to visually demonstrate the principles of electricity and magnetism. (http://web.mit.edu/viz/EM/flash/E&M_Master/E&M.swf).

Electronic Books in Practice

The following links provide examples of the use of electronic books for educational purposes.

Darden Students Test the Amazon Kindle DX
http://www.virginia.edu/uvatoday/newsRelease.php?id=9509

The University of Virginia's Darden School of Business is participating in an Amazon-sponsored program to test the Kindle DX. The pilot aims to assess the effect of electronic books on teaching and learning, determine whether the school can reduce its carbon footprint by employing the devices, and explore potential cost savings for students and the university.

DeepDyve
http://www.deepdyve.com

DeepDyve is an extensive online collection of scientific, technical, and medical research. Articles are either open access or premium; premium articles may be rented and read online for twenty-four hours at a cost of $0.99.

Sony Reader Project at The Penn State University Libraries
http://libraries.psu.edu/psul/lls/sony_reader.html

Students may check out a Sony Reader from the library, complete with leisure reading titles including both fiction and non-fiction.

Sophie
http://sophiecommons.org

Sophie is an open source tool, maintained by the University of Southern California's School of Cinematic Arts, for creating and reading rich media documents in a networked environment. Sophie authors can easily combine a variety of media — text, images, video, and audio — to develop sophisticated multimedia works.

Swapping Textbooks for E-books
http://www.edtechmag.com/higher/march-april-2009/swapping-textbooks-for-e-books.html

(Lee Copeland, *EDTECH,* March-April 2009.) In a pilot program at Northwest Missouri State University, 500 of the school's 6,500 students will receive electronic textbooks instead of, or in some cases in addition to, printed copies.

For Further Reading

The following articles and resources are recommended for those who want to learn more about electronic books.

7 Things You Need To Know About Sony Readers in a Higher Ed Environment
http://libraries.psu.edu/etc/medialib/psulpublicmedialibrary/lls/documents.Par.53256.File.dat/7things_SonyReader.pdf

This white paper from the Penn State University Libraries describes relevant uses of Sony's Reader in the classroom, in the library, and as a tool for the visually disabled. Pros and cons of using e-books are discussed.

Clive Thompson on the Future of Reading in a Digital World
http://www.wired.com/techbiz/people/magazine/17-06/st_thompson

(Clive Thompson, *Wired Magazine,* 22 May 2009.) Thompson makes a case for digitizing books: in addition to enhancing sales of the printed book, e-books enable ongoing reader dialogs.

Devices to Take Textbooks Beyond Text
http://www.nytimes.com/2009/12/06/ business/06novel.html

(Anne Eisenberg, *The New York Times,* 5 December 2009.) New e-book readers, in addition to displaying standard text, offer liquid-crystal displays to better show graphics and other items found in color in textbooks.

E-Book Fans Are Proving to be Enthusiastic Readers
http://www.nytimes.com/2009/10/21/ technology/21books.html

(Brad Stone, *The New York Times,* 20 October 2009.) Fans of e-readers suggest that the convenience of using these products, which offer a sense of control and customization that consumers have come to expect from all their media gadgets, has created a greater interest in books.

How the E-Book Will Change the Way We Read and Write
http://online.wsj.com/article/ SB123980920727621353.html

(Steven Johnson, *The Wall Street Journal,* 20 April 2009.) While electronic readers satisfy our desire for instant gratification, they may compromise the sanctity of an author, a reader, and a book. The author predicts that electronic books will fundamentally change the way we interact with the printed word.

Kindle for the Academic
http://www.insidehighered.com/views/2009/11/03/ golub

(Alex Golub, *Inside Higher Ed,* 3 November 2009.) The author discusses the pros and cons of electronic readers, particularly the Kindle, from the point of view of a reader of academic works (as opposed to textbooks or leisure reading).

Students Give E-readers the Old College Try
http://www.columbiatribune.com/news/2009/ oct/20/students-give-ereaders-old-college-try

(*Columbia Daily Tribune,* 20 October 2009.) Students weigh in on the Kindle. Included are benefits and drawbacks from a number of participants in this year's Kindle pilot program.

Delicious: Electronic Books
http://delicious.com/tag/hz10+ebooks

Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report.* To add to this list, simply tag resources with "hz10" and "ebooks" when you save them to *Delicious.*

SIMPLE AUGMENTED REALITY

Time-to-Adoption Horizon: Two to Three Years

While the capability to deliver augmented reality experiences has been around for decades, it is only very recently that those experiences have become easy and portable. Advances in mobile devices as well as in the different technologies that combine the real world with virtual information have led to augmented reality applications that are as near to hand as any other application on a laptop or a smart phone. New uses for augmented reality are being explored and new experiments undertaken now that it is easy to do so. Emerging augmented reality tools to date have been mainly designed for marketing, social purposes, amusement, or location-based information, but new ones continue to appear as the technology becomes more popular. Augmented reality has become simple, and is now poised to enter the mainstream in the consumer sector.

Overview

The expression *augmented reality* (AR) is credited to former Boeing researcher Tom Caudel, who is believed to have coined the term in 1990. The concept of blending (augmenting) virtual data — information, rich media, and even live action — with what we see in the real world, for the purpose of enhancing the information we can perceive with our senses is a powerful one. Augmented reality itself is older than the term; the first applications of AR appeared in the late 1960s and 1970s. 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 augmented reality possible are powerful and compact enough to deliver AR experiences to personal computers and mobile devices. Early mobile applications began to appear in 2008, and several augmented reality mapping and social tools are now on the market.

Wireless mobile devices are increasingly driving this technology into the mobile space where the applications offer a great deal of promise. Initially, AR required unwieldy headsets and kept users largely tethered to their desktop computers. The camera and screen embedded in smart phones and other mobile devices now serve as the means to combine real world data with virtual data; using GPS capability, image recognition, and a compass, AR applications can pinpoint where the mobile's camera is pointing and overlay relevant information at appropriate points on the screen.

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.

Currently, many augmented reality efforts are focused on entertainment and marketing, but these will spill into other areas as the technology matures and becomes even more simplified. Layar (http://layar.com) has been a leader in this space with AR applications for Android and iPhones. Layar's mobile application features content layers that may include ratings, reviews, advertising, or other such information to assist consumers on location in shopping or dining areas. Other mobile applications that make use of AR for social or commercial purposes include Yelp, another review and rating service; Wikitude, which overlays information from Wikipedia and other sources onto a view of the real world; and a handful of Twitter clients. The mobile media company Ogmento develops AR games for mobiles.

The improvement in technology allows more streamlined approaches and wider user adoption.

Market projections for augmented reality on mobile devices predict revenues of $2 million in 2010, rising to several hundred million by 2014 ($350 million, according to ABI Research; Juniper Research's projections are even higher). Augmented reality is poised to enter the mainstream in the consumer sector, and the social, gaming, and location-based applications that are emerging point to a strong potential for educational applications in the next few years.

Relevance for Teaching, Learning, or Creative Inquiry

Augmented reality has strong potential to provide both powerful contextual, *in situ* learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world. Mechanics in the military and at companies like Boeing already use AR goggles while they work on vehicles; the goggles demonstrate each step in a repair, identify the tools needed, and include textual instructions as well. This kind of augmented experience especially lends itself to training for specific tasks.

Applications that convey information about a place open the door to discovery-based learning. Visitors to historic sites can access AR applications that overlay maps and information about how the location looked at different points of history. An application currently in development by the EU-funded iTacitus project (http://itacitus.org/) will allow visitors to pan across a location — the Coliseum, say — and see what it looked like during an historical event, complete with cheering spectators and competing athletes. People, too, will soon be explored through augmented reality. The TAT Augmented ID application, still in development, uses facial recognition technology to display certain, pre-approved information about a person when he or she is viewed through the camera of a mobile device. SREngine is another augmented reality application, also in development, that will use object recognition to display information about everyday things one encounters in the real world —

comparing prices in a shopping center, for instance, or identifying trees.

Of particular relevance to education is augmented reality gaming. Games that are based in the real world and augmented with networked data can give educators powerful new ways to show relationships and connections. Games using marker technology often include a flat game board or map which becomes a 3D setting when viewed with a mobile device or a webcam. This kind of game could easily be applied to a range of disciplines, including archaeology, history, anthropology, or geography, to name a few. Another approach to AR gaming allows players or game masters to create virtual people and objects, tying them to a specific location in the real world. Players interact with these constructs, which appear when the player approaches a linked location in the real world.

Augmented reality can also be used to model objects, allowing learners to envision how a given item would look in different settings. Models can be generated rapidly, manipulated, and rotated. Students receive immediate visual feedback about their designs and ideas in a way that allows them to spot inconsistencies or problems that need to be addressed. Researchers in the Human Interface Technology Laboratory at the University of Canterbury in New Zealand have created a tool that translates sketches into 3D objects and uses augmented reality to allow students to explore the physical properties and interactions between objects. Simple controls, drawn on slips of paper, are used to alter the properties of the sketched objects (see a demonstration video at http://www.youtube.com/watch?v=M4qZ0GLO5_A). At Mauricio De Nassau College in Brazil, architecture students are exploring the possibilities of using augmented reality to project scale models of buildings, cutting down on the time required to construct and present architectural proposals. For another idea of how augmented reality could be applied to the study of architecture, see the concept video *Realtà Aumentata* (http://vimeo.com/2341387), created as a thesis project by

a student at the Valle Giulia Faculty of Architecture in Italy.

Augmented books, now just beginning to enter the market, are another interesting application of this technology. The German company Metaio is developing books that include AR elements, such as globes that pop up on the pages. The books are printed normally; after purchase, consumers install special software on their computers and point a webcam at the book to see the visualizations. The technology allows any existing book to be developed into an augmented reality edition after publication; an atlas featuring 3D views of geographic locations is currently in development.

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

- **Astronomy.** Google's SkyMap is an augmented reality application that overlays information about the stars and constellations as a user views the sky through the camera on his or her mobile phone. Other astronomy applications, such as pUniverse, key detailed (and precisely oriented) maps of the sky to a user's location and orientation.

- **Architecture.** ARSights is a website and tool that allows users to visualize 3D models created in Google's SketchUp. Pointing a webcam at a 2D printout causes a 3D model to appear on the screen. It can be turned and manipulated by moving the sheet of paper (see http://www. inglobetechnologies.com/en/products/arplugin_su/info.php).

- **Computer Science.** The FourEyes Lab at the University of California Santa Barbara is creating a finger-sensing augmented reality program. The software determines the finger positions of the user's hand (spread out, close-fisted, etc.) and moves an illustration on the screen accordingly (causing a rabbit to crouch or jump, for example).

- **Student Guides.** Gratz University of Technology, Austria, has developed campus and museum tours using augmented reality. Looking through the camera on a mobile phone while walking the campus, students see tagged classrooms inside the buildings. At the museum, a virtual tour guide accompanies users through the halls.

Simple Augmented Reality in Practice

The following links provide examples of simple augmented reality.

ARhrrrr - An Augmented Reality Shooter
http://www.youtube.com/watch?v=cNu4CIuFOcw&feature=player_embedded

This video demonstrates an augmented reality game created at Georgia Tech Augmented Environments Lab and the Savannah College of Art and Design Atlanta. The dynamic, interactive game uses a handheld mobile device and a table map — and Skittles.

ARIS Mobile Media Learning Games
http://arisgames.org

ARIS is an alternate reality gaming engine created by the University of Wisconsin's Games, Learning and Society research group. Virtual objects and characters can be placed at certain locations in the physical world; players can interact with them using their mobile devices.

Mirror Worlds
http://www.augmentedenvironments.org/lab/2009/10

Students at Georgia Tech have created a tour of campus that switches between a view of an avatar in a virtual world and augmented reality superimposed on the real world. Users chose their view and can move back and forth between the two.

Video: TAT's Augmented Reality Concept Unveiled
http://www.engadget.com/2009/07/09/video-tats-augmented-reality-concept-unveiled/

(Joseph L. Flatley, *Engadget,* 9 July 2009.) Swedish company The Astonishing Tribe (TAT)

is developing augmented reality software for mobiles that allows users to tag themselves with their Facebook page, Twitter account, a business card, and more. When a tagged person is viewed through others' mobiles, these tags appear and, when selected, open specific links.

Wikitude World Browser
http://www.wikitude.org/world_browser

With the Wikitude World Browser, users can view their surroundings through the camera on a mobile device, seeing historical information, nearby landmarks, and points of interest. Content is drawn from Wikipedia, Qype, and Wikitude, and users can add information of their own.

Wimbledon Seer App Serves Augmented Reality on a Grass Court
http://www.fastcompany.com/blog/kit-eaton/technomix/augmented-reality-hits-wimbledon-tennis-championship

(Kit Eaton, *Fast Company,* 22 June 2009.) An augmented reality app assisted the 500,000 ticket holders at Wimbledon this year. Fans saw information about each match, news feeds, menus of local restaurants, and more superimposed on a view of the venue on their mobiles.

For Further Reading

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

Augmented Learning: An Interview with Eric Klopfer (Part One)
http://henryjenkins.org/2008/07/an_interview_with_eric_klopfer.html

(Henry Jenkins, *Confessions of an Aca-Fan,* 7 July 2008.) Henry Jenkins interviews AR game developer Eric Klopfer, who gives insights into why this area of AR has promise in education and beyond. A link to part two is available on the above page.

Augmented Reality in a Contact Lens
http://spectrum.ieee.org/biomedical/bionics/augmented-reality-in-a-contact-lens/0

(Babak Parviz, *IEEE Spectrum Feature,* September 2009.) Developers at the University of Washington in Seattle have created a contact lens that features augmented reality. They are also exploring the use of contact lenses to measure blood glucose, cholesterol, and more.

If You Are Not Seeing Data, You are Not Seeing
http://www.wired.com/gadgetlab/2009/08/augmented-reality/

(Brian Chen, *Wired Gadget Lab,* 25 August 2009.) This *Wired* article gives a good overview of augmented reality, including where it currently is situated and what to expect in the future.

Map/Territory: Augmented Reality Without the Phone
http://radar.oreilly.com/2009/08/mapterritory-augmented-reality.html

(Brady Forrest, *O'Reilly Radar,* 17 August 2009.) This brief interview discusses what forms augmented reality might take beyond its application for mobile devices.

Visual Time Machine Offers Tourists a Glimpse of the Past
http://www.sciencedaily.com/releases/2009/08/090812104219.htm

(*ScienceDaily,* 17 August 2009.) New apps for smartphones offer augmented reality on the go. While on location, users view historical sites as they were hundreds of years ago.

Delicious: Simple Augmented Reality
http://delicious.com/tag/hz10+augmentedreality

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GESTURE-BASED COMPUTING

Time-to-Adoption Horizon: Four to Five Years

For nearly forty years, the keyboard and mouse have been the primary means to interact with computers. The Nintendo Wii in 2006 and the Apple iPhone in 2007 signaled the beginning of widespread consumer interest in — and acceptance of — interfaces based on natural human gestures. Now, new devices are appearing on the market that take advantage of motions that are easy and intuitive to make, allowing us an unprecedented level of control over the devices around us. Cameras and sensors pick up the movements of our bodies without the need of remotes or handheld tracking tools. The full realization of the potential of gesture-based computing is still several years away, especially for education; but we are moving ever closer to a time when our gestures will speak for us, even to our machines.

Overview

It is already common to interact with a new class of devices entirely by using natural gestures. The Microsoft Surface, the iPhone and iPod Touch, the Nintendo Wii, and other gesture-based systems accept input in the form of taps, swipes, and other ways of touching, hand and arm motions, or body movement. These are the first in a growing array of alternative input devices that allow computers to recognize and interpret natural physical gestures as a means of control. We are seeing a gradual shift towards interfaces that adapt to — or are built for — humans and human movements. Gestural interfaces allow users to engage in virtual activities with motion and movement similar to what they would use in the real world, manipulating content intuitively. The idea that natural, comfortable motions can be used to control computers is opening the way to a host of input devices that look and feel very different from the keyboard and mouse.

As the underlying technologies evolve, a variety of approaches to gesture-based input are being explored. The screens of the iPhone and the Surface, for instance, react to pressure, motion, and the number of fingers touching the devices. The iPhone additionally can react to manipulation of the device itself — shaking, rotating, tilting, or moving the device in space. The Wii and other emerging gaming systems use a combination of a handheld, accelerometer-based controller and stationary infrared sensor to determine position, acceleration,

and direction. The technology to detect gestural movement and to display its results is improving very rapidly, increasing the opportunities for this kind of interaction. Two new gaming systems are expected to be released in 2010 — a Sony platform based on a motion sensor code-named Gem, and the Microsoft Natal system. Both of these systems take a step closer to stripping the gesture-based interface of anything beyond the gesture and the machine, at least in terms of how it is experienced by the user.

Gesture-based interfaces are changing the way we interact with computers, giving us a more intuitive way to control devices. They are increasingly built into things we can already use; Logitech and Apple have brought gesture-based mice to market, and Microsoft is developing several models. Smart phones, remote controls, and touch-screen computers accept gesture input. As more of these devices are developed and released, our options for controlling a host of electronic devices are expanding. We can make music louder or softer by moving a hand, or skip a track with the flick of a finger. Apple's Remote app for the iPhone turns the mobile device into a remote control for the Apple TV; users can search, play, pause, rewind, and so on, just by gliding a finger over the iPhone's surface. Instead of learning where to point and click and how to type, we are beginning to be able to expect our computers to respond to natural movements that make sense to us.

Currently, the most common applications of gesture-based computing are for computer games, file and media browsing, and simulation and training. A number of simple mobile applications use gestures. *Mover* lets users "flick" photos and files from one phone to another; *Shut Up,* an app from Nokia, silences the phone when the user turns it upside down; *nAlertme,* an anti-theft app, sounds an alarm if the phone isn't shaken in a specific, preset way when it is switched on. Some companies are exploring further possibilities; for instance, Softkinetic (http://www.softkinetic.net) develops platforms that support gesture-based technology, as well as designing custom applications for clients, including interactive marketing and consumer electronics as well as games and entertainment.

Because it changes not only the physical and mechanical aspects of interacting with computers, but also our perception of what it means to work with a computer, gesture-based computing is a potentially transformative technology. The distance between the user and the machine decreases and the sense of power and control increases when the machine responds to movements that feel natural. Unlike a keyboard and mouse, gestural interfaces can often be used by more than one person at a time, making it possible to engage in truly collaborative activities and games. Our perception of the kinds of activities that computers are good for is also altered by gestural interaction — activities that require sweeping movements, such as many sports or exercises, are suited to gestural interfaces.

Relevance for Teaching, Learning, or Creative Inquiry

The kinesthetic nature of gesture-based computing will very likely lead to new kinds of teaching or training simulations that look, feel, and operate almost exactly like their real-world counterparts. The very ease and intuitiveness of a gestural interface makes the experience seem very natural, and even fun. Already, medical students benefit from simulations that teach the use of specific tools through gesture-based interfaces, and it is easy to see how such interfaces could be applied in the visual arts and other fields where fine motor skills come into play. When combined with haptic (touch or motion-based) feedback, the overall effect is very compelling.

Larger multi-touch displays support collaborative work, allowing multiple users to interact with content simultaneously. In schools where the Microsoft Surface has been installed in study areas, staff report that students naturally gravitate to the devices when they want to work together to study collaboratively. The promotional video for Microsoft's Natal system shows a family taking on different roles in a racing game — driver, pit crew — and suggests that role-playing activities where several students work together to perform different but related tasks will be a scenario made common by tools that use gesture-based computing.

Pranav Mistry, while at the MIT Media Lab, developed a gesture-based system called Sixth Sense that uses markers to allow interaction with all sorts of real-time information and data in extremely intuitive ways. He recently announced the release of the platform into open source (http://www.youtube.com/watch?v=YrtANPtnhyg), which is likely to stimulate a raft of new ideas. Mgestyk's gesture-based system of control uses a 3-dimensional camera to capture user movements. The system has been demonstrated with Microsoft Flight Simulator, and allows players to fly a simulated plane by simply moving their hands — without any joystick or remote (see http://www.youtube.com/watch?v=FZyErkPjOR8). The system is expected to release to market in late spring 2010 at a cost comparable to that of a high-end webcam. It is not difficult to picture similar applications, a little further down the road, that could be used to simulate many kinds of experiences.

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

■ **Kinesiology.** Dutch company Silverfit uses a gesture-based system to deliver fitness games designed for the elderly. Used in elder care organizations, the games provide gentle exercise and "activity of daily life" practice.

- **Medicine.** Digital Lightbox by BrainLAB is a multi-touch screen that allows doctors and surgeons to view and manipulate data from MRI, CT, x-ray, and other scan images. The system integrates with hospital data sources to enable health professionals to collaborate throughout the cycle of treatment.

- **Sign Language.** Researchers at Georgia Tech University have developed gesture-based games designed to help deaf children learn sign language. Deaf children of hearing parents often lack opportunities to pick up language serendipitously in the way hearing children do; the game provides an opportunity for incidental learning.

- **Surgical Training.** After discovering the significant improvement in dexterity that surgeons-in-training gained from interacting with the Wii (in one study, those who warmed up with the Wii scored an average of 48% higher on tool tests and simulated surgical procedures than those who did not), researchers are developing a set of Wii-based medical training materials for students in developing countries.

Gesture-Based Computing in Practice

The following links provide examples of gesture-based computing.

CMU Grad Students Build 3-D Snowball Fight
http://www.post-gazette.com/pg/09308/1010559-96.stm

(Ann Belser, *Pittsburgh Post-Gazette,* 4 November 2009.) As an assignment, several graduate students at Carnegie Mellon University created a gesture-based snowball fight game using PC software and components from the Nintendo Wii.

Microsoft's Finally Got Game
http://blog.newsweek.com/blogs/techtonicshifts/archive/2009/11/05/microsoft-s-finally-got-game.aspx

(Nick Summers, *Newsweek,* 5 November 2009.) Microsoft's Project Natal engages full-body movement to interact with this game console — without any kind of controller or remote. The product, still in development, uses an infrared light and camera to sense the users' movements, eliminating the need for hand-held equipment and placing the user's own silhouette in the game world.

Parkinson's Patients Go to Wii-hab
http://www.livescience.com/technology/090611-wii-parkinsons.html

(*LiveScience,* 11 June 2009.) In a study undertaken at the Medical College of Georgia's School of Allied Health Sciences, Parkinson's patients showed significant improvement when playing games on the Wii was added to their therapy.

University Offers New Technology to Help Students Study
http://www.unr.edu/nevadanews/templates/details.aspx?articleid=5194&zoneid=14

(Skyler Dillon, *Nevada News,* 1 October 2009.) The Mathewson-IGT Knowledge Center at the University of Nevada in Reno has installed two Microsoft Surfaces in its study area and developed a custom anatomy study guide. Placing a coded lab assignment or tagged model on the screen calls up diagrams related to the material. Students can manipulate the diagrams using hand and finger gestures while they study independently or collaboratively.

The Virtual Autopsy Table
http://www.visualiseringscenter.se/1/1.0.1.0/230/2/

Researchers at Norrkoping Visualization Centre and the Center for Medical Image Science and Visualization in Sweden have created a virtual autopsy using a multi-touch table. Detailed CT scans are created from a living or dead person and transferred to the table where they are manipulated with the hands, allowing forensic scientists to examine a body, make virtual cross-sections, and view layers including skin, muscle, blood vessels, and bone.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about gesture-based computing.

The Best Computer Interfaces: Past, Present, and Future

http://www.technologyreview.com/ computing/22393/page1

> (Duncan Graham-Rowe, *Technology Review,* 6 April 2009.) This article discusses a variety of human-computer interfaces, including gesture-sensing, voice recognition, and multi-touch surfaces.

A Better, Cheaper Multitouch Interface

http://www.technologyreview.com/ computing/22358/?a=f

> (Kate Greene, *Technology Review,* 30 March 2009.) New York University is developing a new multi-touch interface that accepts gesture-based input on a specially designed pad. The Inexpensive Multi-touch Pressure Acquisition Device (IMPAD) is a very thin surface that can be used on a desktop, a wall, a mobile device, or a touch screen.

Sony Motion Controller Demo: Dueling Domino Snakes

http://www.shacknews.com/onearticle.x/60518

> (Nick Breckon, *ShackNews,* 18 September 2009.) Sony is developing a motion controller to be released in 2010. This article includes a video demonstration of some of the system's capabilities. The system is characterized as somewhere in between the Nintendo Wii and the unreleased Microsoft Natal system in terms of how it is controlled.

Touching: All Rumors Point To The End Of Keys/Buttons

http://www.techcrunch.com/2009/09/29/ touching-all-rumors-point-to-the-end-of-keysbuttons/

> (MG Siegler, *TechCrunch,* 29 September 2009.) This article describes a number of touch- and gesture-based devices from Apple and speculates on what might be forthcoming.

Why Desktop Touch Screens Don't Really Work Well For Humans

http://www.washingtonpost.com/wp-dyn/content/ article/2009/10/13/AR2009101300113.html

> (Michael Arrington, *The Washington Post,* 12 October 2009.) Desktop touch screens are available (like the HP TouchSmart line), but they are difficult to use over long periods. This article suggests another design approach.

Delicious: Gesture-Based Computing

http://delicious.com/tag/hz10+altinput

> Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report.* To add to this list, simply tag resources with "hz10" and "altinput" when you save them to *Delicious.*

VISUAL DATA ANALYSIS

Time-to-Adoption Horizon: Four to Five Years

Visual data analysis blends highly advanced computational methods with sophisticated graphics engines to tap the extraordinary ability of humans to see patterns and structure in even the most complex visual presentations. Currently applied to massive, heterogeneous, and dynamic datasets, such as those generated in studies of astrophysical, fluidic, biological, and other complex processes, the techniques have become sophisticated enough to allow the interactive manipulation of variables in real time. Ultra high-resolution displays allow teams of researchers to zoom in to examine specific aspects of the renderings, or to navigate along interesting visual pathways, following their intuitions and even hunches to see where they may lead. New research is now beginning to apply these sorts of tools to the social sciences and humanities as well, and the techniques offer considerable promise in helping us understand complex social processes like learning, political and organizational change, and the diffusion of knowledge.

Overview

Over the past century, data collection, storage, transmission, and display has changed dramatically, and scholars have undergone a profound transformation in the way they approach data-related tasks. Data collection and compilation is no longer the tedious, manual process it once was, and tools to analyze, interpret, and display data are increasingly sophisticated, and their use routine in many disciplines. The options for illustrating trends, relationships, and cause and effect have exploded, and it is now a relatively simple matter for anyone to do the sorts of analyses that were once only the province of statisticians and engineers.

In advanced research settings, scientists and others studying massively complex systems generate mountains of data, and have developed a wide variety of new tools and techniques to allow those data to be interpreted holistically, and to expose meaningful patterns and structure, trends and exceptions, and more. Researchers that work with data sets from experiments or simulations, such as computational fluid dynamics, astrophysics, climate study, or medicine draw on techniques from the study of visualization, data mining, and statistics to create useful ways to investigate and understand what they have found.

The blending of these disciplines has given rise to the new field of visual data analysis, which is not only characterized by its focus on making use of the pattern matching skills that seem to be hard-wired into the human brain, but also in the way in which it facilitates the work of teams working in concert to tease out meaning from complex sets of information. While the most sophisticated tools are still mostly found in research settings, a variety of tools are emerging that make it possible for almost anyone with an analytical bent to easily interpret at all sorts of data.

Self-organizing maps are an approach that mimics the way our brains organize multi-faceted relationships; they create a grid of "neuronal units" such that neighboring units recognize similar data, reinforcing important patterns so that they can be seen. Cluster analysis is a set of mathematical techniques for partitioning a series of data objects into a smaller amount of groups, or clusters, so that the data objects within one cluster are more similar to each other than to those in other clusters. Visual, interactive principal components analysis is a technique once only available to statisticians that is now commonly used to identify hidden trends and data correlations in multidimensional data sets. Gapminder (http://www.gapminder.org/), for example, uses this approach in its analysis of multivariate datasets over time.

These sorts of tools are now finding their way into common use in many other disciplines, where the

analytical needs are not necessarily computational; visualization techniques have even begun to emerge for textual analysis and basic observation. Many are free or very inexpensive, bringing the ability to engage in rich visual interpretation to virtually anyone.

Online services such as Many Eyes, Wordle, Flowing Data, and Gapminder accept uploaded data and allow the user to configure the output to varying degrees. Many Eyes, for instance, allows people to learn how to create visualizations, to share and visualize their own data, and to create new visualizations from data contributed by others. Some, like Roambi, have mobile counterparts, making it easy to carry interactive, visual representations of data wherever one goes. Even quite public data, such as the posts made in Twitter, can be rendered visually to reveal creative insights. For instance, New Political Interfaces (http://newpoliticalinterfaces.org) created a visualization examining political topics as expressed on Twitter, charting which topics are — and are not — being discussed by politicians, news outlets, and other sources.

Relevance for Teaching, Learning, or Creative Inquiry

As stated previously, one of the most compelling aspects of visual data analysis is in the ways it augments the natural abilities humans have to seek and find patterns in what they see. By manipulating variables, or simply seeing them change over time (as Gapminder has done so famously) if patterns exist (or if they don't), that fact is easily discoverable. Such tools have applicability in nearly every field.

As the tools, their capabilities, and their variety continue to expand, their use is already making its way out of scientific and engineering labs and into business and social research. Creative inquiry is benefiting from a wide range of new tools that are exposing trends and relationships among both qualitative and quantitative variables in real time, and making longitudinal relationships easier to find and interpret than ever. Textual analysis is an area that

tools like Wordle have revealed as especially suited to visual techniques.

The promise for teaching and learning is further afield, but because of the intuitive ways in which it can expose intricate relationships to even the uninitiated, there is tremendous opportunity to integrate visual data analysis into undergraduate research, even in survey courses. Models of complex processes in quantum physics, organic chemistry, medicine, or economics are just a few of the ways in which the outcomes of visual data analysis can be applied to learning situations.

Visual data analysis may help expand our understanding of learning itself. Learning is one of the most complex of social processes, with a myriad of variables interacting in ways that are not well understood, making it an ideal focus for the search for patterns. Related to this is the opportunity to understand the variables influencing informal learning and the social networking processes at work in the formation of learning communities. The tools for such analyses exist today; what is needed are ways to balance privacy with the kinds of data capture that can inform such work.

A sampling of visual data analysis applications for a variety of purposes includes the following:

- **Astrophysics.** Harvard scientists are using data visualization from the Chandra X-Ray Observatory to measure the expansion velocity of supernova remnants. Visual data analysis has also enabled scientists to more fully understand the effects of multiple points of explosion in a supernova.

- **Fluid Dynamics and Human Physiology.** Researchers working with Amira, a visual data analysis tool created originally at the Zuse Institute in Berlin, have created a range of models of biological processes from MRI data, fluid flows, and other complex datasets. Insights from the study of fluid dynamics over complex surfaces informed work that models blood flows and arterial mapping.

- **Marine Geology.** Published by the Lamont-Doherty Earth Observatory at Columbia University, the Virtual Ocean, similar to Google Earth, offers students a three-dimensional view of the Earth's oceans (http://www.virtualocean.org).

- **Composition and Rhetoric.** Using tools like Many Eyes and Wordle, students can easily analyze the contents of their papers visually for insights into what points might need further development, and whether or not certain language has been overused.

Visual Data Analysis in Practice
The following links provide examples of visual data analysis.

28 Rich Data Visualization Tools
http://www.insideria.com/2009/12/28-rich-data-visualization-too.html
> (Theresa Neil, *O'Reilly's Inside RIA,* 10 December 2009.) This article contains visual examples of dozens of data analysis displays. Listed are twenty-eight tools for creating charts, graphs, and other data displays for use by developers.

Best Science Visualization Videos of 2009
http://www.wired.com/wiredscience/2009/08/visualizations/all/1
> (Hadley Legget, *Wired,* 19 August 2009.) From simulating the way waves break against a ship to visualizing seasonal carbon dioxide accumulation in North America, these videos demonstrate the diversity of data visualization.

Brain Structure Assists in Immune Response, According to Penn Vet Study
http://www.upenn.edu/pennnews/article.php?id=1531
> (Jordan Reese, Media Contact, Office of University Communications, University of Pennsylvania, 28 January 2009.) Analytics and data visualization allowed researchers at the University of Pennsylvania to visually model (in real time) the response of the body's immune system to a parasitic infection.

Gapminder
http://www.gapminder.org
> Gapminder, a Swedish-based nonprofit organization, seeks to promote sustainable global development using data visualization as a major tool.

Visual Complexity
http://www.visualcomplexity.com/vc
> A wide variety of data visualization projects are featured on this site. Browse everything from changes in the text from one edition of *The Origin of the Species* to the next, to *Cymatics,* a visualization of the study of sound vibrations on matter.

Worldmapper
http://www.worldmapper.org
> Worldmapper is a visualization tool that redraws maps based on the data being displayed. For instance, on a world map showing population, countries with more people swell while those with fewer people shrink.

For Further Reading
The following articles and resources are recommended for those who wish to learn more about visual data analysis.

7 Things You Should Know About Data Visualization II
http://net.educause.edu/ir/library/pdf/ELI7052.pdf
> (*Educause,* August 2009.) This article discusses data visualization as it relates to higher education: who's using it, why they're using it, and what to expect in the future.

New Visualization Techniques Yield Star Formation Insights: Gravity Plays Larger Role Than Thought
http://www.sciencedaily.com/releases/2008/12/081231152305.htm
> (*Science Daily,* 4 January 2009.) Early in 2009, a new computer algorithm developed at

the Harvard Initiative in Innovative Computing demonstrated that data visualization is critical in the discovery of new information, not just in the final presentation of data.

The Technologies of G21: How Government Can Become a Platform for Innovation
http://www.huffingtonpost.com/gadi-benyehuda/ the-technologies-of-g21-h_b_266532.html

(Gadi Ben-Yehuda, *Huffington Post,* 24 August 2009.) The author discusses the changes in data collection, storage, transmission, and display over the past century, noting that data visualization is now in the hands of the people for the first time.

Visualization and Knowledge Discovery: Report from the DOE/ASCR Workshop on Visual Analysis and Data Exploration at Extreme Scale
http://www.sci.utah.edu/vaw2007/DOE-Visualization-Report-2007.pdf

This report from the Department of Energy describes fundamental research in visualization and analysis that is enabling knowledge discovery from computational science applications at extreme scale.

Delicious: Visual Data Analysis
http://delicious.com/tag/hz10+analytics

Follow this link to find additional resources tagged for this topic and this edition of the *Horizon Report.* To add to this list, simply tag resources with "hz10" and "analytics" when you save them to *Delicious.*

METHODOLOGY

The *Horizon Report* is produced each fall using a carefully constructed process that is informed by both primary and secondary research. Nearly a hundred technologies, as well as dozens of meaningful trends and challenges are examined for possible inclusion in the report each year; an internationally renowned Advisory Board examines each topic in progressively more detail, reducing the set until the final listing of technologies, trends, and challenges is selected. The entire process takes place online and is fully documented at *horizon.wiki.nmc.org.*

The process of selection, a modified Delphi process now refined over several years of producing *Horizon Reports,* begins each summer as the Advisory Board is convened. About half of the forty or so members are newly chosen each year, and the board as a whole is intended to represent a wide range of backgrounds, nationalities, and interests. By design, at least one-third of the Advisory Board represent countries outside of North America. To date, more than 400 internationally recognized practitioners and experts have participated. Once the Advisory Board is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertain to emerging technology. Advisory Board members are provided with an extensive set of background materials when the project begins, and then are asked to comment on them, identify those which seem especially worthwhile, and also add to the set. A carefully selected set of RSS feeds from nearly 50 leading publications ensures that these resources stay current as the project progresses, and they are used to inform the thinking of the participants through the process.

Following the review of the literature, the Advisory Board engages in the process of addressing the five research questions that are at the core of the Horizon Project. These questions are the same each year, and are designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the Advisory Board:

1 *What would you list among the established technologies that learning-focused institutions should all be using broadly today to support or enhance teaching, learning, or creative inquiry?*

2 *What technologies that have a solid user base in consumer, entertainment, or other industries should learning-focused institutions be actively looking for ways to apply?*

3 *What are the key emerging technologies you see developing to the point that learning-focused institutions should begin to take notice during the next three to five years? What organizations or companies are the leaders in these technologies?*

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

5 *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?*

One of the Advisory Board's most important tasks is to answer these five questions as systematically and broadly as possible, so as to generate a large number of potential topics to consider. As the last step in this process, past *Horizon Reports* are revisited and the Advisory Board is asked to comment on the current state of technologies, challenges, and trends identified in previous years, and to look for metatrends that that may be evident only across the results of multiple years.

To create the *2010 Horizon Report,* the 47 members of this year's Advisory Board engaged in a comprehensive review and analysis of research, articles, papers, blogs, and interviews; discussed existing applications; and brainstormed new ones. A

key criterion was the potential relevance of the topics to teaching, learning, research, or creative inquiry.

Once this foundational work was completed, the Advisory Board moved to a unique consensus-building process that uses an iterative Delphi-based methodology. In the first step, the responses to the research questions were systematically ranked and placed into adoption horizons by each Advisory Board member in a multi-vote system that allowed members to weight their selections. These rankings were compiled into a collective set of responses. From the more than 80 technologies originally considered, the twelve that emerged at the top of the initial ranking process — four per adoption horizon — were further researched. Once this "short list" was identified, the potential applications of these important technologies were further explored by higher education practitioners who were either knowledgeable about them, or interested in thinking about how they might be used. A significant amount of time was spent researching applications or potential applications for each of the areas that would be of interest to practitioners.

Each of these twelve was written up in the format of the *Horizon Report.* With the benefit of knowing how each topic would look in the report, the "short list" was then ranked yet again, this time with a reverse ranking approach. The six technologies and applications that emerged at the top of the rankings — two per adoption horizon — are detailed in the preceding sections, and those descriptions are the final results of this process.

An ongoing component of the project involves a special set of *Delicious* links that have been established to help extend the findings of the project and allow new information to be shared within the community. These *Delicious* tags are listed under the "Further Reading" section of each of the six topic areas, and readers are invited to view the hundreds of resources used in producing the report. These links are enhanced by a vibrant community that contributes new information daily. Readers are encouraged to be part of this community and add their own examples and readings to these dynamic lists by tagging them for inclusion in each category.

2010 HORIZON PROJECT ADVISORY BOARD

NOTES