



# **THE HORIZON REPORT**

2005 EDITION

**NMC: The New Media Consortium  
National Learning Infrastructure Initiative**

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## EXECUTIVE SUMMARY

The second edition of the NMC's annual *Horizon Report* describes the continued work of the NMC's Horizon Project, a research-oriented effort that seeks to identify and describe emerging technologies likely to have a large impact on teaching, learning, or creative expression within higher education. The *2005 Horizon Report* is a collaboration between the New Media Consortium (NMC) and the National Learning Infrastructure Initiative (NLII), an EDUCAUSE program. Produced with the support of McGraw Hill Online Education, the report highlights six areas of emerging technology that the research suggests will become increasingly significant to higher education within three adoption horizons over the next one to five years.

The project draws on an ongoing discussion among knowledgeable individuals in business, industry, and education, as well as published resources, current research and practice, and the expertise of the NMC community itself. The Horizon Project's Advisory Board provides another perspective on the value and importance of each of the six areas identified.

Several important trends underlie the choices for the six technological areas described in the report. As the project unfolded over the last year, these permeated the discussions at every level.

- The locus of ownership of both the process of constructing and sharing knowledge, and of knowledge itself, is shifting. Learners are not only willing to participate in the construction of knowledge; they are starting to expect to.
- New models for sharing and licensing content and software are emerging that will have lasting implications for the way information is distributed and obtained. Open-source software development projects are becoming more common. Forms of license that not only allow, but also promote the sharing of resources are on the rise. An example is the Creative Commons

([www.creativecommons.org](http://www.creativecommons.org)), a nonprofit organization that supplies flexible copyright statements for creative work.

- The lines defining what can be done with desktop computers as opposed to laptops, handhelds, or even cell phones are blurring. In response to consumer demand, device manufacturers and software producers are increasingly focused on interoperability and compatibility.
- Access to the Internet is increasing, not only in terms of who has it, but also in terms of what devices can do it. This trend, driven by the increasing demand to keep in touch and stay informed, is resulting in more possibilities for communication and information retrieval. Increased access is augmented by new developments in wireless technology.
- People are using technology to connect with each other easily, informally, and on many levels. This is one of the most interesting current developments in educational technology. The fear that technology-enhanced communication will replace face-to-face interaction is subsiding, replaced by a dawning understanding that enabling social interaction and interpersonal connections is a valuable aspect of technology.
- Content is valued over format, meaning that consumers are less concerned with where content comes from or how it is packaged and more concerned with what it actually is. This is resulting in content offered in a variety of formats, often with different costs associated with the various formats (consider Amazon.com's "search inside the book" feature, which grants access to part of a book for free).

The likely impacts of these six trends for teaching and learning are significant and broad-reaching. Even more than their potential for the classroom, each of the trends is influencing the others in ways that

continue to unfold. As they do, it is a virtual certainty that new forms of communication, collaboration, and learning will follow.

## Technologies Detailed in the 2005 Horizon Report

The technologies chosen for the *2005 Horizon Report* are framed within three adoption horizons that presume three different assumptions about when the targeted technologies will begin to see significant adoptions on university campuses. The first assumes a high likelihood of broad adoption within the next year; the second, adoption within two to three years; and the third, adoption within four to five years. The choices in the first category, extended learning and ubiquitous wireless, are seen in use already at leading campuses across North America and Europe. Applications for both can be expected to grow substantially within that timeframe.

Four additional technologies are spread along the two more distant horizons, and as one might suspect, they are increasingly less well defined as we move out in time. All are seeing significant development in the private sector, but their applications for higher education are still unfolding. As the discussions in this report move further out along the adoption horizon, the reader will note the examples and applications are more conceptual and prototypical. We found considerable interest in these topics in our research. Each area poses interesting possibilities for teaching and learning, and early experiments with all of them seem quite promising. Our consensus is that within the next two to five years, all four will see broad usage within colleges and universities.

- **Extended Learning.** On some campuses, traditional instruction is augmented with technology tools that are familiar to students and used by them in daily life. Extended learning courses can be conceptualized as hybrid courses with an extended set of communication tools and strategies. The classroom serves as a home base for exploration, and integrates

online instruction, traditional instruction, and study groups, all supported by a variety of communication tools.

- **Ubiquitous Wireless.** With new developments in wireless technology both in terms of transmission and of devices that can connect to wireless networks, connectivity is increasingly available and desired. Campuses and even communities are beginning to regard universal wireless access as a necessity for all.
- **Intelligent Searching.** To support people's growing need to locate, organize, and retrieve information, sophisticated technologies for searching and finding are becoming available. These agents range from personal desktop search "bots," to custom tools that catalog and search collections at an individual campus, to specialized search interfaces like Google Scholar.
- **Educational Gaming.** Taking a broad view of educational gaming, one finds that games are not new to education. Technology and gaming combine in interesting ways, not all of which are about immersive environments or virtual reality. What is evolving is the way technology is applied to gaming in education, with new combinations of concepts and games appearing on the horizon.
- **Social Networks and Knowledge Webs.** Supplying people's need to connect with each other in meaningful ways, social networks and knowledge webs offer a means of facilitating teamwork and constructing knowledge. The underlying technologies fade into the background while collaboration and communication are paramount.
- **Context-Aware Computing/Augmented Reality.** These related technologies deal with computers that can interact with people in richer ways. Context-aware computing uses environmental conditions to customize the user's experience or options. Augmented reality provides additional

contextual information that appears as part of the user's world. Goals of both approaches are increased access and ease-of-use.

It is worthy of note that the two technologies in the four-to-five year adoption horizon, Context-Aware Computing/Augmented Reality and Social Networks and Knowledge Webs, appeared in the 2004 edition of the *Horizon Report* on the same adoption horizon, but in a slightly different form. Our research indicates that these technologies are converging with related trends in some very interesting ways.

For example, last year, it was not at all apparent that Social Networks could be related to Knowledge Webs, but with the emergence of several newly-developed tools and techniques, it is clear that they are converging. Likewise, it is now clear that last year's topics of Context-Aware Computing and Augmented Reality have become essentially two sides of the same coin as the underlying technologies converged.

The format of the report deserves some mention as it has been carefully designed to preserve the central perspective of the Horizon Project. A great many other authors and organizations have done very good work in detailing the technologies from a technical view. The Horizon Project has focused from its inception on practical applications of interesting emerging technologies and ideas for teaching, learning, and creative expression. As such, the description of each technology includes a discussion of its relevance for those uses, links to examples of how the technology is being or could be applied, as well as an annotated list of additional readings.

## About the Horizon Project

Since the project launch in March 2002, the NMC has held an ongoing series of conversations with more than 500 technology professionals in the Silicon Valley, senior IT reps and faculty leaders from colleges and universities, and representatives of leading corporations. The "horizon" in the project's name refers to the time horizon anticipated before a

technology is adopted for use by a significant number of colleges and universities, and is intended as a basis for planning.

The project considers three time horizons in its research: a very near-term horizon of 12 months or less before broad adoption; a mid-range horizon of 2-3 years; and a long-term horizon of 4-5 years. The project uses qualitative research methods to identify the technologies selected for inclusion in each annual 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, 20-30 of these technologies may be identified for further investigation.

By engaging a wide community of interested parties, and diligently searching the Internet for relevant articles and websites, enough information is gathered early in the process to allow the Advisory Board members to form an understanding of how each of the discovered technologies may be being used in settings outside of academe, of the potential the technology may have for higher education settings, and to envision applications of the technology for teaching, learning, and creative expression. 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.

During the working sessions that led to the *2005 Horizon Report*, the Advisory Board discussed existing applications, brainstormed new ones, and ultimately ranked the items on the list of candidate technologies for their potential relevance to teaching, learning, and creative expression. Only a handful of those technologies ranked highly enough to be

carried forward, and the “short list” that emerged formed the basis for this report.

Once the final list was identified, the potential applications of these important technologies were furthered 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 we hoped would be of interest to practitioners. The discussions that follow are the final results of this process.

# EXTENDED LEARNING

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

*Extended learning – augmenting traditional instruction with communication tools, especially those already familiar to students and used by them in daily life – increases opportunities for learning and is beginning to open new doors for collaborative work.*

### Overview

Extended learning is a term in broad use among institutions offering distance learning programs. However, extended learning may also be thought of as more than a course offered at a distance. Grounded in the classroom, extended learning experiences take advantage of an enriched environment where classroom instruction is supplemented by an interactive component facilitated by technology tools. Expanded opportunities for communication are possible in extended learning courses.

Hybrid or blended learning programs, which combine face-to-face instruction and distance learning, merge the best aspects of both types of instruction to offer an enhanced learning experience for students. Extended learning goes beyond typical hybrid courses by including active channels that make it easy for substantive communication and interaction to take place. Extended learning programs use the classroom as a home base while offering additional opportunities for learning and communication to take place outside of class.

It is not uncommon to hear debates on campuses today about banning technologies like cell phones, instant messaging or chat, and even Internet connectivity for classes in session. These can be a distraction, interrupting a class and drawing students' attention away from the professor. However, some faculty and programs are beginning to rethink this stance and devise ways to exploit the educational potential of these and similar tools.

Tools like instant messaging, blogs, RSS\*, wikis, and others are used frequently by many students in their personal lives. Students also commonly carry cell phones, digital cameras, iPods, and other small

devices. As students become more familiar with (and more dependent upon) these tools, they are bringing them into the classroom, albeit not always for purely academic purposes. Extended learning courses provide opportunities for taking advantage of devices students already carry.

*\*RDF [Resource Description Framework] Site Summary*

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

Blogs, wikis, and other asynchronous forums encourage sharing of multiple perspectives in a safe atmosphere. Familiarity with the toolset may lead to increasingly creative approaches to learning on the part of students. The potential of these tools is to connect students in new ways, in new groupings, and for new purposes. Where these tools are being applied, ownership of the process of discovering or acquiring knowledge is beginning to move from the teacher alone into the hands of the educational group comprised of teacher and students. Successful collaborative workspaces, both on- and offline, are supported by common tools that students know well.

Extended learning models allow faculty to offer courses in more flexible ways. Classroom efficiency is maximized by providing students with access to web-based resources and online learning activities, affording greater learning opportunities. This helps to lessen instructor workloads, accommodate various student learning styles, and personalize the student learning experience.

Extended learning also requires fewer hours of classroom time. With course materials accessible



24 hours a day, students can access information at times more conducive to their schedules. This makes the learning environment more flexible and accommodating to the needs of the student. Students can access materials that appeal to varying learning styles, communicate with peers and the instructor, navigate through course materials in a more self-directed style, and find information they need on their own time and in their own way with the support and motivation they would receive in a traditional classroom.

Students communicate using instant messaging and cell phones outside of class. Incorporating these and similar tools for classroom use may be a means for increasing meaningful peer interactions during the learning process.

Extended learning examples can be found in almost all disciplines and the potential exists to apply extended learning in any learning situation, particularly those where learning communities will help the outcome. Consider the following possibilities:

- In a discussion-based class, as the instructor leads the discussion from the front of the room, perhaps showing slides on the screen, students are encouraged to conduct a parallel discussion using an instant messaging backchannel. The teaching assistant leads that discussion, posing questions to guide the conversation. Students who would not normally speak up in class are actively involved in the text-based discussion.
- Students in a business management course are assigned a group project to create a business plan. Working sometimes in the library, sometimes in the coffee house, and sometimes from their various dorms and apartments, the students collaborate, keeping track of their discussion, research and ideas using a blog. The business plan itself takes the form of a jointly-created wiki, which is the product of their groupwork.

- Wanting to involve every student in answering questions in class, a professor sets up a polling system using cell phones already carried by her students. She poses a question and students dial one number for yes and another for no, giving the professor an instant picture of whether her students are following along and understanding the material.
- To address the issue of getting students to listen to language exercises when they don't have enough time to log the hours in the language labs, Dartmouth College uses iPods for language exercises. Students check them out from library with listen-and-repeat exercises preloaded on the iPods so they can practice on the go.

## Examples of Extended Learning

The following links provide examples of extended learning applications or programs.

### **The Distributed Learning Initiative, University of Central Florida**

**[pegasus.cc.ucf.edu/~rite/ImpactEvaluation.html](http://pegasus.cc.ucf.edu/~rite/ImpactEvaluation.html)**

The University of Central Florida has had an established extended learning component (the Distributed Learning Initiative) since fall of 1996. The results of ongoing evaluation of the courses are available at the URL above. The Virtual Campus (*distrib.ucf.edu/*) offers extended learning courses that integrate a variety of communications tools with hybrid instruction.

### **Hybrid Course Website, University of Wisconsin at Milwaukee**

**[www.uwm.edu/Dept/LTC/hybrid/](http://www.uwm.edu/Dept/LTC/hybrid/)**

The University of Wisconsin at Milwaukee has received a grant to help faculty develop hybrid courses. A specially designed website explains what hybrid courses are and how to prepare to develop and teach them.

**Rick Effland's Blog**

[homepage.mac.com/reffland/blogwavestudio/index.html](http://homepage.mac.com/reffland/blogwavestudio/index.html)

Richard Effland at Maricopa Community Colleges is using a blog to get his students to reflect and write about issues in the study of what makes us human. Now in its second generation (and still evolving), the blog serves as a database of ideas upon which students construct higher-level concepts.

**New Writing Course, Bemidji State University**

[cal.bemidjistate.edu/english/blikis.html](http://cal.bemidjistate.edu/english/blikis.html)

This course in the English department teaches “online writing” using blogs and wikis. Students create a blog or wiki, maintain it over a semester, and analyze the experience.

**For Further Reading**

The following articles and resources are recommended for those who wish to learn more about extended learning, hybrid learning, and related topics.

**Apple Computer's Higher Education Discovery Tour**

[ali.apple.com/ali\\_sites/ali/tours/hed.html](http://ali.apple.com/ali_sites/ali/tours/hed.html)

This site contains resources and suggestions for using technology to extend traditional classroom experiences.

**Blogger**

[new.blogger.com](http://new.blogger.com)

Blogger (owned by Google) is a popular blogging tool. Designed to make web publishing easy and instantaneous, Blogger focuses on “helping people have their own voice on the web and organizing the world’s information from a personal perspective.”

**Guidelines for Good Practice: Technology-Mediated Instruction**

[www.academicssenate.cc.ca.us/Publications/Papers/tech\\_mediated\\_instruction.html](http://www.academicssenate.cc.ca.us/Publications/Papers/tech_mediated_instruction.html)

Published by the Academic Senate for California Community Colleges, this article presents some suggestions for managing extended learning experiences.

**Hybrid Teaching Seeks to End the Divide Between Traditional and Online Instruction**

[chronicle.com/free/v48/i28/28a03301.htm](http://chronicle.com/free/v48/i28/28a03301.htm)

(Jeffrey R. Young, in *The Chronicle of Higher Education*: March 22, 2002) This article provides an overview of hybrid learning trends at selected institutions, including Pennsylvania State University, Fairleigh Dickinson University, Harvard Extension Schools, Maricopa Community Colleges, the University of Wisconsin at Milwaukee, and Ohio State University.

**Instant Messaging—Collaborative Tool or Educator's Nightmare?**

[www.unb.ca/naweb/proceedings/2003/PaperFarmer.html](http://www.unb.ca/naweb/proceedings/2003/PaperFarmer.html)

(Robert Farmer, Mount Saint Vincent University, Canada, 2003) This paper discusses instant messaging among students and in industry, including the results of a student survey on technology usage and an in-class instant messaging trial.

**Netcraft: Of Blogs and Wikis**

[news.netcraft.com/archives/2004/03/26/of\\_blogs\\_and\\_wikis.html](http://news.netcraft.com/archives/2004/03/26/of_blogs_and_wikis.html)

This brief article describes blogs and wikis and links to examples.

**What is Hybrid Learning?**

[www.norquest.ab.ca/distance/hybridlearning.htm](http://www.norquest.ab.ca/distance/hybridlearning.htm)

NorQuest College provides an introduction to the concept of hybrid learning.

# UBIQUITOUS WIRELESS

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

*The ready availability of wireless connectivity is of increasing benefit as more and more portable devices are able to take advantage of wireless connections. People are finding new ways to connect with each other and accessing information on demand wherever they happen to be. The real potential of ubiquitous wireless lies in the activities that it makes possible.*

### Overview

Believers in the premise that wireless connectivity should just be available anywhere, universities, airports, and even small towns are increasingly offering the service freely to their constituents. A new generation of broadband wireless technologies, including 802.11n and 802.16 (WiMAX), is emerging that will continue to support the trend of ubiquitous wireless access. Both technologies significantly increase both throughput and reach of the standard wireless mobility experience, providing faster, more cost-effective access while requiring fewer transmitters.

A range of devices, from laptops to handhelds to cell phones, can take advantage of wireless access, although not all devices use the same type of wireless technology. For laptops and handhelds, WiMAX, a set of standards-based technologies for high-speed wireless access, may present an alternative to wired DSL, cable modem, and leased services. WiMAX technology can provide service in areas that are difficult to wire and reduce installation costs.

Rural communities are beginning to view Internet access as they view other utilities like water and electricity: a necessity for a modern community. WiMAX and broadband will democratize wireless access, closing the gap between those who have high-speed Internet access now and those who cannot afford it or receive it at their locations because of barriers to installation. A single WiMAX transmitter is capable of sending a signal up to 30 miles, though realistically most will probably cover a 3 to 5 mile radius. Since the channels used by WiMAX are not regulated by the FCC, local governments, campuses, and even individuals are setting up transmitters.

Cell phones, which are rapidly becoming as commonplace as land lines, are graduating from mere convenience to real usefulness. Besides the obvious benefits of being able to place or receive a call anywhere at any time, cell phones can serve as geolocation devices, accurate to within about a city block. Services like *dodgeball.com* take advantage of this capability to transmit a person's location to nearby friends (and friends of friends), facilitating social connections based on immediate proximity. If someone with a cell phone is hungry and in an unfamiliar part of town, his or her cell phone is already the gateway for recommendations for nearby restaurants.

As the need to stay connected, to get information, and to keep in touch with peers and colleagues grows, ubiquitous wireless connectivity presents an attractive alternative to "plugging in" with wires. Looking further down the road, as more people carry cell phones with an increasing array of features, ubiquitous wireless will become more valuable as a means for connecting people and providing instant access to information.

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

Campuses have been gradually adding wireless access points for several years, to the point where many campuses now have wireless everywhere. The kinds of activities that have resulted provide an indication of how to apply this to learning. The social dynamics that occur when wireless is everywhere are key. For example, consider the following real-life scenario:

*A group of students sits in a coffee house near campus. They are sipping coffee and talking about coursework, and their laptops are open; if asked, they would say they are not doing anything on the Internet. However, when a question comes up, someone Googles it right away for an answer. They each have several instant messaging windows open; much of the conversation revolves around parties that are happening next Friday night, but some of it involves classmates who are not present in the coffee house but who are nonetheless taking part in the discussion. Communication occurs effortlessly in many dimensions among this group, much of it enabled by the wireless connection available to them.*

Using geolocation and cell phones, students on field trips could locate nearby libraries, museums, bookstores — and classmates. Ubiquitous wireless opens up communication channels to allow multiple types of connections. Converged wireless, which enables combinations of wireless functionality in devices as diverse as notebook computers, mobile phones, printers and MP3 players, will afford more creative opportunities for communication and collaboration. Imagine using a cell phone to send a document from your own hard drive to a colleague's printer while standing in her office.

Applications across a sampling of disciplines include the following:

- **Archaeology.** Students in the classroom are able to access a website showing a live video feed from a dig halfway across the state, or the country. The site contains data entered only a few minutes ago by the field researchers, so students assemble field reports from the data as if they were on the dig. Later, they compare their field reports with those written by the researchers.
- **Humanities.** A group of students and their teacher take their laptops outside on a nice day and have class outside. After an in-depth verbal discussion of the literary work the class

has been reading, the teacher uses a wiki to facilitate a collaborative written analysis, right there on the lawn.

- **Math & Computer Science.** At Marquette University, a prototype course is in development that seeks to integrate ubiquitous networking and handheld wireless devices in a problem-based learning setting.
- **Music.** A Dartmouth College music professor worked with information technology staff to create a library of operatic selections that students could access from anywhere on campus using their own computers. Students could listen to the selections at any time, as often as they wished, while keeping the libretto or other notes right in front of them.
- **Psychology.** Using donated wireless devices, a Dartmouth psychology professor integrated wireless polling in his course to engage each student in thinking about and answering questions every time he asked one.

## Ubiquitous Wireless Examples

The following examples demonstrate a variety of ways in which ubiquitous wireless can be applied to learning contexts.

### CER Mobile Computer Classroom Enhances Biology Labs

[www.cer.jhu.edu](http://www.cer.jhu.edu)

Students at Johns Hopkins University take advantage of wireless connectivity to complete online interactive exercises during biology labs.

### Handheld Devices for Ubiquitous Learning

[gseacademic.harvard.edu/~hdul/whd-overview.htm](http://gseacademic.harvard.edu/~hdul/whd-overview.htm)

An ongoing project at Harvard University explores the possibilities of ubiquitous learning.

## **Ubiquitous Wireless on Campus: Dartmouth College**

**[www.dartmouth.edu/comp/resources/network/wireless/technical.html](http://www.dartmouth.edu/comp/resources/network/wireless/technical.html)**

Dartmouth has offered wireless access on campus since 2000. The wireless network itself consists of over 475 access points in 160+ buildings, providing nearly seamless coverage across the 200-acre campus. Articles about the implementation and management of the network are available.

## **Wireless Instant Polling, University of Maryland, Baltimore County**

**[asp1.umbc.edu/newmedia/studio/stream/qt/detail.cfm?recordID=328](http://asp1.umbc.edu/newmedia/studio/stream/qt/detail.cfm?recordID=328)**

UMBC professors have been experimenting with instant student response systems from eInstruction and Turning Technologies, respectively. In this online presentation they share lessons learned and demonstrate the Turning Technologies product.

## **For Further Reading**

The following articles and resources are recommended for those who wish to learn more about ubiquitous wireless and related topics.

### **IEEE 802.16 and WiMAX: Broadband Wireless Access for Everyone**

**[www.techonline.com/community/related\\_content/30627](http://www.techonline.com/community/related_content/30627)**

This Intel white paper illustrates the properties of WiMAX from an industry perspective.

### **Pedagogy and Wireless Computing**

**[cet.middlebury.edu/bryan/wireless/](http://cet.middlebury.edu/bryan/wireless/)**

This workshop explores the pedagogy of mobile, wireless computing in the liberal arts setting. As college campuses set up wireless networks, and the number and variety of networked devices increase, how do we best teach and learn in this environment? We describe the evolving world

of wireless networks, including 802.11x(WiFi), Bluetooth, and cellular. Additionally, we examine how devices such as Personal Digital Assistants (PDAs), laptops, tablets, and cell phones are being leveraged to create a new ubiquitous computing environment.

### **Unlocking the Learning Value of Wireless Mobile Devices**

**[www.blackwell-synergy.com/links/doi/10.1046/j.0266-4909.2003.00028.x/full/](http://www.blackwell-synergy.com/links/doi/10.1046/j.0266-4909.2003.00028.x/full/)**

This paper examines challenges, research needs, and implementation requirements for wireless mobile devices used in education.

### **The WiMAX Forum**

**[www.wimaxforum.org/home](http://www.wimaxforum.org/home)**

The WiMAX Forum is an industry-led, non-profit corporation formed to promote and certify compatibility and interoperability of broadband wireless products.

### **WWiSE Words on 802.11n**

**[www.wwise.org](http://www.wwise.org)**

Industry leaders Airgo, Bermai, Broadcom, Conexant, STMicroelectronics and Texas Instruments have proposed a standard for 802.11 implementations which achieves a 540 Mbps data rate, meets stringent world-wide regulatory requirements and provides important legacy interoperability with existing Wi-Fi devices.

# INTELLIGENT SEARCHING

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

*With so much information available on the Internet, finding what is wanted is only half the problem. Keeping track of, organizing, and returning to found resources is as important as locating them in the first place. Intelligent searching technologies offer increasingly sophisticated means for finding and taming information.*

### Overview

Search agents, federated search, and the increasing sophistication of services like Google and Blinkx are making it easier to find — and keep track of — answers, information, and materials. Search agents can take “instructions” about the types of things a person is interested in, report immediate findings, and even remember search parameters over time, repeating the search at intervals to add to the results and create customized research lists.

Federated search technology allows searching of multiple archives, repositories, and databases with a single query. Google releases new features regularly: at the time of this writing, Google Scholar (which returns results found in scholarly journals and papers) and Google Suggest (which offers keyword suggestions as the user types into the search box) are making it easier than ever to find desired information. Technologies like RSS\* bring tailored results right to a user’s own web page; the live data feed keeps content fresh, piping it in from other sources on the Internet.

The need for information is constant and pressing. Tools that make it easier to find, retrieve, and organize information will be in demand more and more as the amount of available information continues to increase. Utilities like Blinkx and Google Desktop, unobtrusive but powerful tools that index and search the contents of a user’s hard drive as well as resources on the Internet, enable users to re-find documents when they are needed, whether they are stored in email, directories, or elsewhere. In a world where information overload is a daily challenge, search agents are now and will continue to be highly useful.

\*RDF [Resource Description Framework] Site Summary

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

The implications for researchers are clear: search agents are making it easier to find sources of information, check facts, and build bibliographies. When applied to a learning context, these tools can be used in other ways as well.

With new technologies for searching and finding, collections of course readings that were once photocopied and bound are increasingly seen in digital form, making them easy to assemble, update, and access. Material in multiple repositories can be located quickly with federated search. Increasingly intelligent tools (agents) are allowing collections to grow over time as new materials are produced, enlivening course content and keeping it up to date.

These search agents may assist in locating resources offered under education-friendly licenses, in connecting people or organizations working on similar grants or projects, and in building shared resource lists for similar courses at different institutions. By searching for content created by a particular person, search agents may someday be able to provide continually up-to-date portfolios of research and other work.

Institutions may offer customized intelligent search tools focused internally on their own collections. Offered perhaps through a web portal, these search tools will return reliable, accessible results for the campus community. As the tools become more sophisticated they will be able to search different collections of a variety of materials, regardless of format or of where the materials may be housed. For example, the Massachusetts Institute of Technology’s DSpace ([dspace.mit.edu/](http://dspace.mit.edu/)) enables advanced

searching of research in digital form held by MIT. Users can create their own collections within DSpace to bookmark articles of interest.

Potential applications across a sampling of disciplines include the following:

- **Arts & Design.** Using new search tools like IBM's Query By Image Content (QBIC), students sift through the department's online database of thousands of images, specifying content-based parameters like texture, shape and color that search the visual properties of images without using text descriptors.
- **Medicine.** Medical students use a special search tool with integrated thesaurus to locate references tagged with a variety of related keywords, producing an extensive list of resources around a single topic.
- **Science.** Using intelligent search agents and a technology like RSS, a biologist creates a custom web page that automatically finds and posts new research abstracts in her field as they are published.
- **Theater.** A costume designer collects images and descriptions of period clothing, easily locating source documents related to a particular period with a single search, whether the documents reside on his own system, the university's digital archives, or elsewhere on the Internet.

## Examples of Intelligent Searching

The following examples show how intelligent searching is being applied in various settings.

### ACM Digital Library

[portal.acm.org/dl.cfm](http://portal.acm.org/dl.cfm)

The ACM Digital Library offers a service to its subscribers called My Binders, in which users can save found articles. Articles can be added manually, by means of a saved search, or by an Agent which can periodically run the search and add any new findings.

### Blinkx

[www.blinkx.com](http://www.blinkx.com)

Free-to-download, Blinkx automatically and intelligently links to relevant information anywhere and in any format: on the Web, in the news, in the user's email archives, or on his or her hard drive.

### The Open Video Project

[www.open-video.org/project\\_info.php](http://www.open-video.org/project_info.php)

The purpose of the Open Video Project is to collect and make available a distributed repository of digitized video content on a wide range of subjects for the digital video, multimedia retrieval, digital library, and other research communities. It is hosted as one of the first channels of the Internet 2 Distributed Storage Infrastructure Initiative, a project that supports distributed repository hosting for research and education in the Internet 2 community.

### StumbleUpon

[www.stumbleupon.com](http://www.stumbleupon.com)

This free tool creates a custom toolbar that allows users to find, review, and share interesting web pages. Users choose pages to recommend, and recommendations are sent to others based on personal preferences.

## For Further Reading

The following articles and resources are recommended for those who wish to learn more about intelligent searching and related topics.

### Browsing Art Collections, Bit by Bit

[www.coe.berkeley.edu/labnotes/1002/forsyth.html](http://www.coe.berkeley.edu/labnotes/1002/forsyth.html)

Browsing a large museum of fine art can be an overwhelming experience. On the other hand, losing yourself in the galleries can be rewarding. But if you're seeking a particular subject matter – say, representations of horses – browsing is like searching for a needle in a haystack. To help navigate the sprawling art landscape, UC Berkeley Computer Science professor

David Forsyth and his graduate students are integrating computer vision technology with natural language processing to create visual summaries of massive art collections available online.

### **Dashboard**

***[www.nat.org/dashboard/](http://www.nat.org/dashboard/)***

As you go about your work, Dashboard proactively finds documents, links, bookmarks, and other files related to whatever you happen to be doing, and displays these in a friendly way, keeping relevant files at your fingertips.

### **Gnooks.com**

***[www.gnooks.com](http://www.gnooks.com)***

Discover new writers (or movies or music) you might like, discuss your favorites, and “travel the map of literature” with Gnooks.com. Type in the name of an author you like to get suggestions for similar authors. The suggestions don’t appear as a list of names; instead, your author’s name appears in the middle of the page with related authors’ names ranged around it, floating closer or farther away depending on how similar they are.

### **Refining the Search Engine**

***[www.acm.org/ubiquity/interviews/v5i29\\_jain.html](http://www.acm.org/ubiquity/interviews/v5i29_jain.html)***

This interview in Ubiquity discusses emerging models of information retrieval.

### **Why Use A9.com?**

***[a9.com/-/company/whatsCool.jsp](http://a9.com/-/company/whatsCool.jsp)***

A9.com is a powerful search tool designed to make searching and finding easier. This page describes the features available in A9 and is an interesting read in terms of finding out what’s possible with advanced searches.



# EDUCATIONAL GAMING

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

*Educators have been tapping into the potential of gaming as a learning tool for years. With new technologies for creating complex, interactive environments, immersive educational games are just over the horizon.*

### Overview

Computers and games go hand in hand, but games themselves are perhaps as old as humankind. Social or solitary, simple or complex, collaborative or competitive, games give us an opportunity to exercise the sense of play that makes us different from almost any other creatures. Children are able to learn games before they can talk (peek-a-boo!) and continue to expand their gaming repertoire as they get older.

Games of all kinds have enormous potential to reach people. In terms of education, games are engaging and adaptable to almost any subject. They are particularly useful for teaching cause-and-effect relationships, and the lessons learned from games stay with students because of the interactive nature of the learning experience. While technology is by no means necessary for educational games, games and technology are increasingly being combined in interesting ways.

The term *educational gaming* tends to conjure images of virtual reality environments or console-type video games, but those are only an interesting subset of the domain. It is difficult to justify the production costs for VR or video games when so many equally effective game types are much easier to develop. Simulations, which may include animations, video, and images, or may be purely text-based, allow students to explore roles that they otherwise could not, all in a safe, encouraging setting. Technology can facilitate connections between players, making games more dynamic and interesting. Cooperative play lends another dimension to learning through games.

Not all games are zero-sum; especially in education, there is room for games where the goal is to solve a problem cooperatively, and everyone can win. If the

outcome of a game is not to have a single winner, but to have a group come up with a perfect solution to a problem, more than one group may achieve this outcome. Thus the point becomes problem-solving and working together rather than winning or defeating opponents. This is not to say that educational games should not have individual winners; in some cases, such as in a business school setting where players compete to gain the biggest market share, winning is obviously a desirable outcome.

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

Even children are able to master the rules of very complex games quickly; just watch a group of eight-year-olds playing *Magic: The Gathering*. Provide an interesting premise, and students will learn the rules and play the game. Playing doesn't feel like working, so students may spend more time with a game than they would reading related material. The multidisciplinary nature of games lends itself to whole-curriculum programs, where knowledge is applied across many subjects. It can be difficult to isolate a single skill or discipline in a game, and the interrelation of content can itself be very instructive.

Obviously, not all topics are suitable for adaptation to games. However, systems like physics, whose rules are simple even though there are many of them, are likely to be good choices. Material that has clearly defined levels of abstraction or specifically sequenced processes, like economics or biology, lends itself to games with levels or steps. Any subject matter that tells a story or allows students to experience the world as if they were someone else (history, literature, social sciences) could be adapted for role-playing.

As an example, consider this activity used in a University of California, Berkeley chemistry class. Students were asked to take the roles of employees in a startup company that manufactured airbags for automobiles. Given a set of design constraints, the students were to come up with solutions to the problem of how to create an airbag that would inflate properly, quickly, without exploding, and without leaking deadly chemicals in case of a rupture.

Using that premise, the game could very easily take place with no technology other than paper and pencil. However, the students had access to three simulated laboratories, where they could test different chemical mixtures, see videos of the results of igniting those mixtures in air, play around with different temperature and pressure combinations to see which would make their mixtures expand at the necessary rates, and examine how an airbag actually works within a car.

Continuing to weave technology into this experience, the professor might have asked the students to keep their lab notes in a blog or wiki. Students might keep in touch with instant messaging, perhaps with part of the team in the library doing research while the rest of the team performs experiments in the chemistry lab.

Another game currently in development in the area of business management is played by a group of students, each of whom owns a brewery. Each student connects to the game from a different computer, and each has to contend with issues of production, marketing, sales, and distribution. The students compete to manage the most successful business, while the simulation engine handles interactions between players and their suppliers (played by the computer).

## Examples of Educational Gaming

The examples that follow show educational gaming in use or in development.

### Games-to-Teach

***educationarcade.mit.edu/gtt/***

In its first year, the Games-to-Teach Project designed a set of ten conceptual frameworks of educational games in math, science, engineering, social science, and humanities. The goal of this exercise was to develop a vision of how games could be used to support learning, as well as to research the issues behind developing and marketing next-generational games.

### Room 130

***labweb.education.wisc.edu/room130/***

Room 130 is an interdisciplinary faculty, student, and industry consortium devoted to research in the areas of digital games, game design, and digital cultures. Room 130 seeks to provide empirical, investigative data, as well as theoretical accounts on the nature of learning and literacy in these contexts from the perspectives of humanities, education technology, second language acquisition, cognitive psychology, learning sciences, linguistics, and critical pedagogy.

### Unfiction: Alternate Reality Gaming

***www.unfiction.com***

Alternate Reality Gaming (also known as beasting, unfiction, or immersive fiction) is an interactive fusion of creative writing, puzzle-solving, and team-building, with a dose of role playing thrown in. It utilizes several forms of media in order to pass clues to the players, who solve puzzles in order to win pieces of the story being played out. Clues can be passed through web pages, email, voicemail, snail mail, television advertisements, movie posters, campus billboards, newspaper classifieds, and other means.

## For Further Reading

The following articles and resources are recommended for those who wish to learn more about educational gaming and related topics.

### The Education Arcade

[www.educationarcade.org](http://www.educationarcade.org)

A consortium of international game designers, publishers, scholars, educators, and policy makers, the Education Arcade seeks to demonstrate the social, cultural, and educational potentials of games by initiating new game development projects, coordinating interdisciplinary research efforts, and informing public conversations about the broader and sometimes unexpected uses of this emerging art form in education.

### Game Culture & Technology Lab

[proxy.arts.uci.edu/gamelab/](http://proxy.arts.uci.edu/gamelab/)

The mission of the Game Culture & Technology Lab is to expand the notion of how game metaphors, design principles, and technologies can be utilized for alternative content and context delivery. The Lab's approach combines theory and practice, science and art, education and entertainment, to create an environment that supports diverse forms of expression in a wide range of applications. The Game Lab brings together interdisciplinary faculty from both the UC Irvine and UC San Diego campuses.

### Michael Schrage on Innovation

[www.acm.org/ubiquity/interviews/v5i39\\_schrage.html](http://www.acm.org/ubiquity/interviews/v5i39_schrage.html)

In this interview in Ubiquity, MIT's Michael Schrage discusses innovation and the role of play in work.

### Ricardian Explorer

[www.wesleyan.edu/re/](http://www.wesleyan.edu/re/)

Ricardian Explorer is an interactive computer game that simulates the functioning of a simple model of international trade. Designed to complement courses in international trade, it can also be used in introductory and intermediate microeconomics courses and as a research tool for experimental economists to collect data for their studies. To facilitate the use of the game in an instructional sequence the site will provide information on how to set up different games, instructor and player manuals, and utilities for post-game data analysis.

### Virtual Learning Arcade

[www.bized.ac.uk/virtual/vla/](http://www.bized.ac.uk/virtual/vla/)

The Virtual Learning Arcade (VLA) provides interactive online models and simulations for economics and business teachers, lecturers and students. The simulations also have support materials that have been written to enhance their educational value. These include explanations of relevant theories, interactive worksheets, definitions and guidelines on using the models.

# SOCIAL NETWORKS & KNOWLEDGE WEBS

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

*Social networks and knowledge webs enable people to connect with the right people at the right time and to build and share a body of information. Communities are no longer defined by space and time, and expertise and experiences can be shared instantly and accessed on demand. As technology brings people together in new ways, new possibilities and new forms for collaboration are emerging.*

### Overview

Social networks that use technology as a mediator of social interaction and collaboration could have significant application for teaching and learning, especially at a distance. What makes these networks interesting is that the technology-enabled interactions are generally founded on a set of intuitive strategies that foster high-quality and efficient communication. A variety of simple but easily accessible tools make these interactions possible over a wide variety of modalities. The result is more effective knowledge generation, knowledge sharing, collaboration, learning, and collective decision-making, and is especially applicable to distributed learning, research, and work settings.

Social networking tools are not new. Recent developments focus on interoperability and ease of use, two features that will help to make the technology more transparent so that the social aspect of the activities can come to the forefront. The value is often the social space itself, which belongs to and is driven by the users. More than simply a means of connecting with others, the social networks that thrive are those offering a means to connect with others for a particular purpose.

For example, *dodgeball.com*, also described as an example wireless application, is a social networking website that takes advantage of the fact that many young people carry mobile phones. Users send a text message listing their whereabouts to Dodgeball which is relayed to their friends, and receive messages about which friends (or friends-of-friends) are nearby. Dodgeball.com uses the web and mobile phone technology to facilitate social interactions among its members.

Professional working teams are using social networking to create flexible workspaces where a team can interact synchronously and/or asynchronously, contribute work, and see and react to the work of others. Over time, these workspaces become knowledge webs, dynamic bodies of information constructed by the group during the process of doing work.

An interesting problem arises as these knowledge webs grow: how best to map emerging knowledge and ideas, not only in terms of abstract models but also in practical ways that allow navigation of emerging streams of information and their interconnections. The more information a knowledge web contains, the greater the potential for difficulty in navigation or in forming a mental model of the space.

Students already use social networking tools like Flickr ([www.flickr.com](http://www.flickr.com)) and Typepad ([www.typepad.com](http://www.typepad.com)) because of the interactions they make possible. Flickr, for instance, is an online tool for storing, searching, and organizing photographs, but the thing that makes it so powerful and appealing is that it is also a tool for *sharing* photographs. Users can upload digital photos and set permissions governing who can view or comment on their pictures. Tags describing the content can be attached, not only by the photo's owner, but by others with permission, making it easier to search for images.

Typepad is a blogging service; many young people are using blogs as journals, trip logs, and private conversation spaces with friends. Flickr and Typepad, incidentally, have a connection: Flickr makes it very easy to publish photos in a Typepad blog.

## Relevance for Teaching, Learning, or Creative Expression

Social networks can support and extend communities of practice. Distributed project teams, connected through social networks, are building knowledge webs as they create documentation, collect resources, and share progress; an example is the Pachyderm Project ([www.nmc.org/pachyderm](http://www.nmc.org/pachyderm)).

Partners refer to the project website for news and archived documents, but social networking tools facilitate the daily link among members who are located across North America. Tools used by the project include a wiki, instant messaging and peer-to-peer videoconferencing, email distribution lists, telephone conference calls, and a blog; participants choose one tool over another based on the type of work or type of communication needed at any given moment. A byproduct of using this kind of social network is a rich picture of the project as it develops over time.

This model could be applied to student group work as well. Wikis, for example, have been used successfully in classroom settings where students have created a “mini-encyclopedia” on a particular topic. The wiki is used to facilitate group construction of information in a setting where the technology is secondary and the experience of building a shared information space is the primary activity. The students are in control of the information space.

In addition to their use as a framework for constructing learning, knowledge webs have an obvious value as research tools; those created by communities of practice tend to have a high degree of validity and can be trusted as source material. What is especially interesting about social networking and knowledge webs, and what differentiates these from extended learning, is the idea of knowledge sharing. Blogs used by work teams as social networking tools are not like self-published writings for a communications class; instead they serve as the locus for a real interchange of ideas between professionals.

The more transparent the technology, the easier it is for people to connect and work together whether or not they are in close physical proximity. Social networking tools and knowledge webs are experiencing more widespread use, not only for social purposes, but for professional purposes as well. Given that many of today’s students are already familiar with tools like these, it is not unlikely that they will become part of many course tool sets over the next several years.

A sampling of applications across various disciplines includes the following:

- **Distributed Research Projects.** Students in any discipline could work together using an array of tools for creating and recording their work process and products. Like the Pachyderm Project mentioned above, such research efforts might incorporate a wiki and a blog as a lasting record of work while communications are facilitated through instant messaging and other mediums.
- **Music.** *World Music in Contemporary Life*, a knowledge web hosted at San Diego State University, starts with a plain-text interface but soon becomes a clickable concept map inviting exploration.
- **Writing & Language Studies.** Collaborative writing projects using wikis could enable students to work together to develop novellas, anthologies, and other writings. Blogs make it easy for students to post their work and comment on the work of others.

## Examples of Social Networks & Knowledge Webs

The following links showcase some examples of social collaboration and knowledge webs.

**The Composers of Internet2, Wheaton College**  
[www.wheatoncollege.edu/it\\_s/internet2/C12/](http://www.wheatoncollege.edu/it_s/internet2/C12/)

Wheaton College has used Internet2 for collaborative activities in music and French. The

Composers of Internet2 introduces a musical composition competition as the venue for putting young student composers in touch with a professional community of practice using social networking.

### **CAS: Chemical Abstracts Service**

[www.cas.org](http://www.cas.org)

CAS is a knowledge web for the chemical (and other) sciences, gathering published research from journal and patent literature from around the world.

### **Emerson College's Learning Portals Project**

[institute.emerson.edu/learningportal](http://institute.emerson.edu/learningportal)

Emerson College has embarked on a multi-year project to design and build an interactive and customizable web portal that will support college-wide initiatives in multimodal literacy and integrative learning. Over the next three years, the College will develop a "toolkit" of proprietary, non-proprietary, and locally developed Web applications to support teaching and learning and to extend and make more coherent the interactive resources available to faculty and students.

### **MERLOT's Peer Review Process**

[www.merlot.org](http://www.merlot.org)

The Multimedia Educational Resource for Learning and Online Teaching (MERLOT) project includes peer-review boards whose work is facilitated by a custom-built peer review workspace within MERLOT. The collaborative workspace enables members of the review boards to share comments and manage the process of working together on several reviews at once.

### **Wikipedia**

[www.wikipedia.org](http://www.wikipedia.org)

The Wikipedia, an online encyclopedia featuring over 200,000 articles (in early 2004), is a living example of a wiki. Although anyone can edit any article, the information tends to be current, accurate, and on-topic.

## **For Further Reading**

The following articles and resources are recommended for those who wish to learn more about social networking, knowledge webs, and related topics.

### **Collaborative Learning Environments Sourcebook**

[www.criticalmethods.org/collab/v.mv?d=1\\_1](http://www.criticalmethods.org/collab/v.mv?d=1_1)

A sourcebook for academics and students who want to develop collaborative learning environments (or communities of practice), this site is itself a knowledge web about creating knowledge webs.

### **James Burke's KnowledgeWeb Project**

[www.k-web.org/index.html](http://www.k-web.org/index.html)

This project, a particular kind of knowledge web, seeks to present information in "a highly interconnected, holistic way that makes it possible to follow an almost infinite number of paths of exploration among people, places, things, and events."

### **Neighornodes**

[www.neighornode.net](http://www.neighornode.net)

Neighornodes are group message boards on wireless nodes, placed in residential areas and open to the public. These nodes transmit signal to about 300 feet, so everyone within that range has access to the board and can read and post to it. This means that with a Neighornode you can broadcast a message to roughly everyone whose apartment window is within 300 feet of yours (and has line of sight), and they can broadcast messages back to you. Boards are only accessible from computers that go through the local node. Additionally, Neighornodes are linked together, making up a node network to enable the passing of news and information on a street-by-street basis throughout the wider community.

# CONTEXT-AWARE COMPUTING/ AUGMENTED REALITY

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

*Already beginning to surface in disciplines like medicine, engineering, the sciences, and archaeology, context-aware computing and augmented reality show promising new ways for humans to interact with technology. The goal, as these techniques are further refined, is that the human-computer interface will become more transparent, increasing access and ease of use.*

## Overview

*Context-aware computing* refers to computing devices that can interpret contextual information and use it to aid decision-making and influence interactions. Contextual cues may include what the user is attending to, the user's location and orientation, the date and time of day, lighting conditions, other objects or people in the environment, accessible infrastructure in the immediate vicinity, and so forth. Context-aware devices and applications can make decisions based on such information without the need for user input.

*Augmented reality* refers to a composite view made up of what the user is actually seeing along with a virtual scene generated by the computer that overlays additional information on the scene. Augmented reality differs from virtual reality in that the real world is still very much present in an augmented reality setting, whereas it is entirely replaced by a virtual reality. The augmentation may take any of several forms, and is designed to enhance the user's experience and perception of the world, based on contextual cues as to time, place, etc.

Both context-aware computing and augmented reality reflect a changing attitude towards human-computer interaction. A context-aware system senses the environment and provides access to information or changes the interface in response to current conditions. Augmented reality systems add another layer of information about what the user is currently seeing or doing. Both of these technologies demonstrate the growing importance of having the

computer system respond to specific needs the user may be having, with or without direct instruction from the user.

The technologies that underlie both approaches are the same. Sensors pick up on environmental cues, and output is altered as a result. Both context-aware computing and augmented reality have to do with computers that are able to interact with people in new and richer ways.

## Relevance for Teaching, Learning, or Creative Expression

The technologies underlying context-aware computing and augmented reality are developing rapidly, but there are still few examples of applications for teaching, learning or creative expression. It is not difficult to imagine what some of these applications may eventually be. Current research in sensor technology is promising; experimental development of responsive systems shows that practical applications of these technologies are not far off.

Augmented reality may be useful across disciplines in training scenarios, where learners see techniques demonstrated even if the necessary equipment is unavailable. Instructions could be superimposed onto equipment when it is present, guiding new users through the process step by step. In medicine, an augmented reality display could overlay the data from a CAT scan directly onto a patient; a surgeon would see the information as he operated.

Performance art pieces taking advantage of augmented reality might allow viewers to wander through new landscapes (or seascapes, or moonscapes), in and out of bizarre or improbable architectural spaces, or among imaginary flora and fauna. In museums, historical buildings, and other settings, contextual data displays might appear as someone approached a landmark, showing historical information. Botanical gardens might include contextual displays or recordings with botanical information as viewers pass by.

Applications for context-aware computing are no less intriguing. Devices could adapt to the needs of their users by changing display resolution or font size if more than one person is detected in front of the monitor. Experimental “chameleon mugs,” intended first to indicate whether a beverage was too hot to drink, could be adapted for use in chemistry classes, where the mug could change color based on chemical properties of a liquid placed in it.

Devices that automatically adapt to user needs or conditions of use could make computing more “friendly.” Examples are computer monitors that change the contrast of the display to match lighting conditions, or pattern recognition systems that recognize the outward indications of motor difficulties and trigger a switch to a verbal interface.

## Examples of Context-Aware Computing and Augmented Reality

The following examples illustrate some applications of context-aware computing and augmented reality.

### Augmented Reality at Bauhaus University [www.uni-weimar.de/~bimber/research.php](http://www.uni-weimar.de/~bimber/research.php)

Research and experimental development of a number of augmented reality projects, from entertainment systems to artworks to contextual data delivered using cell phones, is being conducted at the Bauhaus University (Weimar, Germany).

### Augmented Reality in Architecture

[www.columbia.edu/cu/gsap/BT/RESEARCH/ar.html](http://www.columbia.edu/cu/gsap/BT/RESEARCH/ar.html)

Columbia University’s Department of Computer Science has teamed up with the Building Technologies Group in the Graduate School of Architecture to develop augmented reality systems to improve methods for the construction, inspection, and renovation of architectural structures.

### Augmented Reality & Computer-Augmented Environments

[www.csl.sony.co.jp/project/ar/ref.html](http://www.csl.sony.co.jp/project/ar/ref.html)

This website lists a variety of ongoing projects in augmented reality.

### BotFighters

[www.botfighters.com](http://www.botfighters.com)

BotFighters, a location-based mobile game, is a pervasive combat game where you play in the real world. Using geolocation technology, the streets become the game arena and any stranger might be your ally or enemy.

### Campus Tours at Arizona State University

[www.asu.edu/asunews/university/gpstourlive\\_082704.htm](http://www.asu.edu/asunews/university/gpstourlive_082704.htm)

Arizona State University is offering GPS-enabled, self-guided walking tours to visitors at its Tempe campus. Using a hand-held computer and global positioning satellite technology, visitors can see and hear tour information when entering dozens of GPS hot spots located across the campus.

### Context-Aware Computing, MIT Media Lab

[context.media.mit.edu](http://context.media.mit.edu)

Projects in context-aware computing at the MIT Media Lab explore its possibilities.

### The Invisible Train

[studierstube.org/invisible\\_train/](http://studierstube.org/invisible_train/)

The Invisible Train is a multi-user augmented reality application for handheld devices (PDAs). Unlike other projects, in which wearable devices



were merely used as thin-clients while powerful (PC-based) servers performed a majority of the computations (such as graphics rendering), the Invisible Train runs independently on off-the-shelf PDAs, eliminating the need for an expensive infrastructure.

### **Some Problems with the Notion of Context-Aware Computing**

**[www.ece.rutgers.edu/~parashar/Classes/02-03/ece572/perv-reading/erickson.pdf](http://www.ece.rutgers.edu/~parashar/Classes/02-03/ece572/perv-reading/erickson.pdf)**

This article describes potential pitfalls of context-aware computing.

## **For Further Reading**

The following articles and resources are recommended for those who wish to learn more about context-aware computing, augmented reality, and related topics.

### **Augmented Reality: A New Way of Seeing**

**[www.sciam.com/article.cfm?articleID=0006378C-CDE1-1CC6-B4A8809EC588EEDF](http://www.sciam.com/article.cfm?articleID=0006378C-CDE1-1CC6-B4A8809EC588EEDF)**

(Steven K. Feiner, in *Scientific American*, April 2002) This early article presents augmented reality, with descriptions of technologies that are making it possible and examples for its applied use.

### **Augmented Reality Page**

**[www.se.rit.edu/~jrv/research/ar/](http://www.se.rit.edu/~jrv/research/ar/)**

This website provides links to a wide variety of examples and articles about augmented reality.

### **The Context Fabric: An Infrastructure for Context-Aware Computing**

**[www.cs.berkeley.edu/~jasonh/publications/CHI2002-confab-final.pdf](http://www.cs.berkeley.edu/~jasonh/publications/CHI2002-confab-final.pdf)**

This short article describes a proposed framework for building context-aware computing systems.

### **How Augmented Reality Will Work**

**[computer.howstuffworks.com/augmented-reality.htm](http://computer.howstuffworks.com/augmented-reality.htm)**

This article describes possible implementations of augmented reality in layman's terms.

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