



Into the Future

A glimpse of the technologies most likely to affect teaching and learning 10, 20, even 30 years from now.

Let's say that in 15 years, affordable bandwidth becomes prevalent, the research behind constructivist learning becomes accepted and understood by most educators, and software developers are able to turn intricate neurological and cognitive nuances into programs that invisibly support student interactions and production. Let's say that an information network called the World Board, tied to global positioning satellite data, brings interpretive information to individuals, and haptic and other sensory interfaces on wearable computers allow people to taste, smell, and feel information wherever they are.

In this rosy scenario, three groups of students from communities in California, Japan, and Italy—places that share similar types of ecosystems—could be simultaneously developing prototypes for small boats with underwater observation equipment. There will no longer be “classes” or “subjects” because school projects combine mathematics, writing, building, device use, foreign language, communication, science, etc. Students and teachers know and discuss what concepts and skills they are developing while they are working on the project, but there are no “tests” because assessments are built into their communication devices. For example, when students are visiting one another with their avatars in an online world, and in another screen,

talking to and seeing one another as they collaborate on creating the boat prototype, there is software built in that will measure certain types of progress.

New skills are measured, such as knowledge-sharing and collaboration. Feedback is integrated into devices and conversations so students can learn what they need to know to finish their projects. Online, students use variations of an increasingly global “visual language” that incorporates cross-cultural symbols and keywords from different languages. Students collaborate in virtual space to create a prototype.

Their virtual space also includes relevant portals to the information they will need from a global multi-lingual database that includes “the right information at the right time in the right way,” personalized for the individual’s learning style and interests. When the students in the three countries agree on the prototype, they can print it out in three-dimensional form, then gather what they need to build the actual boat and equipment.

School is now a place with rooms for discussions, quiet study, recreation, and presentations by inspirational people. Their project team visits people in their own community physically and people in other countries virtually. These people, who share the students’ interests, have been identified and leveraged for education

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through sophisticated network mapping. Mentors from around the world have been hired by school districts to participate in online worlds.

Much of the day is spent off campus in small groups with mentors, visiting museums, workshops, and other places that can contribute knowledge that will help them do their project. Most places students go have “information in place” so they can learn as they explore. Objects and places have interpretive information, once found only in tourist sites and museums, tied to them through the World Board and visible with special glasses that show writing in the air so anyone could learn about anyplace, whether the plants in the rainforest or the architectural features of city hall.

Students all know their cognitive styles (through highly incisive testing), and part of their education is to learn how to interact with people who have different styles. Because they know their strengths, and are encouraged to use them, they are more creative and therefore less frustrated than students are today. The pervasiveness of personalized nutraceuticals, pharmaceuticals, and biological implants enables most to compensate for mental blocks or emotional problems that previously deterred learning.

The biggest problem for students is the privacy issue, now that the world seems transparent and technology

exists for parents to see what their students are doing while they are doing it. Report cards consist of multimedia files showing students at work and identifying how much further they need to go to finish a project.

The Nano-Cogno-Info-Bio-Socio Technology Convergence

Nothing in this scenario involves fictional technology—it could happen using technology that has already been developed. Today’s devices are continuing to evolve and will become more embedded, interoperable, and easy to use over the next two to three decades. It’s possible that some of them will come together in unexpected ways to become drivers of social change and influence the approach to learning in public schools.

The search for clues for plausible future scenarios can cover the far reaches of technology development, from smart dust to bio-implants to molecular computing, along with the big-picture ideas of theorists who are leading global thought about how those technologies are likely to come together. Jim Spohrer of IBM, for example, is among those pioneering the concept of the “nano-cogno-info-bio-socio technology convergence.” This theory, a framework being explored

by the National Science Foundation, explores the intersections of nanoscience and nanotechnology, biotechnology and biomedicine, and information technology. Spohrer has added “socio” to emphasize the importance of social context to technology adoption. Spohrer, who is the inventor of the World Board, is fascinated by the way different streams of technology produce surprising confluences.

The diffusion of technology ultimately has more to do with the nature of people and institutions than with tools, as demonstrated by how the fruits of the last technology revolution entered—or failed to enter—the classroom.

A nano-cogno-info-bio-socio convergence is the scientific way of looking at a holistic approach to life, in which all the types of factors that affect us as human beings work together as opposed to being treated separately. There are so many possible combinations of the five elements and the types of technologies that could emerge from them. Could such a convergence also bring with it the possibility that people will understand one another and their world better? “The near-term benefits of the nano-cogno-info-bio-socio convergence will be more in material science, then health benefits and faster electronics,” suggests Spohrer. “By 2015 we should see a significant impact in K–12 education with advances in computing speed and communications technology. Basically, you could have learning conversations with all of human knowledge, not just with teachers and parents. Imagine the *Encyclopedia Britannica* with an interactive dialog

component. Students could ask any question they want and get a customized answer.”

To imagine how that convergence might realistically affect education, the clues are found in the past and present. The diffusion of technology ultimately has more to do with the nature of people and institutions than with tools, as demonstrated by how the fruits of the last technology revolution entered—or failed to enter—the classroom. With few exceptions, most schools run about the same way today as they did 30, 60, or 120 years ago—Industrial Age institutions with Knowledge Age features largely underused. National education surveys have shown that only one third of U.S. teachers felt well-prepared to use technology for a variety of potential uses in the classroom.

Outside of the school setting, however, there are some startling ways youths are using technology. Among the most extreme are virtual games occurring parallel to regular life, where ordinary places like the grocery store may become part of a real-life gameboard for participants competing for treasures invisible to those around them. Currently, massive multiplayer games such as EverQuest, the Sims Online, There, and Star Wars Galaxies occur in virtual space. Andrea Saveri, a director at Institute for the Fu-

ture who has studied these games, says they carry important clues about emerging technologies because they require cooperation and interdependence to do well and succeed. The games are rooted in building social networks of trust and reputation. Players learn how to read a virtual environment and other characters/persona for their reputation and trust.

In the future, these virtual worlds can be fused with actual physical places with geo-URLs and location-based data. That would create alternate realities. There are some alternate-reality games, like the early classic game *The Beast*, which brought the game world into the players’ physical environment using available media like faxes, phone calls, posters, and live events. (Note that the term “real world” wasn’t used here, as both the virtual reality and physical reality are real to players, thus the term alternate realities.) Saveri says these are very promising environments for simulation and learning for young people and adults alike.

Today there are also online worlds where international students and experts gather not just for real-time communication and information exchange in specific subject areas, but also for emotion-rich social activities that create a learning community. Again, these are not part of “regular school”. Designers of educational simulations lament that they had the technology more than 20 years ago that would allow youths to enjoy the study of physics and chemistry as much as they enjoy Play Station but, unable to get education funding, many shifted their focus to the electronic entertainment business. That’s beginning to change with new academic interest and investments in educational 3D simulations. Following the 30-year diffusion theory, it’s likely that sophisticated simulations and virtual worlds will, within the next few years, be the next “new thing” in mainstream education. As one Ph.D. student studying emerging technologies said, “We used to think of devices as a way to share information. Now we are sharing experiences.”

There are also technologies on the horizon that, until a few years ago, would have seemed like the stuff of science fiction, but are now in practice and could find their way into the classroom in some form over the next 30 years. Consider that right now:

- There is a form of smart dust, a series of small microcomputers that talk things over among themselves before reaching a decision, capable of being deployed in forests for early detection of wildfires.
- There are electronic “pets” that follow elderly people who need reminders about taking medication and other daily necessities that might be forgotten.
- There is rapid prototyping that allows the immediate creation of three-dimensional objects from a computer being used in the construction and architecture industries.
- There are experiments with molecular computing in which live organisms are used to process information with the promise of exponential increases in the speed of computing.

Adopting and Adapting New Technologies

In the context of historical patterns, the technologies most likely to be adopted early are those that involve incremental change in human habits, even if the tools themselves seem radical. For example, instant messaging for today's students is the equivalent of yesterday's "passing notes" (and is equally annoying to teachers). E-mail replaces photocopied memos. Interfaces that seem familiar hold promise for children who, for example, might accept help from a play dog more easily than from an impersonal machine. "A key driver of technology adoption," says Saveri, "is the sociability of devices—devices that become our social partners and part of our social networks."

People often are unable to tell you what kind of device or technology they want in the future, but they can tell you about their pains, frustrations, desires, and aspirations. Adoption often is shaped by hooking into one of those—a real pain that can be solved or an aspiration, like giving your children a leg up in life by buying them a computer without really knowing what to do with it. Also, Saveri adds, "devices and technologies are often adopted for one reason but then they are used in various ways not considered by the developers."

Everett Rogers, author of *The Diffusion of Innovations*,

talks about how users reinvent technologies to their local context. In today's world of configurable and personalizable devices, this happens a lot. The answering machine was sold to help people not miss calls while they were out, but many people use it to screen calls when they are home. Palm Pilot was sold as an "electronic organizer"—a natural extension of a paper day-planner—compared to the earlier Apple Newton, which was described as something people hadn't heard of before, a "personal digital assistant." People bought electronic organizers and used them as PDAs, something they didn't know they needed.

How will today's existing technologies be adapted for learning in the future? Here are a few ideas:

- In the future it should be commonplace for haptic and other sensory interfaces on computers—technologies that now support students left out of the loop because of physical limitations or alternative learning abilities—to allow all people to taste, smell, and feel information. And instead of sitting at a "special computer" to do so, they will have highly portable combinations of biological, information, and communication devices.
- Holograms that now are being used for electronic dance competitions could become commonplace in classrooms, bringing in people's forms from across the globe, a natural technological extension of the pen pal.
- Rapid prototyping could easily replace model-building

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in classrooms; instead of printers for blueprints, engineering and architectural courses would have computers hooked up to manufacturing machines printing in layers so that a 3D form is created.

The most significant discoveries usually involve a brilliant rearrangement of existing technologies.

- Bio-implants could replace latchkeys and fingerprinting, and—how else will teenagers shock their parents—body-part modification could be the next version of piercing and tattoos.
- Learning objects with an internationally standardized system of metatags are likely to feed the next generation of Google, the online search engine that some educational gurus have called the best learning technology of our time.

These ideas have varying degrees of probability and impact, but all are extensions of something that already exists, something we currently know and understand and recognize. Constructing knowledge means reinterpreting information so it has personal meaning, and that involves a community. Increasingly, educational technologies are designed to enhance rather than replace social interactions. Responsive, communicating devices and objects could become part of our social world. The fusion of digital with physical and the embedding of information and connectivity in objects can enable this phenomenon, which The Institute for the Future calls “seamlessness,” to happen.

Innovation and Disruptive Change

So we are still left with the question of what could possibly occur that would be as disruptive to society and as promising for human potential as the Internet. Could the

next breakthrough be the kind that would change the way educational institutions work, allowing the “system” to accommodate what we now know about learning, in an environment that embraces diversity of all kinds, and provides access to the wealth of global information and expertise to students who will grow up feeling responsible and competent to make the world a better place?

Some educators working to transform public schools have suggested that the ultimate goal of education should be simply to help youths discover what will give them satisfying and productive lives. More than information, they need personalized opportunities to construct knowledge so that “...students discover their individual capabilities and passions in life,” say Linda Keller and Ron MacDonald of the Gates Foundation-funded Model Secondary Schools Project. To that end, a very different kind of technology would be needed. The innovation likely will be found at the intersections of different types of technology.

In the early 1960s, when Doug Engelbart, the pioneer of personal computers, looked at the giant computers spitting out ticker-tape data, he envisioned a different kind of computer—one that was instantly responsive to the user and networked people around the world to solve human problems. By 1968, in “the mother of all demos,” he demonstrated collaborative networked computing, video conferencing, hypertext, integration of text and graphics, spreadsheets, e-mail, online journals, and a framework for augmenting both individual productivity and the collective IQ. He demonstrated a networked computer system with a screen, a keyboard, and something to manipulate the data on the screen: the mouse—his most mundane but most prevalent invention. He saw more than a computing tool; he was among the first to see its potential as a communication device. This vision led to other breakthroughs, many of which he was involved with creating—the desktop computer, the Internet, and the World Wide Web.

Today Engelbart, who won the highest honor in his field in 2000, the National Medal of Technology, is working on new human and tool systems to augment individual productivity and collective IQ by providing a framework that enables people to connect ideas quickly, globally, and in new ways. The ultimate result of the success of something like this would enable communities to come together to collectively solve individual and global problems by facilitating the evolution of both human and tool systems. He envisions dynamic knowledge repositories where new representations of ideas allow people to find and manipulate related information and sources.

Engelbart’s story is a reminder that the most significant discoveries usually involve a brilliant rearrangement of existing technologies. It’s an exciting prospect that the components of tomorrow’s breakthrough technology revolution are probably scattered around us right now. As Paul Saffo, a director at Institute for the Future, says, “it takes 30 years to create an overnight sensation.” <

Valerie Landau, assistant professor of multimedia in the School of Information Technology and Communication Design at California State University, Monterey Bay, also contributed to this article.

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