Technology 2008: Preparing Students for Our Changing World

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Enormous changes are occurring in technology, from the Internet to the integration of biotechnology, information technology, and nanotechnology. What will today's students need to know and be able to do in order to be successful in the world in which they will live?

U.S. society and the world in general are also undergoing fundamental change. Evidence of a changing world:

- Of the 191 countries in the United Nations, only 22 percent existed as nations 50 years ago.

- 100 years ago, the difference between the richest and poorest nations in terms of personal wealth was 50 to one; today it is 390 to one.

- When Bill Gates retired as CEO of Microsoft in 1998, 23 years after he founded the company, he was worth more than all the gold in Fort Knox, more than the GNP of China, more than the 100 poorest nations in the world.

- Singapore became an independent country in 1965. Before that it had hoped Malaysia would take it over, but that country said no, deciding that absorbing Singapore would make Malaysia poorer. In 2001, Singapore is the ninth wealthiest country in the world in terms of wealth per person. The U.S. was 10th, and Malaysia was 82nd.

- To achieve a 25 percent penetration rate in U.S. homes, it took 35 years for the telephone, 26 years for television, 16 years for personal computers, seven years for the Internet, and three years for personal digital assistants (PDAs).

The rate of change has been phenomenal and will become even faster. Yet, even with all these changes, if Rip Van Winkle woke up today, he would be comfortable in most American classrooms.

I believe this nation is too naïve about what is happening in information technology, biotechnology, and nanotechnology and their impacts on our children's lives and on America's ability to be competitive in the global economy. Our schools are so engrossed in trying to solve the problems of the day, and there are many, mostly imposed from outside the system, that they cannot see the bigger issues.

In 1968, Gordon Moore created a theory, which came to be known as Moore's Law, that the capacity of technology would double every 18 months and the cost would be cut in half every three years. We can see his theory at work with respect to personal computers. In 1992, the typical PC purchased had 2 megabytes of computing capacity and cost $3,000-4,000, or at least $1500 per megabyte. In 2002, a PC would have 128 megabytes and cost $1,000-1,300, which is about $9.40 per megabyte. If we project these figures out to 2012, PCs would have 16,384 megabytes, larger than the largest mainframe computer today, and cost $300-400, or two cents per megabyte. When Bill Gates spoke at the 2002 Consumer Electronics Conference in Las Vegas, he indicated that now we can expect the capacity of technology to double every nine months. That means that what Moore's Law projected would happen in 2012 will now be in place in 2006, according to "Gates' Law."

Introducing the Semantic Web

The World Wide Web was created by Tim Berners-Lee in December 1990. It is managed by the World Wide Web Consortium (W3C), whose 400 members create the protocols for using the Web. And they have made some interesting observations. One is that in the next three years, the Web will change far more than it has in its first 12 years. It will soon become what is known as the Semantic Web.

The Semantic Web is based upon three levels of new technology adaptation. The first level is Extensible Markup Language (XML). Extensible Markup Language is similar in many ways to Hypertext Markup Language (HTML), which gives meaning to information that is used in creating Websites. HTML deciphers coded directives about such surface-level data as content placement and format variables — color, chart and tabular layouts, type size, etc. In effect, HTML encodes and gives structure, shape, and form to information entered into a database as a Website is developed.

Extensible Markup Language, by comparison, in effect gives a deeper level of *meaning* to words. Without getting into an overly technical explanation here, picture that XML tags, or affixes to, words (and meaning-embedded content) *additional* information and provides the *context* in which words and phrases can be interpreted. For example, the number 13019 could be a zip code, a date of birth, a sales report for an item, or other designation. XML would look at the underlying coded information, called "metadata," surrounding that number and thereby determine what 13019 *means*. XML works by linking metadata between related chunks of information in much the same way as the human brain processes data, by connecting new information to recognizable prior knowledge via its underlying deeper meaning. The World Wide Web Consortium has already developed XML.

A second level of technology being used to create the Semantic Web is something called the Resource Description Framework (RDF). RDF takes a larger "chunk" of meaning such as an entire sentence or phrase and provides it, via a huge relational database, with *additional* embedded "meaning" — just as XML provides additional meaning to an individual word. RDF development is nearing completion.

The third level of the Semantic Web's development is underway. This technology, generically labeled an "inference engine," is built around and utilizes XML and RDF. But, whereas XML gives meaning to individual words or bytes of information and RDF gives meaning to sentences or phrases, this third technology embeds *entire concepts* with "deeper" linkable meaning. Developing this level will require tens of billions of dollars, but fortunately, keenly interested major corporations and organizations around the globe, including Microsoft, Cisco Systems, government laboratories, and others, are already supporting research and development. The goal is the creation of a common new language that will serve as the international and universally understandable dictionary or thesaurus not only for words and phrases, but also for entire concepts. Concepts will be cross-referenced to this common dictionary, and an entirely new communication system will be developed. This new system will be in place no later than 2007, according to even worst-case estimates.

With the Semantic Web it will be possible to key in basic information (for example, I want to travel from Boston to San Francisco on February 1 and return on February 4). The Semantic Web will return a report with all options on all airlines to all airports in the vicinity. Anytime a question is asked or information is sought, the Semantic Web creates a new database or adds to an existing one. The Semantic Web will be the equivalent of one gigantic brain to which everyone has access.

Today we use the World Wide Web for browsing. Tomorrow we will use the Semantic Web to create information and resolutions to problems that are exceedingly difficult to solve using conventional methods. This technology will change the concept of literacy as we have historically defined it. Schools need to broaden their definition of literacy beyond prose literacy to include document literacy and

quantitative literacy. Prose literacy encompasses continuous text sources, such as magazine articles, reference sources, and fiction. Document literacy refers to information contained in functional reading materials, such as job applications, payroll forms, transportation schedules, online consumer surveys, maps, tables, and graphs. Quantitative literacy relates to the integration of numbers and text.

Evaluating information and contextualized decision making will be key competencies. My fear is that our schools are so focused on today's battles — teaching to the tests — that our students are not receiving the education they need for the world in which they will live.

Technology will eliminate any task that is routine, concrete, and sequential, an advance that will change society in general and the workplace in particular forever. What kinds of jobs can be taken over by use of the Semantic Web? Travel agents, accountants, inventory clerks, buyers, even lawyers may find themselves increasingly supplanted by technology.

Other Technology Frontiers

Bioinformatics combines information systems and the life sciences. For example, it can interlock the binary code of information systems with a genetic code.

Genetic alterations are happening throughout agriculture. In Japan, farmers have produced square watermelons to make them easier and more economical to pack and ship. In this country, scientists have produced chickens with no feathers. The chickens grow faster, have more meat and less fat on them, and are easier to clean for the retail market. Changing the genetic code alters the message and changes the product or outcome.

Animal protein, an important ingredient in pharmaceuticals for treating cystic fibrosis, cancer, and other diseases, is being grown in agricultural crops, such as corn. Animal genes are inserted in seeds and result in *transgenic* crops that make proteins much cheaper and faster to produce than via other methods.

Question: Is this scientific advancement or tampering with nature?

Within five years we will be able to take a DNA test at a pharmacy to reveal predispositions to diseases. It will also be possible to do a gene analysis and enter the data into the Semantic Web to yield a diagnosis that is much more on target than is available with today's technology.

The Bionic Human

Enormous advances in the field of bionics are making replacement body parts and imbedded processors to control them a reality. Here are some examples from the September 2002 issue of *Wired Magazine* of what is already available, along with the cost.

- Paralyzed vocal chords are restored to speech by implants that force them to tighten ($2,500-5,000).

- Epileptic seizures and depression are alleviated by an electrode imbedded in a neck nerve, which activates a generator every few seconds ($30,000).

- A knee can flex up to 20 degrees when a friction-controlled device is inserted into the joint socket ($16,000-20,000).

- New bone growth is stimulated by calcium phosphate and other synthetic materials used to replace bone marrow ($575 for 10cc).

- A cochlear implant receives a digital code transmitted from a processor worn behind the ear, which is then interpreted as sound by the acoustic nerve ($50,000).

- Fine motor control is possible with an artificial hand when electrical signals from arm muscles and tendons are transmitted to a belt-mounted computer that controls sensors in the individual fingers ($20,000).

Nanotech refers to extremely small devices that are built at a molecular level. Engineers in Great Britain have developed a "tooth phone." The tooth phone, which has a tiny vibrator and a radio wave receiver, can be implanted in a tooth through "routine" dental surgery. The phone receives a digital radio signal, which it transfers to the inner ear by bone resonance. Information can be received at any time, anywhere, and no one else can tell that it is being transmitted. Think about the implications.

A Final Thought

We are entering an era of rapid change. The future will be much different from the past. Our definitions of *educated* and *literacy* from the 20th century may not apply to the same degree in the 21st. Other skills needed for the adult roles that our students will assume may be quite different, too. We need to look closely today at how and what we teach, and we must be prepared to recognize how that mix needs to change. The question is: How will schools accomplish this? There is no easy fix or pat answer to this question, but we must pursue it — honestly and courageously — in order to prepare our students for the world of tomorrow.

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