

# Technology Literacy:<sup>1</sup>

## Educating Children to Create Their Own Future

*“My association with attempts to create programs for educational uses at the Lawrence Hall of Science, Los Alamos National Laboratory, and the University of Minnesota has been disappointing . . . Like the phonograph, radio, and television, the computer will transform education — Not!”*

—Robert W. Seidel, director of the Charles Babbage Institute, University of Minnesota, in an online debate about computers in education, hosted by the *Chronicle of Higher Education*: Jan. 14, 1998.

“TECHNOLOGY LITERACY” IS INCREASINGLY becoming an explicit goal of schools throughout the country. But few educators, parents, or policymakers have a clear idea of what they mean by that phrase.<sup>2</sup>

In the broadest sense, technology literacy begins at an early age, in an informal way, long before students begin to use computers. Whether they are banging on pots and pans to make music or inventing new games with sticks and string, young children spend much of their time developing their tool-using capacities. Children’s lives are full of technologies of every kind, and they gradually develop a variety of relationships with a whole range of tools. Consequently, the first challenge in addressing this issue is to expand our own conception of technology literacy far beyond the current narrow focus on computer skills.

Older students must eventually come to grips quite consciously with the profound and pervasive impact that technologies of all kinds — from the simplest to the most complex — have had, and will have, in their own lives and on society.<sup>3</sup> As parents and teachers, we can

help them achieve this kind of sophisticated technology literacy. We must start by recognizing that there are at least three main aspects to the task:

- 1. Knowing how to use or operate particular tools.**
- 2. Understanding, at least in a rudimentary way, how they work.**
- 3. Developing the capacity to think critically, for one’s self, about the entire realm of designing, using and adapting technologies to serve personal, social, and ecological goals in ways that will sustain life on earth.**

As children turn simple objects into tools for their own use, they nearly always learn at all three levels. They intuitively explore not only how the objects work but also how they fit into the world they make for themselves.

Unfortunately, when it comes to high technology, schools generally focus only on the first level. It is the simplest to learn, but also the

least important for students, given how rapidly any particular high-tech tool is likely to become outdated. Schools frequently neglect the second, leaving even older students mystified and overawed by the inner workings of sophisticated hardware and software. And they almost uniformly ignore the third, which is the most critical and the most appropriate task of the three for publicly-funded education.

In a democracy, the point of technology literacy is to prepare students to be morally responsible citizens, actively participating in shaping the nation's technological future, rather than merely reacting to it as passive consumers. All technologies, after all, have social effects and many have had profound moral and political repercussions as well. No technology is the result of inevitable forces. Its design and its pattern of use reflect a series of human choices — some explicit and some tacit. For that reason, it is possible to imagine alternative designs and alternative patterns of use that might have resulted — and might yet result — from different choices.<sup>4</sup>

Helping all students prepare to take part in this kind of democratic decision-making is a major new challenge for educators precisely because advanced technologies have become so dominant in our culture. Ultimately, how well our schools and colleges educate students for this kind of thoughtful technological citizenship is far more critical to the future of democracy than how well they train students to operate the latest generation of computers.

Richard Sclove, founder of the Loka Institute and author of *Democracy and Technology*, argues that technology has such profound social impact that it is itself a form of politics.<sup>5</sup> A thorough grasp of technology as politics, he suggests, is as essential to real technology literacy as it is rare:

Today leaders among our technical elite ... argue that scientific and technological illiteracy have reached epidemic proportions, threatening national economic well-being and democracy itself. According to the Clinton administration, "The lifelong responsibilities of citizenship increasingly rely on scientific and technological literacy for informed choices." However, if the most important knowledge about a technology involves not its internal principles of operation but its structural bearing on democracy, then presumably the latter kind of knowledge should constitute the very core of technological literacy. Yet experts, even the elite, typically know little about this first-order issue — not even that it is an issue. Must one not reluctantly include among the technologically illiterate — in that term's socially most meaningful sense — the majority of technical experts?<sup>6</sup>

Considering the importance of preparing young people for the moral responsibilities of making decisions about technology, it seems scandalous how little space this issue gets in public discussions of education. In the interest, therefore, of provoking the discourse, we offer here four suggestions for educators, parents, and policymakers who are interested in developing more thoughtful approaches to technology literacy.

**1. In early childhood and at least throughout elementary school, concentrate on developing the child's own inner powers, not exploiting external machine power.**

Knowledgeable, caring teachers — not machines — are best able to mediate between young children and the world. Low-tech tools like crayons, watercolors, and paper nourish the

child's inner capacities and encourage the child to freely move in, directly relate to, and understand the real world. Simple objects like blocks, balls, and ribbons stimulate connections between the rich world of the child's imagination and the equally rich physical world in ways no complex symbolic machine can.

In the same way, a well-loved teacher who helps draw the child's inner life and the world's outer reality together is a much more inspiring and appropriate model for the child to imitate than a programmed machine. Recent research confirms the importance of such strong emotional bonds between children and live, caring adults for healthy intellectual development.

Such an emphasis in the early grades will also boost children's confidence in their own abilities and their own identity as active, competent learners. It will prepare them to relate later to more advanced technologies as tools that they can learn to operate with the same self-confidence and sense of personal competence that they developed using simpler technologies. Peter Nitze, global operations director at AlliedSignal (an aerospace and automotive-products manufacturer), made just that point in speaking about his own elementary education in a hands-on environment that de-emphasized technology:

If you've had the experience of binding a book, knitting a sock, playing a recorder, then you feel that you can build a rocket ship— or learn a software program you've never touched. It's not a bravado, just a quiet confidence. There is nothing you can't do. Why couldn't you? Why couldn't anybody?<sup>7</sup>

As young students grow in their own skills and their understanding of the world, they experience learning as a living transformation

that occurs within themselves. We also model for them the critical thinking skills so essential to a humane technological future. As adults they are more likely to feel able to choose among a range of technologies — from the simplest to the most complex — based on which provides the best means for the task at hand.

In contrast, children trained from the earliest ages to expect that they will need computers for even the most elementary lessons may experience learning as a manipulation of random facts stored in an electronic box outside themselves, behind a seemingly all-knowing screen. Such children receive a debilitating message: that they — unlike generations of children before them — are incapable of learning the basic skills of arithmetic, reading, and writing without expensive and sophisticated machines.

The approach recommended here is as practical as it is pedagogically sound. Parents who worry about their child's typing, word-processing, spreadsheet, and Web search skills (the underlying fear, of course, is about earning a decent living) should consider what every experienced technology instructor knows: all of these skills can be taught in a one-semester course for older students. Must kindergarten students really be trained to operate high-tech machinery to get a jump start on job skills? Is our economic outlook really so desperate and the development of our children's autonomy so inconsequential as that?

In fact, students who use computers intensively from early childhood could find themselves at a later disadvantage in the job market. They may suffer repetitive stress injuries that result in permanent impairment. They will have more obsolete "computer skills" to unlearn. And, if their early learning years are

too much focused on computers instead of more developmentally appropriate kinds of play, they may be deficient in creativity, imagination, and problem-solving abilities — the very skills that companies most want in young workers.

Albert Einstein, explaining his path to formulating the theory of relativity, noted that as a young child he lagged behind other children in intellectual and social development. It was this very slowness in developing, he suggested, that later served him well. It meant that when he finally did consider the relationship of space and time as an adult, he brought a powerful combination of intellectual maturity, freshness, and a sense of childhood wonder to the task. In contrast, most other adults had already accepted the conventional ideas on those subjects:

When I ask myself why it should have been me, rather than anyone else, who discovered the relativity theory, I think that this was due to the following circumstance: An adult does not reflect on space-time problems. Anything that needs reflection on this matter he believes he did in his early childhood. I, on the other hand, developed so slowly that I only began to reflect about space and time when I was grown up. Naturally I then penetrated more deeply into these problems than an ordinary child would.<sup>8</sup>

Current high-tech tools will be updated several times and probably replaced long before today's first-graders graduate from high school. (The World Wide Web didn't even exist 12 years ago.) It makes little sense to waste precious time wiring the developing brains of young children to what will soon be yesterday's hardware and software.

The high-school graduates of such a system may be well indoctrinated into the need for

constant technical retraining, perhaps out of fear of being discarded themselves. But they are not likely to have learned how to stand apart from the integrated technology and decide whether this is the work that ought to be done, or the kind of life they really want to live. They may achieve mental flexibility within the limits of the computer environment. But the cost could well be mental rigidity in shaping that environment, or venturing beyond it. Those trained from preschool to think primarily “within the electronic box” are likely to be the least capable of imagining creative alternatives apart from those suggested by the technical system itself.

## **2. Infuse the study of ethics and responsibility into every technology-training program offered in school.**

Given the profound impact of computer technology on contemporary life, we have a pressing educational responsibility to direct our students' attention to the social issues related to it. This starts with simple, straightforward tasks such as teaching good “Netiquette” — the appropriate manners employed in online communication — before students get their own e-mail accounts. It extends to complex issues regarding global responsibility and cultural awareness that should be a prerequisite to Web access.

Few educators are even aware that such issues exist. But the issues are not new. Twenty years ago Joseph Weizenbaum, one of the pioneers of computer science at the Massachusetts Institute of Technology, reminded his teaching colleagues that social obligations with regard to computer technology

“begin from the principle that the range of one’s responsibilities must be commensurate with the range of the effects of one’s actions.”<sup>9</sup>

In the age of global telecomputing the range of each person’s actions is enormous. And so, therefore, are each one’s responsibilities.

We are now placing in students’ hands machines more powerful and with a far greater reach than any tools young people have ever before possessed. The demand that students be given the opportunities these machines afford has been loud and unrelenting. Yet the voices grow weak when it comes to the profound responsibilities we all have in using these powerful machines for the benefit of humanity rather than simply exploiting them for our own personal profit or pleasure.

To send young people out into the world with great skill in operating these machines but no ethical instruction to guide their use is educationally and socially irresponsible. Real technology literacy will be based on an investigation of ethical issues surrounding the use of powerful technologies. The focus on ethical questions should continue throughout the time that these powerful technologies are made available to students in school.

**3. For high school students, consider making the study of the fundamentals of how computers work part of the core curriculum.**

It’s one thing for students simply to learn how to use computers. But to develop any real control over them, students must understand how information technologies fit into the history of humanity’s toolmaking, and how computers do their work. By formalizing this study, schools can help high-school students

gradually demystify the black boxes that otherwise, when unthinkingly accepted, gain improper authority over our lives.

Helping students gain a deep grasp of the history and technology underlying the computer is hard work, however — just as teaching physics or American history is hard work. If there is technophobia in education, it is the unwillingness of educators and schools to do this hard work by genuinely confronting the computer. As with television’s sad history, the easiest course is just to abandon our children to whatever the technology delivers. And, as with television, the easiest course is also the least healthy.

A high-school course that started with the basics of simple electrical circuits and advanced to the fundamental design of televisions and computers would help correct this omission. Basic comprehension of these technologies would begin to counteract the awe and deference that children and adults often lavish on machines today.

To better understand the basic principles of how computers function, students could take apart and reassemble a very simple version of a computer. They could learn what algorithms are, the sort of tasks for which the computer’s algorithmic processing is proficient, and the kinds for which it is less useful. They could learn, for example, why computers are perfectly designed to sort and manage massive amounts of information that can be easily categorized.

And they could learn that computers cannot be trusted to make appropriate decisions based on that information alone because they are unable to understand the context of any particular situation. Through such an investigation students would come to a better understanding of which aspects of the human

mind these manmade logic machines reflect, and which aspects of our humanity they do not.

This would encourage critical thinking about what the technology is good for, and what it is not so good for. Students would then be prepared to analyze for themselves the vast gulf between the spectacular gifts of mind, body, and heart that being human entails and the infinitely more narrow range of operations that defines the most advanced machine. They would come to recognize that the computer, by its very nature as a logic machine, is capable of embodying more tendencies, biases, assumptions, cultural imperatives, and hidden agendas than any other technology ever developed. And they would be intellectually primed to explore for themselves what those biases are.

**4. Make the history of technology as a social force a part of every high school student's schooling.**

This could be done as a separate course on the philosophy or sociology of technology, or as an ongoing part of social studies and other courses, as is now done with concerns about multiculturalism and gender issues — or both. The goal of such instruction would be to help students understand that technologies, from fire to the most advanced information devices, have had profound social, political, and environmental consequences, both positive and negative, intended and unintended, throughout human history.

Such instruction should also clarify, through historical analysis, how the use of technology is rooted in social choices and political processes. That is, technologies are social products — not the result of some inevitable chain reaction in

which a scientific discovery leads inexorably to a particular technological innovation.

In recent years, professional associations of scientists and engineers have strongly recommended that schools add the history of science and technology to their regular history curricula because of the crucial roles they have played in human cultures. Scholars who study the history of technology agree that a complex dynamic exists by which human societies both shape technologies and are, in turn, shaped by them. As the pace of technological change quickens, that issue looms ever larger. A substantial literature already exists to support teachers who challenge students to analyze critically this pressing question: Are they doing the shaping, or are they being shaped?

If such education is to be more than mere propaganda, however, it must help students explore the full range of cultural effects associated with science and technology — what Howard P. Segal, professor of history at the University of Maine, calls “the mixed blessings of technology in America.”<sup>10</sup> Again, educators will find many competing scholarly positions to draw from in helping students think about this issue for themselves. For example, students might study the checkered history of the automobile as both America's dream machine, in terms of speed and freedom, and a leading suspect in the generation of smog, flight from urban neighborhoods, and global warming. They might study the more recent advent of genetic engineering, both in animals and crops, and the benefits and problems that may be realized by this technological innovation. The issues are not hard to find — that they are extremely difficult to resolve makes it all the more imperative that their study be undertaken in our schools.

## TECHNOLOGY LITERACY: Guidelines for a More Democratic Future

1. In early childhood and at least through elementary school, concentrate on developing the child's own inner powers, not exploiting external machine powers.
2. Infuse the study of ethics and responsibility into every technology training program offered in school.
3. For high school students, consider making the study of the fundamentals of how computers work part of the core curriculum.
4. Make the history of technology as a social and political force a part of every high school student's schooling.

Because computers and other new information technologies are wielding an ever-expanding influence on all our daily lives, information technologies should be a high priority for this kind of critical historical analysis.

This would include, for example, the U.S. military's leadership in funding and promoting many of the major innovations in computer technology over the last 50 years. This reflects the pivotal role that computers played in strategic Cold War planning for using or defending against nuclear weapons — and their expanding role in current military strategies for using information to dominate any battlefield.<sup>11</sup>

By studying the motivation and purpose behind the development of the computer and related technologies, students will better be able to judge the value of the inherent qualities built into the technology and what purposes it serves best, and least. Internet pioneer and technology expert Howard Rheingold points out that “a

computer is, was, and will be a weapon. The tool can be used for other purposes, but to be promoted as an instrument of liberation, [computer-mediated communications] should be seen within the contexts of its origins, and in full cognizance of the possibly horrific future applications by totalitarians who get their hands on it.<sup>12</sup>

### The Goal of Technology Literacy

All this should be seen as a fundamental responsibility of education in a computerized world. If we do not help our children gain a sound understanding of the computer, they will inevitably defer to it in unhealthy ways. We already see far too many cases of students saying, “It's on the Internet. It must be right.”

These recommendations depend and build on a childhood that rejects a subservient attitude toward the machine. Instead, schools can help children develop a healthy, autonomous sense of self and a gradually

expanding, humane relationship to the world. As young people move toward that goal, they will be able to determine for themselves the appropriate place for computers and other technologies in their deepening relationship with the world, rather than have that relationship defined by the technology.

Ultimately, that should be the goal of technology literacy: to enable young people to develop their own creative and critical capacities in relating to technology, not to train them to be machine operators. Then they will clearly see that their own choices are not limited to adjusting themselves to a 21st century determined by technology. Instead, this new generation will have the awareness, the moral and ethical sensibilities, and the will to adjust technology to fit into their 21st century.



<sup>1</sup> An excellent resource for educators, parents, policymakers, and anyone else interested in technology literacy is *Confronting Technology* ([www.grinnell.edu/individuals/MONKE/books.html](http://www.grinnell.edu/individuals/MONKE/books.html)), a Website developed by computer-science educator Lowell Monke of Wittenberg University. The site includes an annotated bibliography of texts that emphasize critical thinking in reflecting on the impact of technology, as well as our roles and responsibilities in designing and using technologies.

Also, for innovative approaches to promoting democratic participation in the design, use, and evaluation of technologies, see the website of the Loka Institute, [www.loka.org](http://www.loka.org).

Also, see *NetFuture*, an online newsletter that deals with technology and human responsibility, at [www.netfuture.org](http://www.netfuture.org).

Also, see the Website of Knowledge Context, a nonprofit group in the San Francisco Bay area that offers a sample curriculum for learning about technology in the context of history, science, mathematics, and language arts. Its curriculum does not appear, from the information posted on the Web, to probe technology's social and political ramifications

as deeply as the other resources listed above. But it does represent an unusual effort to help teachers and students from fourth grade up go beyond mere technical issues in thinking about technology. At <http://KnowledgeContext.org>.

<sup>2</sup> See, for example, the story of how officials at the National Science Foundation coined the term “computer literacy” in the 1970s precisely because “nobody can define it... It was a broad enough term that you could get all of these programs [in computer-based instruction] together under one roof,” as one NSF official put it. Recounted by Douglas D. Noble in “Mad Rushes into the Future: The Overselling of Educational Technology,” *Educational Leadership*, November 1996, pp. 18-23.

<sup>3</sup> See, for example, Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology*, Chicago: University of Chicago Press, 1986, for a penetrating and readable analysis of the social, political, and philosophical implications of technology.

<sup>4</sup> Richard E. Sclove, *Democracy and Technology*, New York: Guilford Press, 1995, especially p. 19. In this groundbreaking book, Sclove provides a comprehensive vision for achieving a more democratic politics of technology.

<sup>5</sup> Ibid, p. 102.

<sup>6</sup> Ibid, p. 53.

<sup>7</sup> Todd Oppenheimer, “Schooling the Imagination,” *Atlantic Monthly*, September 1999.

<sup>8</sup> Quoted from a letter Einstein wrote to a colleague, the Nobel laureate James Franck, by the author Albrecht Fölsing, in *Albert Einstein: A Biography*, translated from the German by Ewald Osers, Viking Press, 1997, p. 13.

<sup>9</sup> Joseph Weizenbaum, *Computer Power and Human Reason: From Judgment to Calculation*, New York: W. H. Freeman, 1976, p.261.

<sup>10</sup> Howard P. Segal, *Future Imperfect: The Mixed Blessings of Technology in America*, Amherst: University of Massachusetts Press, 1994.

<sup>11</sup> For a clear account of the Pentagon's historical role and continuing interest in promoting the development and the commercial success of new



computer technologies with important military applications, see The White House National Economic Council, National Security Council, Office of Science and Technology Policy, *Second to None: Preserving America's Military Advantage Through Dual-Use Technology*, The White House, February 1995.

The report notes that the Department of Defense “funded nearly all of the early R&D [research and development] in computers, setting the stage for the vibrant commercial industry... Although the role of defense investment is less central now, DoD can still accelerate and influence the direction of new technologies” (p. 15).

The National Science and Technology Council's report, *Technology in the National Interest*, explains that “thirty-five years ago, U.S. war planners undertook an effort to ensure the survivability of America's computing and communications capabilities in a nuclear first strike to preserve a credible U.S. retaliatory capability. From this initiative the first network, ARPAnet, was established, allowing geographically separated researchers to share computer resources and laying the foundations for today's Information Superhighway” (Executive Office of the President of the United States, 1996, p. 66.)

<sup>12</sup> Howard Rheingold, *The Virtual Community: Homesteading on the Electronic Frontier*, New York: HarperPerennial, 1994, p. 290.

