Children and Computer Technology: Analysis and Recommendations

“Across the world there is a passionate love affair between children and computers... And more than wanting [computer technology], they seem to know that in a deep way it already belongs to them. They know they can master it more easily and more naturally than their parents. They know they are the computer generation.”

—Seymour Papert, The Connected Family, 1996

Feeding children’s passion for computers, billions of dollars in both public and private funds are being spent to give children access in school, at home, and in the community. Nearly every school is now equipped with computers, and over two-thirds of our nation’s children have access at home. But is computer technology improving children’s lives? This journal issue examines how children are affected by the emerging world of computers. It explores how computer use is affecting children’s development physically, intellectually, socially, and psychologically; whether computers are increasing or decreasing the disparities between rich and poor; and whether computers are being used effectively to enhance classroom instruction.

This article reviews the main themes of the journal issue by summarizing highlights of both the promise as well as concerns surrounding children’s use of computers, and by focusing on factors society should consider when making choices about the role of technology in children’s lives. Why is access important? Who needs access and for what? How can we assure that access leads to positive learning experiences at school and at home? As computers become ubiquitous in our daily lives, it is important to understand how computer technology can enhance or detract from a child’s growth and development. Computers are not an end in themselves, but a means to an end. We must determine what we want our children to experience and learn from their use of computers so that they are empowered to take control of this powerful new tool in their lives.

The Importance of Access

Computer technology has transformed society in profound ways. For better or worse, the increasing pervasiveness of computer technology is a reality no one can ignore. Computers are fast becoming integrated
into nearly every aspect of daily living—from school to work, to banking and shopping, to paying taxes and even voting. They provide access to a wide range of information without a trip to the library. They convey personal messages in place of the post office or telephone. And they compete with newspapers, radio, and television in providing entertainment and news of the day.

Computer technology also has a profound effect on our economy. Not only are computers changing the way goods and services are manufactured, distributed, and purchased, but they are also changing the skills workers need to be productive and earn a living. Almost every job today requires at least some knowledge of computers, and for an increasing number of jobs, productivity is directly related to an individual’s level of computer expertise. As the economy moves increasingly to computer-based work, the changes are bringing a societal transformation as significant as the Industrial Revolution. Just as society was transformed when families migrated from an agrarian way of life to work in factories 200 years ago, in the “Digital Age,” computer technology is transforming society by enabling many people to work anytime, anywhere, freed from a workplace anchored in time and space.

Political participation is also changing because of computer technology. The Internet is increasingly the primary access point for disseminating information about government policies, programs, and services. E-mail lists and chat rooms have become popular vehicles for forming political coalitions at the national, state, and local levels. In 1999, more than 23 million individual taxpayers (about 19%) filed their returns via the Internet, and the number is expected to double by 2006. And in what many see as the wave of the future, the nation’s first legally binding public election using the Internet took place in March 2000, when 42% of those voting in Arizona’s Democratic Party presidential primary cast their ballots online.

The public generally agrees that for children to participate socially, economically, and politically in this new and different world, they must acquire a certain level of comfort and competence in using computers to enable them to learn adequate computer skills and improve their education. In surveys, most parents and children report that they view computers and the Internet as a positive force in their lives, despite concerns about exposure to inappropriate commercial, sexual, and violent content. Most parents believe that the Internet can help children with their homework and allow them to discover fascinating, useful things, and that children without access are disadvantaged compared to those with access. According to Chen’s commentary in this journal issue, in the minds of many parents and policymakers, “equality of digital opportunity” is fast becoming synonymous with “equality of educational opportunity.”

As a result, growing numbers of parents are providing their children with access to computers at home. Among households with children ages 2 to 17, home computer ownership jumped from 48% in 1996 to 70% in 2000, while connections to the Internet catapulted from 15% to 52% over the same 5-year period. This rapid diffusion of technology is quite phenomenal—the spread of Internet access has been described as nine times faster than that of radio, four times faster than the personal computer, and three times faster than television.
In addition, Congress has made it a national priority to provide all our nation’s children with access to computers at school. Declaring that the use of technology can help students meet high standards of learning, and that such use is essential to develop and maintain a technologically literate citizenry and an internationally competitive workforce, in 1994 Congress enacted the Goals 2000: Educate America Act and the Improving America’s Schools Act and created several programs to help elementary and secondary schools acquire and use technology to improve the delivery of educational services.13 (See Appendix A by Linda G. Roberts, director of the Office of Educational Technology, U.S. Department of Education.) Largely as a result of these programs, between 1994 and 1999, the percentage of public elementary and secondary schools with computers connected to the Internet increased from 35% to 95%.1

Children are spending an increasing amount of time with computers at school and at home, yet surprisingly little systematic research has examined the effects of computer use on children. Nevertheless, as detailed throughout the remainder of this article, the limited data available, combined with the rich body of literature on child development, learning, and children’s use of other media, suggest certain general observations. First, children’s healthy development requires involvement in a variety of physical and social activities. The time children spend in front of screens of any type should not take up a disproportionate amount of their day. Second, parents, teachers, and other adults who work with children need guidance and support in their efforts to ensure that all children learn to use computers effectively and responsibly. More “high-quality” digital content and models of exemplary technology-supported practices are needed—uses of computers to educate and inspire, not just entertain. And third, evidence suggests that use of computers can improve learning among children under certain circumstances, but these circumstances may be more limited than parents and policymakers realize. Much remains to be accomplished if we are to ensure that our nation’s children not only acquire the necessary skills to use computers effectively as a tool in their daily lives, but also benefit from technology’s potential to enrich their learning both inside and outside the classroom.

The Risks and Benefits of Use

Excessive, unmonitored use of computers, especially when combined with use of other screen technologies, such as television, can place children at risk for harmful effects on their physical, social, and psychological development. Children need physical activity, social interaction, and the love and guidance of caring adults to be healthy, happy, and productive.14 Too much time in front of a screen can deprive children of time for organized sports and other social activities that are beneficial to child development.15 In addition, children may be exposed to violent, sexual, or commercial content beyond their years, with long-term negative effects.16 To ensure healthy and appropriate use of computers both at school and at home, children’s computer time must be limited and their exposure to different types of content must be supervised.

Limits on Extent of Exposure Needed

At present, excessive use of computers among children, especially younger children, is not typical. National survey data gathered in spring 2000 indicate that children ages 2 to 17 spent about 34 minutes per day, on average, using computers at home, with use increasing with age.17 (Preschoolers ages 2 to 5 averaged 27 minutes per day, school-age children ages 6 to 11 averaged 49 minutes per day, and teens ages 12 to 17 averaged 63 minutes per day.) Available data on computer use at school suggest that exposure in the early primary grades, at least, is relatively modest. A spring 1999 survey of 26 elementary schools in the heart of Silicon Valley, where computer use might be expected to be high, found that although 70% of teachers in kindergarten through third grade had their students do some work on computers, the students’ computer time averaged less than 10 minutes per day.18 These data suggest that younger
children in particular are not currently using computers for excessive amounts of time.

Usage is on the rise, however, and some children—especially older teenage boys—have reported spending 4 hours a day or more using their home computers. In addition, it appears that time spent using home computers does not displace much, if any, time spent watching television; instead, access to home computers appears to increase the amount of children’s overall “screen time.” Survey data gathered in spring 2000 indicate that when children between the ages of 2 and 17 have access to computers and video games as well as television, they spend, on average, about 5 hours a day in front of some type of screen, over an hour more than children without such access.

Children who spend an excessive amount of time in front of computers and other screens are likely to be displacing activities required for healthy development and increasing their risk of obesity. In addition, children’s increased computer time could expose them to harmful impacts on their eyes, backs, and wrists. Although the number of studies documenting the relationship between children’s computer use and such harmful effects is limited, such studies, taken together with findings on the effects of other media on children and findings on the effects of computer use on adults, suggest that the risks of excessive computer use can be significant.

For example, although little systematic research documents the relationship between children’s computer use and obesity, evidence does show that obesity in children is linked to excessive time in front of a television screen—defined as five or more hours a day. The sedentary time spent in front of a computer screen likely poses a similar risk.

Also, some researchers have issued warnings about the risk of repetitive strain injuries from use of computers at workstations not well designed for children, and possible harmful effects on children’s vision from staring too long at a computer screen. Most of the evidence concerning these physical risks is inferred from studies of adult use of computers in the workplace. For example, the Occupational Safety and Health Administration (OSHA) within the U.S. Department of Labor has reported that each year, 230,000 workers suffer injury from overexertion or repetitive motion, such as that caused by excessive computer use. Citing the potential risks from, among other things, “using a keyboard again and again,” in November 1999, OSHA proposed new ergonomics requirements to reduce injuries among workers caused by excessive computer use. Excessive use of computers by children could put them at risk for similar injuries. More child-focused studies are needed to determine how much computer use is too much for children of different ages and how to intersperse breaks and provide ergonomic supports to minimize risk.

Excessive computer use may also affect children’s social development. By the age of about seven years, a child’s interactions with family, peers, school, community networks, and media all play an important role in the development of interpersonal skills and social competence. Computers are now part of that mix, and concerns have been raised that children who form “electronic friendships” instead of human friendships might be hindered in developing interpersonal skills. Such concerns are heightened by reports that among children ages 8 to 16, some 20% have computers—and 11% have Internet access—in their bedrooms, which suggests that a sizable number of children may use computers in social isolation. Indeed, some research has documented negative social effects from time spent on computers. For example, one in-depth analysis of the effects of Internet use among a group of 93 families found that, during their first year with access, teens who spent more time online experienced greater declines in social involvement and increases in their feelings of loneliness and depression. Similarly, in the school setting, although group use of computers is more common, concerns have been raised about the possibility that computers may be used to replace, rather than augment, child-to-child and child-to-teacher relationships.
To minimize the increased risk of obesity, as well as several other harmful effects of extensive media exposure, the American Academy of Pediatrics advises parents to limit children’s time spent with computers, video games, and other media to perhaps no more than one to two hours a day, and to emphasize alternative activities such as imaginative play and sports.30

**Supervision of Activities and Content Quality Needed**

In addition to the extent of time, the types of activities children engage in while using computers can also affect their intellectual, social, and psychological well-being. The allure of computers stems from the fact that they can be used for a wide range of purposes. Although 1998 census data indicated children were still using computers primarily to play games and to run stand-alone software,31 their use of the Internet is increasing rapidly.17 As of 2000, an estimated 21 million children and teens were accessing the Internet from home.32 And once online, a child can choose to engage in activities across a wide range of possibilities. When games were the principal option, boys spent much more time with computers than girls did.33,20 Now that the array of nongame applications has widened, girls report use of home computers as often, and with as much confidence, as boys do.34 Children of both genders surf the Web for music and photos of movie stars, use e-mail to exchange messages with friends, and especially among teens, use the Internet to visit multiuser domains (MUDs) and chat rooms.

Not surprisingly, the effects of computer use vary significantly by the type of activity and the quality of content. The experiences of children playing violent computer games are quite different from those playing educational games; the experiences of children visiting informative, nonprofit Web sites are quite different from those logging on to sites sponsored by media conglomerates and toy companies; and the experiences of children exchanging e-mails with friends and family are quite different from those communicating with strangers in MUDs and chat rooms. What can be gleaned from the research about the effects of various experiences is summarized below, but the picture is sketchy and incomplete. Much further research is needed before we have sufficient data to understand how different computer activities are affecting our nation’s children.

**Playing Games**

Playing games has long been the most common computer activity for children, especially younger boys. But computer games vary widely in terms of content and potential effects. Some, such as SimCity,35 have been shown to have considerable educational value. Others, however, such as Duke Nukem and Doom, expose children to extreme violence, possibly disposing them to subsequent aggressive behavior.20

As reported in the article by Subrahmanyam and colleagues in this journal issue, some studies suggest that moderate use of computers to play games has no significant impact on children’s friendships and family relationships, and can even enhance certain visual intelligence skills, such as the ability to read and visualize images in three-dimensional space, and to track multiple images simultaneously. Such skills, Subrahmanyam and colleagues contend, can serve as an important building block to computer literacy, and may be especially useful in the fields of science and technology. However, Healy questions these claims in her commentary in this journal issue, noting that there is little, if any, evidence that the visual-spatial skills fostered by computer games contribute in any meaningful way to the academic skills needed for math and science.

In addition, however, just as research has documented that watching violent films and television programming can lead to increased hostility and aggression in children,36 some research also suggests an association between playing violent computer games and increased aggression.37 Although the causal direction of the association is unclear, the critical variable linked to subsequent aggressive behavior appears to be the child’s preference for playing such games. According to Subrahmanyam and colleagues, the
amount of aggression and violence has increased in each generation of computer games, and parents are often unaware of the extent of the violence, even though many of the most popular games have violent themes. A 1998 content analysis of popular video games found that nearly 80% had aggression or violence as an objective. In September 2000, the Federal Trade Commission reported that violent computer games rated “mature” (for adults only) were being marketed aggressively to children under age 17. We agree with the commission that sanctions should be imposed for such marketing violations, and that parental understanding of the ratings should be increased by including the reasons for the rating in all advertising and product packaging.

**Use for Homework**

After games, the next most frequently reported activity on the home computer for children over age eight is school assignments. While use of a home computer is widely assumed to have a positive impact on children’s learning, little research exists to confirm this assumption. The limited evidence available suggests that home computer use is linked to slightly better academic performance, but these studies failed to control for other factors. Thus, it is difficult to know whether a child’s academic performance reflects use of a home computer or a greater level of family income and education—factors that are highly correlated with both home computer ownership and better academic performance.

Nevertheless, Subrahmanyam and colleagues cite one well-controlled study of a computer-based after-school program demonstrating that children who participated in the program achieved small but significant gains in reading, mathematics, computer knowledge, and grammar, were better able to follow directions, and scored higher on school achievement tests, compared with nonparticipants. These effects were found even though the program emphasized voluntary participation in a mix of fun and learning activities rather than a structured instructional intervention.

**Surfing the Web**

The article by Montgomery in this journal issue describes the rich array of Web sites created for children by nonprofit organizations, museums, educational institutions, and government agencies—sites that offer opportunities to form communities with other children, to create original works of art and literature, and to explore the world. For example, one site, Yo! Youth Outlook, sponsored by the Pacific News Service, provides an online version of a monthly magazine by and about young people that lets children speak for themselves. The site Parents and Children Together Online, sponsored by the Family Literacy Center at Indiana University, is designed to facilitate online storytelling. Another site, Planet Youth, sponsored by the U.S. Department of Housing and Urban Development, provides colorful material and links to sites describing Native American culture, history, education, arts, and sciences.

Yet Montgomery describes how, for the most part, educational sites are being overshadowed by the heavily promoted commercial sites, many of which are tied to popular television shows and toy companies. Utilizing the unique interactive features of the Internet, companies are able to integrate advertising and Web site content to promote “brand awareness” and “brand loyalty” among children, encouraging them to become consumers at a very early age. Companies are even employing a variety of strategies to facilitate online purchases by children through the creation of “digital wallets.” According to one industry report, teens spent an estimated $161 million online in 1999 and are expected to spend over $1.4 billion in 2002.

In addition, much information not intended for children is available on the Web—such as instructions on how to build bombs, bulletin boards for hate groups, and sexually explicit imagery—giving rise to a host of concerns about exposure to inappropriate content. Although little research exists on the effects of exposure to various types of Web content, as discussed in the article by Wartella and Jennings in this journal issue, studies of the effects of other types
of media (including film, radio, and television) found that children were influenced by exposure to different types of programming. For example, some studies indicated that children who viewed more cartoons and action-oriented television programming were more impulsive and less analytic in their thinking, whereas children who viewed other types of programming improved their thinking skills and academic performance. Earlier research on other media generally concluded that while the effects of media use could be powerful, such effects are generally mitigated by other important factors, such as the child’s developmental level and family circumstances.

Communicating via the Internet

Children’s use of the Internet to send and receive e-mail and visit chat rooms is changing the way many young people communicate with each other. The limited research on such use, as detailed in the article by Subrahmanyam and colleagues, indicates that to the extent young Internet users are honest about how they portray themselves online (that is, they communicate as their “real selves”), and their online contacts are with family and friends, there are few, if any, negative effects, and perhaps even some positive ones. Teens, especially, report that keeping up with local and distant friends is a very important use of the Internet for them. In addition, the article by Hasselbring and Williams Glaser in this journal issue notes that the opportunity to communicate with others through the computer can free children with special needs from the fear of being stigmatized and can enable them to network with other children to share their feelings about having a disability. The PatchWorx Web site is one example of how the Internet can provide an online community for young people facing illness and disability to “share stories, ideas, laughter and tears, to learn from each other, and to make friends with common interests.”

However, extended use of the Internet to access a virtual world of multiuser domains (MUDs), multi-identity chat rooms, and multiparty games has been linked to increases in loneliness and depression, and to the possible blurring of a child’s ability to distinguish real life from simulation. As described in the article by Subrahmanyam and colleagues, in these virtual environments, where children assume multiple identities and interact with strangers, the distinction between real life and simulation may not always be clear. In chat rooms, there is often no way to know if one is interacting with a “real person” or with a fabricated character. Studies suggest that immersion in a virtual environment can have powerful effects, yet little is known about this phenomenon. As younger children as well as older children begin to participate more frequently in MUDs and simulation environments, it becomes increasingly important to understand the impact of these experiences on children’s psychological development.

Research suggests that time spent in MUDs and chat rooms may be the underlying cause of the increases in loneliness and depression among teens mentioned earlier. In the study identifying this link, many of the teens said they frequented MUDs and chat rooms specifically to interact with strangers. When, over time, they began to use the Internet to communicate more with friends and family, who tend to provide stronger social support, the negative effects diminished.

In sum, research on the effects of computer use is in its infancy, and most findings are only suggestive. Indeed, current research provides few clear answers to many basic questions. For example, some studies suggest that use of computers for playing educational games, visiting non-profit Web sites, and doing homework may provide intellectual and academic benefits, but the gains are generally small or inconclusive. Likewise, some evidence suggests that use of computers for playing violent computer games and visiting MUDs and chat rooms can have negative social and psychological effects on children, but these effects are often mitigated by other important factors, such as a child’s developmental level and family circumstances. Thus, the extent of any negative social or psychological effects is as yet unknown. More systematic, controlled
studies examining the broad range of
topics discussed above are needed to
better understand the effects of computer
use on children’s development and to
help parents and policymakers maximize
the positive effects and minimize the nega-
tive effects of computers in children’s
lives.

**RECOMMENDATION**

- More public and private research dollars
  should be allocated to assessing the effects
  of extended computer use and exposure to
  various types of computer content on chil-
  dren’s physical, intellectual, social, and psy-
  chological development.

Research takes time, however. We
cannot wait until studies are complete to
begin taking action to protect our
nation’s children from potential risks. To
help parents and other adults protect chil-
dren from inappropriate commercial,
sexual, and violent content, many steps
have been initiated, as discussed below.
Further action will be required if we hope
to not only protect children, but to
empower them to use computer technol-
ogy effectively and appropriately as tools
throughout their lives.

**Helping Children Be Safe
and Savvy**

Clearly, our foremost concern must be to
protect our children from harm. Even in
the absence of definitive research, steps
must be taken to protect children from
potential risks through controls and
closer monitoring. While protecting our
children from harm, however, we must
also strive to inspire. Children should be
encouraged to use computers in ways that
instill a thirst for knowledge and a zeal for
positive social engagement.

**Efforts to Protect**

Government and private initiatives have
been introduced to help protect children
from inappropriate content. For instance,
the Children’s Online Privacy Protection
Act, passed by Congress in 1998, requires
parental permission before commercial
Web sites can collect personal informa-
tion from children under age 13. Other
legislative initiatives to prohibit the distrib-
ution of indecent content to minors via
the Internet have been introduced, but
enforcement has been barred pending
constitutional challenges as a violation of
free speech. Meanwhile, several compa-

doies have created a variety of filtering,
blocking, and monitoring software tools
for parents to safeguard their children
from harmful content or predators.

- Parents, teachers, and other adults
  working with children should limit the
  amount of time children spend using
  computers and supervise the content chil-
  dren are exposed to, including games,
  software, and the Web.

**Efforts to Improve Quality**

The software and digital media industries
should also be challenged to examine the
learning experiences being promoted to
our nation’s children through their use of
computers. As noted by Montgomery,
there is little doubt that the emerging
media system will play a significant role in
helping children become consumers, thus
contributing to the growth of our econ-
omy. But new media content should also
play a significant role in helping the next generation become more engaged as citizens, thus contributing to the health of our democracy. A more proactive definition of quality content for children is needed—one that involves the enhancement of children’s learning and development, not merely their freedom from harm.

To ensure the existence and, indeed, the flourishing of civic content on the Web, new partnerships between researchers, software and Internet companies, and government agencies are needed. As detailed in the article by Wartella and Jennings, we know from past experience that market forces alone are not sufficient to provide quality content for entertainment purposes, let alone for more altruistic purposes such as the promotion of positive civic engagement. New incentives are needed to encourage the development of high-quality content that responds to the noncommercial interests and needs of all segments of society. In July 2000, media and technology executives, child advocates, researchers, and federal government officials began a dialogue about creating incentives for providing quality content. Such dialogues should be nurtured, with continued involvement of industry and input from children, to help strategize how the powerful capabilities of computers and the Internet can be used not only to serve commercial and entertainment functions, but to help fulfill our nation’s fundamental democratic values.

**RECOMMENDATION**

- Public, private, and nonprofit groups concerned with the role of computer technology in society should support and encourage the dialogue that has been initiated among researchers, software and Internet companies, and government agencies to create new incentives for developing high-quality content for children.

### Efforts to Promote Computer Literacy

As Lipper and Lazarus note in their commentary in this journal issue, parents can and should play a greater role in guiding their children’s use of new media and advocating in the public policy arena and marketplace for the development of relevant, high-quality content. To help parents fulfill this role, various government and nonprofit groups now provide resources, both in print and online, with tips on how to use the Internet safely and productively. But most children, and indeed, many adults, have difficulty understanding the complex relationship between programming, advertising, and the basic economic structures underlying broadcast media generally and the Web in particular. With training, children as young as five years old can begin to become more critical media consumers, but the ability to comprehend media content and discern underlying messages and motives evolves slowly.

Parents, teachers, other adults who work with children, and children themselves need media literacy training to become safe and savvy computer users. Such training can help users understand the motives underlying various types of content on the Web. According to the American Academy of Pediatrics, research strongly suggests that media literacy training can result in young people becoming less vulnerable to the negative aspects of media exposure and more able to make good choices about how they spend their time on computers.

Better ratings and labeling and quality content cannot improve children’s use of computers unless children are motivated to use the better software and log on to the higher-quality sites. Otherwise, as noted by Dede in his commentary in this journal issue, today’s “couch potatoes” immersed in television fantasy may become tomorrow’s “couch funguses” immersed in virtual environments, and the higher-quality content will be ignored.
RECOMMENDATION

Schools and community organizations should provide media literacy training for teachers, parents, other adults who work with children, and children themselves to strengthen their critical understanding of the motives underlying much of the software and content found on the Web and to empower children to make good choices about their computer use.

Media literacy, however, views computers as analogous to television and other media—with the user passively, albeit critically, receiving the content provided. Computer literacy must encompass a more active role for children, one that empowers them to use computers to create, to design, to invent—not merely to receive information passively from the screen. To paraphrase Resnick’s commentary in this journal issue, children must learn to use computers “more like finger paint and less like television.” To become computer literate in this way, children must have opportunities to use a broad range of applications, from word processing, spreadsheets, and graphics to simulations, networking, and programming.

Even the concept of computer literacy, encompassing a broad range of skills, is too modest a goal, according to an increasing number of experts in the field, because existing skills and applications quickly become outdated. Instead, the concept of “computer fluency” has been introduced to capture the notion of sufficient expertise with and understanding of computers to lay a foundation for lifelong learning. Computer fluency has been defined as the ability to use computers to express oneself creatively, to reformulate knowledge, to synthesize information, and to adapt to continuous change. Supporters of this view maintain that children must achieve computer fluency to become effective and responsible users of technology throughout their lives.

In August 1997, the National Research Council’s Computer Science and Telecommunications Board (CSTB) embarked on an effort to define the skills and knowledge required to achieve computer fluency. Although the focus of the CSTB effort was primarily on college-level education, the conceptual framework was described as a continuum, with relevance for K–12 education as well. In a parallel effort to help define what children need to know about computer technology “to live, learn, and work successfully in an increasingly complex and information-rich society,” the International Society for Technology in Education launched a collaboration to develop national educational technology standards (commonly referred to as “NETS”) for technology-literate students at the K–12 level. Representatives from elementary and secondary schools, universities, corporations, foundations, and government worked together to “generate” a set of profiles reflecting the technology skills needed at key developmental points to support learning, personal productivity, decision making, daily life tasks, and lifelong learning. For each grade level, standards were proposed covering six basic categories of skills:

- Basic operations and concepts
- Social, ethical, and human issues
- Technology productivity tools
- Technology communication tools
- Technology research tools
- Technology problem-solving and decision-making tools

To ensure healthy, age-appropriate, enriching access to technology for all children, parents, teachers, and other adults who work with children must feel well prepared not only to teach basic computer skills, but to empower children to use computers more effectively and responsibly in many different ways throughout their lives. Standards such as NETS provide a useful guide to the technology skills children need for the future. To minimize the potential risks of excessive computer use, as a next step, guidelines for how much time children of different ages should use computers each day would be helpful.
RECOMMENDATION

State and local education agencies should refine and adopt age-appropriate guidelines for children’s computer fluency. Such guidelines should be disseminated to all elementary and secondary teachers and incorporated into pre-service and in-service technology training sessions.

The Equity of Access

The rapid growth of children’s access to computers and the Internet in the United States is impressive. Statistics suggest that as of 2000, over two-thirds of U.S. children have access to computers at home, and virtually all have access at school. Yet underneath the statistics are disparities that reflect and exacerbate socioeconomic differences in U.S. society. A closer look at the data reveals that, both at home and at school, more advantaged children are much more likely than less advantaged children to be provided opportunities to learn to use computers effectively as tools in their lives and experience enriched learning in the classroom.

Family Income Is Key to Home Access

Children’s access to home computers varies widely, based largely on family income. According to an analysis of census data conducted by Becker for this journal issue, some 57% of children overall had access to a home computer in 1998, but only about 22% of children living in families with annual incomes under $20,000 had a home computer, compared with 91% of children living in families with incomes over $75,000. Even when low-income families had a home computer, it was far less likely to be broadly functional—that is, to have a hard disk drive, a CD-ROM drive, a printer, a mouse, and connection to the Internet. Perhaps reflecting such limits, a recent report from the U.S. Department of Education indicated that while 21% of students from low-income families had access to a home computer in 1998, only 5% reported using the Internet at home. The 1998 census data also revealed differences in access linked to ethnicity, apart from income. More recent data suggest that differences based on ethnicity alone are narrowing, however, and that any remaining gaps can be explained almost entirely by differences in income. Nevertheless, as long as income remains a significant barrier to access, and household incomes differ markedly across ethnic groups, disparities in access among ethnic groups are likely to continue.

The history of dispersion of new technologies suggests that initial disparities between the “haves” and “have-nots” widen until dispersion reaches a point of saturation or ubiquity. At that point, as Dede points out in his commentary, the new technology tends to create a more egalitarian society. For example, the world of universal telephone service is a more equitable environment than was the world of messenger boys and telegraph offices. Similarly, universal computer access would provide more equitable access to information and power to create content, unfettered by intermediaries, than do mass communication tools that are controlled by a select few, such as with radio and television. Yet, even if computers contribute to greater egalitarianism, there are still costs for those who are the slowest to gain access, especially if significant disparities in access persist for some time.

In addition, some groups may remain permanently without access if dispersion is left to market forces alone. Experts disagree about the eventual size and significance of any such “disconnected” segments of society, however. On the one hand, despite steadily falling prices over the past 15 years, the percentage of families acquiring home computers appears to be leveling off across every income group. Among families with incomes under $30,000, the percentage owning computers actually declined slightly, from 41% to 40% between 1999 and 2000. Some analysts believe this trend indicates that an income gap in ownership of home computers may not be overcome by market
forces alone. The market has no interest in extending access to those not able or interested in participating in the new digital economy. Thus, market forces will not necessarily serve the needs of those interested in gaining access to the Web for social, educational, or political reasons, nor serve the needs of the very poor.

On the other hand, other analysts believe that significant further market penetration, even among low-income families, is likely. Internet-ready computers can now be purchased for as little as $300 to $400, and alternative devices can make online access even more affordable. New hybrid systems, or “Internet appliances,” provide connection to the Internet without a hard drive for as little as $99, plus monthly connection fees. Handheld devices and other wireless technologies promise additional inexpensive ways to go online. Also on the horizon are the next-generation television and digital “set-top” boxes that can connect a television to the Web. If penetration rates for “Web TV” are similar to those for cable TV, access to the Internet among low-income families could increase dramatically. Even among families with incomes under $25,000, over 70% have cable access in their homes. Whether such devices will help equalize access to computer technology and the Internet, or lead to a two-tiered system of access—one with premium functionality for the wealthy, and another with minimal functionality for the poor—remains to be seen.

To help expand access to home computers and the Internet among low-income families, various strategies have been initiated or proposed to augment free market forces. For example, some employers have sponsored programs to subsidize employees’ home computer purchases and monthly connection fees. Some communication experts have suggested that the “universal access” policy that subsidizes low-income families’ access to telephones in the home be expanded to include home access to computers and the Internet. A federal initiative to subsidize low-income households’ purchase of computers and Internet access was proposed in the fiscal year 2001 budget, but failed to receive funding. To ensure that computer technology helps create a more egalitarian society rather than magnify socioeconomic disparities, additional ways to expand home access for low-income families must be explored.

**RECOMMENDATION**

- The U.S. Department of Commerce should work with industry to expand opportunities for low-income families to acquire home computers and Internet access.

**Community Access Can Help Bridge Gaps**

Due to residential segregation by income level, community effects can exacerbate the already large family-level differences in children’s access to computers. That is, children in low-income families without home computers also tend to live in low-income neighborhoods where they are less likely to have access through a neighbor or friend. To help increase computer access among low-income families, several programs, public and private, are providing access at the neighborhood level through libraries and community technology centers (CTCs). For example, the federal Education-rate (or E-rate) program provides discounts on the cost of telecommunications services and equipment to all public and private schools and libraries, with the largest discounts provided to those in low-income neighborhoods. With the help of this program, thousands of libraries have acquired Internet access. Another federal program, the Community Technology Center program sponsored by the U.S. Department of Education, has provided funding to develop 450 centers in underserved communities across the country, and more are planned for the future. In addition, private foundations have played a major role in helping many libraries and CTCs get their programs up and running.
and running. For example, in collaboration with state library associations, the Gates Foundation pledged $200 million to equip public libraries in low-income communities across the United States and Canada with computer hardware, software, and Internet access.70

Library and community center technology programs can provide wonderful opportunities to introduce children to interactive and creative uses of technology. At the Computer Clubhouse in Boston, for example, inner-city children use computers to tell engaging stories and learn complex ideas. Mentors guide the children in using leading-edge software to create their own artwork, animations, simulations, multimedia presentations, virtual worlds, musical creations, Web sites, and robotic constructions.71 However, most CTC programs focus on community members generally and may not have a component geared specifically to children.72 Those that do may not be staffed with workers trained in more sophisticated uses of technology or age-appropriate skills for children. Steps should be taken to incorporate a focus on children into more library and CTC programs and to improve worker training.

RECOMMENDATION

Public and private funders should support efforts by libraries and community centers to include components within their technology programs focused specifically on children and to provide staff with training in the skills and types of exposure appropriate for children of different ages.

It is questionable, however, whether community access points such as libraries and CTCs can reach a majority of low-income children. Although subsidies and funding to extend access in disadvantaged communities have since increased, in 1998 fewer than 3% of low-income children had access to computers at libraries and community centers.60 Thus, libraries and CTCs are still far from realizing their potential to provide enriching access to computer technology for low-income children. To reach more children, we must look to schools.

Schools Must Play a Critical Role

In the mid-1990s, the Clinton administration enthusiastically embraced the congressional mandate to provide all our nation’s children with access to computers at school, launching the first national educational technology plan, Getting America's Students Ready for the 21st Century, in June 199673 and spending billions of dollars to connect children to computers and the Internet. The Education-rate (or E-rate) program mentioned earlier has been key to this effort. Since its creation in 1996, the E-rate program has provided over $6 billion to help connect schools and libraries to the Internet, with the major portion of funding going to public schools. As of 2000, about 70,000 public schools were participating in the program.69

Regardless of community income level, nearly all public elementary and secondary schools now have access to computers and the Internet. According to the most recent data from the National Center for Education Statistics (NCES), as of 1999, 90% of public schools serving predominantly low-income students had access to the Internet, only slightly less than the 94% of schools serving predominantly high-income students.74 However, having a computer does not necessarily mean it is being used, or used well. In the U.S. Department of Education report The Condition of Education 2000, data from 1998 showed disparities between schools’ reported access to computers and students’ use of computers.60,74 Although over 90% of schools reported having computers connected to the Internet, only 68% of low-income students and 86% of high-income students reported using computers at school. These differences most likely reflect differences in the capabilities and location of the computers available to students.

As discussed in the article by Becker in this journal issue, schools have often been saddled with outdated, stand-alone com-
Despite efforts to replace older machines, as of 1998, fewer than half of school computers were models introduced within the previous five years, and many schools, especially those in low-income areas, could not be described as well equipped, according to Becker. As of 1999, NCES data revealed significant differences in the nature of Internet access in poorer versus richer schools. For example, only 50% of the lowest-income schools had high-speed Internet access, compared with 72% of the highest-income schools.

The location of computers in a school building also can have an important impact on how they are used. Whether a computer is located in a classroom, a computer lab, the library, or the principal’s office makes a great deal of difference in terms of a student’s opportunity for meaningful use. The 1999 NCES data again revealed significant differences in poorer versus richer schools. Only 39% of the instructional classrooms in lower-income schools had Internet access, with a ratio of 16 students per computer. In contrast, some 74% of instructional classrooms in higher-income classrooms were connected, with a ratio of 7 students per computer. If the bulk of well-connected classrooms are also concentrated in advanced classes, as opposed to remedial classes, or in subjects taken predominantly by boys rather than girls, then equity issues may exist within a school as well.

In addition, Becker’s analysis of 1998 data from a nationwide survey of teachers indicates that higher-income schools more often used computers in more intellectually powerful ways to enhance learning compared with lower-income schools. More specifically, higher-income students were more likely to use computers for sophisticated applications such as written expression, making presentations to an audience, and information analysis; in contrast, lower-income students were more likely to use computers for remediation of skills or mastering skills just taught.

Finally, some schools remain disconnected entirely. A September 2000 report from the U.S. Department of Education about progress made under the E-rate program found that although most schools serving low-income students were taking advantage of the program, the very poorest schools were not applying for E-rate discounts as often as other schools. To receive the E-rate discounts, schools must complete an application and contribute 10% in matching funds, which may pose barriers for schools in especially poor areas. Because a major purpose of the E-rate program is to help provide access for schools and libraries in areas of greatest economic need, the Department is now looking for ways to assist the poorest schools to overcome these barriers.

Thus, although most lower-income schools are gaining access to computer technology in comparable numbers to higher-income schools, the disparities in students’ access to enriched learning opportunities with technology may be increasing. In addition to acquiring computers and Internet access, lower-income schools must strive to obtain more advanced software and explore better strategies for integrating appropriate and effective computer use with classroom learning if they are to help bridge the gap in access to technology for their less advantaged students.

RECOMMENDATION

The U.S. Department of Education should assist the poorest schools in applying for E-rate discounts and encourage all schools to offer a broad range of technology-related experiences to their students, preferably connected to the curriculum in ways that have been shown to be appropriate and effective.

Schools should also strive to play an instrumental role in equalizing access to technology and enhanced learning opportunities for children with disabilities. As discussed in the article by
Hasselbring and Williams Glaser, advances in computer technology have opened up many new opportunities for children with disabilities to attend regular schools and learn alongside their nondisabled peers. But for children with disabilities, the type of computer hardware and software used can sometimes pose barriers. According to the World Institute on Disability, a number of relatively simple choices to adopt “universal design” features could enhance access to the Internet for all children, with and without disabilities. Suggested strategies include getting high-speed connections, using a “text-only” option, using larger monitors and font sizes, using headphones, and providing communication tools such as word prediction software. Other helpful devices include a trackball (to replace the mouse), touch screens, alternative keyboards, and voice input and output technology. (See the article by Hasselbring and Williams Glaser for more detailed descriptions of these devices.) A resource guide published by the National School Boards Association and the U.S. Department of Education provides insights into applications of technology in the classroom to assist students with disabilities.

**RECOMMENDATION**

When acquiring new hardware and software, schools should consider options that incorporate universal design features to facilitate access to computers for all students, including those with special needs.

In sum, home access to computers and the Internet varies widely by income, but the gap appears to be narrowing. With market forces driving down costs, and with the support of a few public and private-sponsored initiatives, it is not unrealistic to expect computer technology to help us move toward a more egalitarian society in terms of access to information and power to create content. Meanwhile, libraries, community technology centers, and especially schools play an important role in providing low-income and special needs children with access to and experiences with computers that will help prepare them for life in the twenty-first century.

**The Potential for Enhanced Learning**

Beyond teaching computer skills, there has been a push to use technology in the classroom to enhance instruction. The rationale for increased federal support for computers in schools was, first and foremost, to improve learning and help meet the education goals as laid out in the Goals 2000: Educate America Act of 1994. Yet the body of research linking use of computers to improved learning was—and continues to be—inadequate in many areas, with many questions about the effectiveness of technology across various age groups and subject areas still unanswered. While studies confirm that some models of technology-supported practices can, indeed, promote children’s learning under some circumstances, the research to date does not support broad claims to effectiveness.

Educators have used computers as learning tools in America’s elementary and secondary schools for over 30 years. The 1960s brought computer-assisted instruction to schools, providing individualized drill and practice to reinforce basic skills. With the development and increased availability of lower-cost personal computers, school use of technology broadened in the early 1980s to include applications such as word processing, spreadsheets, and distance learning via two-way audio and video. In the 1990s, even more sophisticated applications, including multimedia educational software and the communication features of the Internet, began to be used to enrich curricula across the range of academic subjects.

To date, however, technology has not been embraced as a tool to transform how and what children learn in the typical classroom. Teacher survey data indicate that in 1998, most students were exposed
to a broad range of computer applications at some point during the school year, but such exposure was generally not linked to curricula in core academic classes, especially in schools serving predominantly low-income students. Instead, for the most part, students used computers primarily in nonacademic courses. As noted by a U.S. Department of Education official at a recent conference, technology has swept the nation in almost every sector except education.83 To understand the reasons for the slow integration of more sophisticated and powerful uses of technology into the curricula in most classrooms, it is helpful to understand the larger debate surrounding elementary and secondary education goals in this country.

**The Larger Debate on Education Reform**

Computers are being thrust into an already highly charged, contentious arena of competing ideas about what and how to teach our nation’s children. In simplified terms, at one end of the spectrum are those who place a heavy emphasis on a return to basics—that is, the fundamentals of reading, writing, and arithmetic. This approach is embodied in many state and local responses to the call for standards in the Goals 2000: Educate America Act and other federal legislation.84 Its supporters maintain that a stronger command of the basics is needed to ensure a competitive workforce in the future. At the other end of the spectrum are those who place greater emphasis on making sure all students learn the “higher-order” skills of problem solving, communicating effectively, analyzing information, and designing solutions. Advocates of this approach believe that higher-order skills can be acquired alongside basic skills and will prove as important as the basics in ensuring that our nation does not lose its competitive edge in the marketplace.35,85

Overlying these different approaches to what students should be taught are different methods of how students should be taught. The traditional “transmission” approach to learning relies primarily on books and lectures to impart knowledge, while students are mostly passive, expected to memorize and recite what they have learned.35 In contrast, a “constructivist” approach to learning focuses more on cultivating student interest through critical thinking and real-world applications and often involves problem solving in small groups. This method expects students to actively “construct” knowledge through direct experience, interpretation, and structured interaction with peers and teachers.

Most teachers, of course, teach a combination of basic and higher-order skills through a variety of methods ranging from more transmission oriented to more constructivist. The emergence of what has been termed “high-stakes testing,” however, has thrust the extremes into the limelight. Over the last few years, an increasing number of states and local school districts have adopted standardized tests, with results often linked to “high-stakes” decisions about student advancement and graduation, teacher pay and promotion, and funding and control of individual schools.86 As a result, teachers are increasingly concerned with linking classroom curricula to the content of such tests—a practice commonly referred to as “teaching to the test.” Because these tests typically focus on basic skills, supporters of higher-order thinking skills fear that standardized tests are leading to a narrowing of curricula. Some go even further, cautioning that if higher-order thinking skills are not emphasized, the entire public education system will become obsolete because it is preparing children for a world that no longer exists.87

How computers are used or not used in the classroom must be seen within the context of this larger debate about education in the twenty-first century and the increasing emphasis on standardized tests. Most teachers, parents, and policymakers agree that children should learn, in age-appropriate ways, how to use computers with a broad array of applications, but there is much less agreement about the extent to which teachers should integrate computers into classroom curricula. One’s stance on the larger issues surrounding education reform influences one’s view of all other factors contributing to decisions about computer use in the classroom, such as evidence of effective-
ness, teacher training, and other organizational supports.

**Limited Research on Effective Applications**

As tools, computers can be used in ways that serve any combination of teaching approaches. For example, to reinforce basic skills, a more traditional approach may be to use a “drill and practice” computer application, while a more constructivist approach might use a computerized tutorial program that involves more interaction and feedback. To teach higher-order skills, a more traditional approach might use the computer for “distance learning,” tapping into an online presentation about problem solving in a community far away. In contrast, a more constructivist approach might involve an exchange of ideas via the Internet between students from two different communities to work toward a solution together. Alternatively, one could choose to teach basic or higher-order skills without any computers at all.

A key factor affecting teachers’ use or nonuse of technology is their degree of confidence that available software or Internet content can be effective in enhancing the curriculum, consistent with their teaching philosophy. However, current research is generally insufficient to give teachers the guidance they need about what application might work best in their classroom and how to use the application effectively to ensure positive results.

Indeed, existing research suggests that not all uses of the computer are effective, or effective in the same ways, and studies often produce mixed results, depending on the applications and outcomes measured. In general, the strongest evidence of positive effects tends to be for constructivist applications designed to teach higher-order thinking skills, but only when success is measured by depth of understanding rather than improvements in basic skills. For example, one of the few large-scale, nationwide studies on the effectiveness of educational technology found that more sophisticated applications increased fourth- and eighth-grade students’ mathematical understanding, while software involving repetitive skill practice apparently decreased understanding. However, more traditional “drill and practice” applications have been found to be more effective at improving performance on basic skills tests. A meta-analysis of over 500 research studies of computer-based instruction found that computer tutoring applications improved students’ scores on achievement tests, whereas other, more sophisticated applications had only minimal effects on such tests.

In the article by Roschelle and colleagues in this journal issue, the authors maintain that positive results from computer use are most likely to be achieved when the applications reinforce one or more of the four fundamental characteristics of learning that underpin the “constructivist” approach: (1) active engagement, (2) participation in groups, (3) frequent interaction and feedback, and (4) connections to real-world contexts. According to learning research, as well as the practical experience of many teachers, such an approach is much better matched to how children learn than the “transmission” approach. When computer-based technology integrates constructivist principles into the learning process, the authors argue it can be an effective tool in helping students learn higher-order skills involving creative or critical thinking about complex ideas.

For example, Roschelle and colleagues describe a computer-based application, “Microcomputer-Based Laboratory,” which allows the instantaneous graphing of data as they are gathered. Use of this software has been found to produce significant gains in middle school students’ ability to interpret and use graphs. Another example cited is ThinkerTools, a simulation program that has been shown to improve students’ learning by representing complex subject matter—in this case, velocity and acceleration—through visualization. This application enabled middle school students to grasp complex scientific concepts several grade levels before they are usually taught.

Other promising applications cited by these and other authors include com-

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puter programming using child-friendly languages such as Logo, which has been shown to increase problem-solving abilities and comprehension; desktop publishing and multimedia software that enables students to take pride in creating elaborate, professional-looking presentations; and the communication features of the Internet, which foster students’ critical thinking skills through collaborative projects with others in the classroom or around the world. Because not all students respond in the same way to specific teaching approaches, the various computer applications—which tend to incorporate verbal as well as nonverbal forms of teaching—are helpful in providing alternative ways to learn. As noted in the article by Hasselbring and Williams Glaser, when such applications are incorporated into classroom instruction, they can be especially helpful to students with mild learning disorders, who account for about 1 out of every 10 students in elementary and secondary classrooms across the country.

Despite such examples, very little research exists on the effectiveness of various computer applications and technology-supported practices in subjects other than math and science, or for younger students in early elementary school or preschool. In contrast to the burgeoning number of products on the market, there has been very little research or product screening and assessment to help teachers identify which applications may be of high quality and aligned with their teaching objectives. In August 1998, the U.S. Department of Education established an expert panel on educational technology to identify promising and exemplary educational technology programs based on quality, significance, replicability, and evidence of success. The panel released its first list of model educational technology programs in September 2000, citing only seven promising programs and two exemplary programs, Challenge 2000 Multimedia Project in California and Generation www.Y in Washington. The low number of programs cited was due, in part, to the lack of research on effectiveness and documentation of success.

As pointed out in the commentary by Dede, compared with other sectors of society, relatively little money is spent on research in education, and as a result, many opportunities for improvement in education are unrealized. Although our nation has allocated a substantial amount of money to creating a technology infrastructure for schools, relatively little funding has gone into assessing the strengths and limitations of learning technologies. More systematic, in-depth research on the effectiveness of learning technology programs and practices is needed.

**RECOMMENDATION**

More public and private research dollars should be allocated to assessing the effectiveness of technology-supported practices in the classroom across various subjects and grade levels and to disseminating the results to state and local education agencies and teachers.

The education sector is just on the threshold of acquiring computers in massive numbers, however, so it should not be surprising if it takes some time for elementary and secondary schools throughout the country to develop strategies for integrating technology into classroom instruction. Just as it has taken many years for technology to transform industry—a transformation still under way—it will likely take many years to achieve a similar shift in education practice. There may be many ways for teachers to use technology to enhance learning in the classroom, across many subject areas and grade levels, but this has yet to be demonstrated. In the meantime, while more definitive research is under way, we should encourage teachers to experiment and exchange ideas and experiences about promising technology-supported practices. To help facilitate such an exchange, the U.S. Department of Education’s Web site could list teacher-recommended technology-supported programs and practices.
organized by subject area, objectives, and grade level, with links to other sites with more information.

**More Teacher Training and Development Is Needed**

Research confirms what parents have known for years: the most critical factor in the quality of a child’s learning experiences— with computers and otherwise—is the quality of a child’s teacher. Strategies that focus on teachers’ skills and abilities may be what are most needed to ensure the educational success of our nation’s children. As Healy points out in her commentary in this journal issue, disadvantaged students without computers but with excellent teachers and curricula are far better off than children who spend time using computers for rote activities without substantive, interpersonal learning experiences.

To help teachers become savvy computer users— knowing when to use computers and when not to, and knowing what technology-supported practices might be appropriate—they need training. Recognizing the important role of teachers, the Clinton administration set as the first goal in its 1996 national educational technology plan that “all teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.” U.S. Department of Education data from 1998 indicate that 78% of teachers nationwide participated in training during the previous year on integrating educational technology in the grade or subject they teach, and subsequently they felt better prepared to use technology in their classroom lessons. Yet in another survey, most teachers said they still lacked the expertise to use the more sophisticated computer-based applications.

For teachers to make informed decisions about using technology to enhance student learning, they must be provided with training so that they know which software applications and technology-supported practices are available, which might be appropriate for their classes, and how they can be integrated effectively into the curriculum. State and local education agencies should ensure that all teachers receive preservice and/or inservice training on how to integrate technology effectively into curricula, including the opportunity to observe models of effective technology-supported practices.

One of the best ways for teachers to develop effective strategies for integrating technology into curricula is through networking and collaborating with other teachers. Yet teachers often have difficulty finding time to engage in such networking, which often does not count toward requirements for professional development. To encourage and reward teachers for time spent networking and collaborating with other teachers to enhance classroom learning using computers, federal, state, and local education agencies could allow such time to count toward professional development requirements for educational technology funds.

**Organizational and Structural Supports Are Also Needed**

Finally, once appropriate technology-supported practices have been identified, organizational and structural supports are needed to promote their effective use. According to a 1999 report from the U.S. Department of Education, teachers cite having an insufficient number of computers as the biggest barrier to effective use. The typical middle school or high school throughout this country places nearly one-half of its computers in shared computer labs, while most academic classrooms have only one or two computers. Becker’s analysis of nationwide survey data gathered from teachers in 1998 found that only 3% of all secondary academic classrooms had both an Internet connection and four or more computers— important ingredients for successful integration with the curriculum. The data also showed that Internet access was twice as likely to be used frequently if classrooms had at least four computers with online connections than if they had only a single Internet-connected computer. To support more integrated use of technology with academic curricula, schools may need to redistribute com-
Computers out of labs and into classrooms. Also, teachers, like other professionals, need technical support to maintain the hardware and troubleshoot glitches with software. A greater proportion of educational technology funds should be devoted to providing such ongoing technical support.

In addition, to the extent that the most appropriate and promising technology-supported practices tend to be those that facilitate the acquisition of higher-order thinking skills, the mismatch with the focus of “high-stakes” student achievement tests on basics can be a disincentive for incorporating technology into the curriculum. In a national survey on teachers’ use of digital content (including software and Web sites), teachers noted the failure of content to link with state and district student achievement tests as a major concern. If age-appropriate higher-order thinking skills are deemed important, it would be helpful to include some measures reflecting these skills on state and local standardized tests. Then “teaching to the test” might include more constructivist approaches with technology to promote students’ deeper understanding of complex concepts. The U.S. Department of Education could assist in this process by sponsoring the development of examples of items that assess age-appropriate higher-order thinking skills for possible inclusion on district- and state-mandated tests.

In sum, beyond a handful of examples, the research on use of educational technology is inadequate to support sweeping claims of effectiveness. We must ask, as Healy does in her commentary, what unique role can computers play in education? Technology should be used for teaching opportunities not otherwise possible, rather than for replacing traditional approaches regardless of whether such use adds value. Much more experimentation and research are needed to identify those opportunities across various grade levels and subject areas. First, decisions must be made about what skills we want our nation’s children to learn; then we must determine if technology-supported practices can effectively enhance the teaching of those skills.

Conclusions

Computer technology is rapidly transforming society. Although the task may seem daunting, we can take several steps to help ensure that children use computers in ways that improve their lives now and in the future.

First, we can ensure that children acquire the necessary skills to navigate the digital world effectively and responsibly. Parents, teachers, and other adults who work with children can teach children to make good choices about the time they spend with computers, to be savvy digital consumers, and to seek out software and online content that educates and inspires, not merely entertains. With our guidance and enthusiasm, children can use the computer to learn about other people and parts of the world, for example, as well as to play video games. If use of higher-quality content increases, industry can be challenged more effectively to meet the demand.

Second, we can ensure that children have opportunities to use computer technology more actively to create, to design, to invent, and to collaborate with children in other classrooms and communities. These are types of activities that empower children to play active roles in the emerging digital world, not merely to navigate through it. With the assistance of highly trained mentors, children can learn to use computers to create finger paintings, or to design and build bird feeders, for example, as well as to surf the Web for the lyrics of hit songs.

Third, we can help reduce disparities between rich and poor by working to narrow the gap in computer access between children who live in low-income neighborhoods compared with those in high-income neighborhoods. Initiatives that help low-income families to afford home computers and that support technology programs in public libraries and community centers can play an important part in equalizing access. As the primary access point for most low-income children, however, schools must play the critical role. To promote “equality of digital opportunity,” we can ensure that schools in low-income neighborhoods are well
equipped with up-to-date hardware, high-quality software, and well-trained teachers so that children learn the skills they will need to live and work in the twenty-first century.

Finally, to harness the potential of computer technology to enhance children’s learning, we can explore ways to use technology effectively in the classroom, ways that add value to traditional curricula and reach students who fail to respond to traditional approaches. Although computers may not be the panacea envisioned by some, certain uses of technology have been demonstrated to benefit students by making learning more interesting and engaging and by providing new approaches to learning complex concepts and critical thinking.

We should identify the technology-supported practices that show the most promise for enhancing learning and support efforts to integrate these practices into the classroom.

Computer technology is only a tool—whether it serves to improve children’s lives depends on how it is used. By taking these steps today, we can help empower all children to use the tool effectively, responsibly, and creatively to shape the digital world of tomorrow.

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19. For example, a survey conducted by America Online in February 1997 found that among the 290 respondents, 20% of boys ages 6 to 19 reported using the Internet 29 hours or more per week.

20. See the article by Subrahmanyam and colleagues in this journal issue for further discussion of this topic.


28. See note no. 2, Woodward and Gridina, p. 3.

30. See note no. 16, AAP. The Academy had earlier advised that television viewing should be limited to no more than one to two hours per day. See *American Academy of Pediatrics. Children, adolescents, and television. Pediatrics* (October 1995) 96:786–87.

31. Based on original analysis of Census data included in the article by Becker in this journal issue.


35. See the article by Roschelle and colleagues in this journal issue.


42. See Web site at http://www.pacificnews.org/ yo.


48. See the article by Becker in this journal issue, Figure 8.


52. See the article by Montgomery in this journal issue for more on this topic.


56. See the article by Wartella and Jennings in this journal issue for a more detailed discussion of this topic.

57. See Web site for the Media Literacy Online Project at http://interact.uoregon.edu/MediaLit/HomePage.

58. For more information about the National Educational Technology Standards (NETS) project, see the ISTE Web site at http://cnets.iste.org.

59. While somewhat dated, survey responses from the Census Bureau's October 1997 and December 1998 Current Population Survey of U.S. Households supplements used by Becker remain the most comprehensive source of data on children's access to and use of home computers.


62. Thierer, A.D. How free computers are filling the digital divide. The Heritage Foundation Backgrounder. April 20, 2000, issue no. 1361.

63. See note no. 10, Roberts, Foehr, Rideout, et al., p. 11.


66. See note no. 10, Roberts, Foehr, Rideout, et al., pp. 11, 14, 23, 26, 34, and 38.

http://www.futureofchildren.org
67. See the article by Becker in this journal issue for further discussion of this topic.

68. The E-rate program was authorized under the Telecommunications Act of 1996, which expanded the principle of universal access for wire and radio communications to include Internet connections for schools and libraries. The program is administered by the Schools and Libraries Division (SLD) of the Universal Service Administrative Company, a not-for-profit corporation appointed by the Federal Communications Commission. For more information, see the “Program Overview” page on the SLD Web site at http://www.sld.universalservice.org.


70. Bill and Melinda Gates Foundation: Overview. Seattle, WA: Bill and Melinda Gates Foundation, 2000. Other private foundations active in supporting access through CTCs and libraries include the Benton Foundation, the Annie E. Casey Foundation, the Kellogg Foundation, and The California Wellness Foundation.


74. See note no. 1, NCES, February 2000. Income status is defined on the basis of the percentage of students eligible for free or reduced-price school lunch. Schools in the highest income bracket have less than 11% of their students eligible for such programs, while schools in the lowest income bracket have 71% or more eligible students.


76. See, for example, note no. 34, AAUW, Tech-savvy; see also Schofield, J.W. Computers and classroom culture. New York: Cambridge University Press, 1995.


79. See note no. 13, P.L. 103–382 (October 20, 1994).


87. See, for example, note no. 83, Forum, December 1999; see also Papert, S. Remarks to a House of Representatives Panel on Technology and Education. Washington, DC: October 12, 1995.


93. See the article by Hasselbring and Williams Glaser in this journal issue for further discussion of this topic.


95. For more information about the panel and its findings, see the Department of Education Web site at http://www.ed.gov/Offices/OERI/ORAD/LTD/panel.html.

96. Who should teach? The states decide. Education Week (January 13, 2000) 19:8–9. See also the articles by Becker, by Roschelle and colleagues, and by Hasselbring and Williams Glaser in this journal issue.


